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USACE / NAVFAC / AFCEC **UFGS-26 11 13.00 20 (November 2021)**

Preparing Activity: NAVFAC **Superseding**
26 11 13.00 20 (April 2007)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025
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SECTION 26 11 13.00 20

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SECTION 26 11 13.00 20

PRIMARY UNIT SUBSTATION
11/21

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NOTE: This guide specification covers the requirements for primary substations and associated load break switches and switchgear.

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

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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NOTE: To download UFGS Forms, Graphics, and Tables, go to: https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables
****

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NOTE: A primary substation as used in this specification is a substation in which the primary and secondary voltages are both rated 1000 volts and above, normally in the medium voltage range of 5 kV to 35 kV. This specification includes indoor and outdoor applications.

USE THE FOLLOWING RELATED GUIDE SPECIFICATIONS FOR POWER DISTRIBUTION EQUIPMENT:

--Section 26 08 00 APPARATUS INSPECTION AND TESTING
--Section 26 12 19 PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS
--Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS
--Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION
--Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION
--Section 26 13 00 SF6/HIGH-FIREPOINT FLUIDS INSULATED PAD-MOUNTED SWITCHGEAR
--Section 26 11 16 SECONDARY UNIT SUBSTATIONS
--Section 26 23 00 LOW-VOLTAGE SWITCHGEAR
--Section 26 24 13 SWITCHBOARDS
****

****
NOTE: The following information must be indicated on the project drawings or specified in the project specifications:

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

2. Location, space available, arrangement, and elevations of substations and switchgear.

3. Grounding plan.

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

5. Minimum and maximum overall dimensions of shipping section which can be handled and installed at destination, as applicable.

6. Transformer primary and secondary voltages. (Use IEEE C57.12.00, Table 11(b), Designation of voltage ratings of three-phase windings".) State the primary voltage (nominal) actually in service and not the voltage class.

7. Special conditions, such as altitude, temperature and humidity, exposure to fumes, vapors, dust, and gases.

8. Where extensions or additions to existing substations or switchgear are being specified, clearly distinguish the difference between existing equipment and the equipment the Contractor is required to provide under this contract. Clearly indicate the extent of the Contractor's responsibility for testing the existing equipment upon completion of his work.
****

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

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

****

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A240/A240M	(2024b) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A653/A653M	(2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

ASTM D117	(2018) Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Liquids
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System
ASTM D2472	(2000; R 2014) Standard Specification for Sulphur Hexafluoride
ASTM D3487	(2016; E2017) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D6871	(2017) Standard Specification for Natural (Vegetable Oil) Ester Fluids Used in Electrical Apparatus

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide https://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1613	(2023) Environmental and Testing Requirements for Devices with Communications Functions used with Electric Power Apparatus
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.04	(2018; Erta 2019; Corr 2021) Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V Corrigendum 1
IEEE C37.06	(2009) Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities for Voltage Above 1000 V
IEEE C37.2	(2022 Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations
IEEE C37.20.2A	(2020) Metal-Clad Switchgear Amendment 1: Control and Secondary Circuits and Devices, and All Wiring
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear

IEEE C37.41	(2016; Corr 2017) Design Tests for High-Voltage (>1000 V) Fuses and Accessories
IEEE C37.46	(2010) Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
IEEE C37.74	(2014) Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV
IEEE C37.90	(2005; R 2011) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C37.94	(2021) IEEE Standard for N times 64 kbps Optical Fiber interfaces between Teleprotection and Multiplexer Equipment
IEEE C37.118	(2021) Standard for Synchrophasor Measurements for Power Systems
IEEE C37.121	(2012) American National Standard for Switchgear-Unit Substations - Requirements
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2023) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.96	(2013) Guide for Loading Dry-Type Distribution and Power Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60068-2-27	(2008; ED 4.0) Environmental Testing - Part 2-27: Tests - Test Ea and Guidance: Shock
IEC 60255-21-3	(1993; ED 1.0) Electrical Relays - Part 21: Vibration, Shock, Bump And Seismic Tests On Measuring Relays And Protection Equipment - Section 3: Seismic Tests
IEC 61000-4-5	(2017) Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge Immunity Test
IEC 61000-6-2	(2021) Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61010	(2021) Overview - Standard for Safety Requirements for Electrical Equipment
IEC 61800-3	(2022) Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods
IEC 61850	(2021) Communication networks and systems for power utility automation

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.4	(1984; R 2011) Registers - Mechanical Demand
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TS-2	(2021) Traffic Controller Assemblies with NTCIP Requirements - Version 03.08
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 1 2024; TIA 24-1) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-232	(1997f; R 2012) Interface Between Data

	Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
TIA-485	(1998a; R 2012) Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

UL SOLUTIONS (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 1437	(2006) Electrical Analog Instruments - Panel Board Types

1.2 RELATED REQUIREMENTS

****
NOTE: Include Section 26 08 00 APPARATUS INSPECTION AND TESTING on all projects involving medium voltage and specialized power distribution equipment
****

Section 26 08 00 APPARATUS INSPECTION AND TESTING and Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

****
NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for

Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

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

****

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

****

NOTE: Include the bracketed options on "DC44 and 074 review" for NAVFAC LANT and NAVFAC SE projects respectively. For other projects, submittal review must be performed by the designer of record. If submittal review by NAVFAC LANT or NAVFAC SE is specifically desired, the responsible Government agency must coordinate with the respective Code DC44 or 074 during the design process. Add appropriate information in Section 01 33 00 SUBMITTAL PROCEDURES to coordinate with the special requirements.

****

[Submit in accordance with paragraph COORDINATED SUBMITTAL REVIEWS herein.

]1.3.1 Coordinated Submittal Reviews

a. Submit transformer submittals to Code [DC44, Atlantic][074, Southern] Division, Naval Facilities Engineering Systems Command for approval. In addition, submit one set of the remaining substation components for surveillance.

b. Submit remaining substation component submittals to Engineer of Record for approval. In addition, submit one set of transformer submittals for review and to insure alignment of equipment and coordination for interconnections.

SD-02 Shop Drawings

Unit Substation Drawings; G, [_____]

[Transformer Drawings[(to Code [DC44] [074])]; G, [_____]

] DC One-Line Diagram; G, [_____]

DC Panel Schedules; G, [_____]

[SCADA Interconnection Diagram; G, [_____]

] SD-03 Product Data

****
NOTE: Use bracketed options referring to Codes DC44 and 074 for NAVFAC LANT and NAVFAC SE projects, respectively. This requires the designer of record to review and approve the substation equipment submittals except for the transformer. The EFD will review and approve the transformer submittals.
****

Primary Unit Substations[Excluding Transformer Data]; G, [_____]

[Unit Substation Transformer[(to Code [DC44] [074])]; G, [_____]

] Submittal must include manufacturer's information for each component, device and accessory provided with the equipment.

SD-05 Design Data

Capacity Calculations for Battery Charger and Batteries; G, [_____]

SD-06 Test Reports

****
NOTE: Include "Calibration test reports" for NAVFAC SE projects.
****

[Calibration Test Reports; G, [_____]

] Submit report of results of Acceptance Checks and Tests specified by paragraph FIELD QUALITY CONTROL; G, [_____]

****
NOTE: Field dielectric tests are recommended only when new units added to an existing installation or after major field modifications. If necessary, service the equipment prior to the field test.
****

[Certified Copies of Dielectric Tests Report; G, [_____]

] SD-09 Manufacturer's Field Reports

****
NOTE: If project includes special requirements or unusual application of the equipment specified in this section, factory tests may be specified on completely assembled unit substations as well as individual components. These completely assembled tests involve additional cost and specific requirements must be added to this specification when they are deemed necessary.
****

Switchgear Design Tests; G, [_____]

Switchgear Production Tests; G, [_____]

Load Interrupter Switch Design Tests; G, [_____]

Load Interrupter Switch Production Tests; G, [_____]

Transformer Design Tests[to Code [DC44] [074]]; G, [_____]

Transformer Routine and Other Tests[(to Code [DC44] [074])]; G, [_____]

SD-10 Operation and Maintenance Data

Primary Unit Substations, Data Package 5; G, [_____]

[Unit Substation Transformer, Data Package 5; G, [_____]

] Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

****
NOTE: Include "Calibration schedule" and "Formal request for settings" for NAVFAC SE projects.
****

[Calibration Schedule; G, [_____]

][Formal Request for Settings; G, [_____]

] Equipment Test Schedule[(to Code [DC44] [074])]; G, [_____]

1.4 QUALITY ASSURANCE

1.4.1 Battery Power Calculations

Submit capacity calculations for battery charger and batteries. Calculation must verify that battery capacity exceeds station d.c. power requirements.

1.4.2 Unit Substation Drawings

Drawings must include, but are not limited to, the following:

a. An outline drawing with front, top, and side views

b. Ampere ratings of bus bars

c. Maximum short-circuit bracing

d. Nameplate data

[e. Provisions for future extension[and future forced air equipment]

][f. Circuit breaker[and switch] type(s), interrupting ratings, and trip devices including available settings

] g. Elementary diagrams and wiring diagrams with terminals identified and indicating prewired interconnections between items of equipment and the interconnection between the items

h. One-line diagram, including switch(es),[circuit breakers,][current transformers, meters,] and fuses

i. Manufacturer's instruction manuals and published time-current curves (on full size 279 by 431 mm 11 by 17 inches logarithmic paper) of the[fuse in the load interrupter switch,][main secondary breaker,][largest secondary feeder device]; transformer thermal and magnetic damage information; and transformer inrush current information (magnetic inrush point). These must be used by the designer of record to verify fuse size and to[provide breaker settings that will] ensure protection and coordination are achieved.

[1.4.3 Transformer Drawings

****
NOTE: Include bracketed option for separate transformer drawings on NAVFAC LANT and NAVFAC SE projects only.
****

Drawings must include, but are not limited to the following:

a. An outline drawing, with top, front, and side views

b. ANSI nameplate data

][1.4.4 Calibration Schedule

****
NOTE: Include "Calibration schedule" and "Formal request for settings" for NAVFAC SE projects only.
****

a. Provide a calibration schedule including the anticipated dates when equipment requiring coordination and protection will be installed, the anticipated date when the Contractor will submit a formal request for settings, and the anticipated date when the manufacturer's technical representative will perform settings and calibrate equipment.

b. Submit the calibration schedule, via the Contracting Officer to:

NAVFAC SE, Code 05, Construction Department

NAVFAC SE; Code 162; Director, Utilities Engineering Division

][1.4.5 Formal Request for Settings

****
NOTE: The "30" days in brackets below may be extended for projects involving major electrical distribution work. Consult with NAVFAC SE Code 162.
****

a. Where settings will be provided by the Government to achieve protection and coordination via relays and protective devices, submit

a formal request for settings [30][_____] days in advance of the date that settings will be needed, to allow the Contracting Officer to forward a copy of approved shop drawings to NAVFAC SE; Code 162; Director, Utilities Engineering Division.

b. The equipment requiring protection and coordination must be installed prior to making this request.

c. Include approved shop drawings, manufacturer's instructions to set the protective devices, and manufacturer's time-current curves.

d. Submit the formal request for settings, via the Contracting Officer to: NAVFAC SE; Code 162; Director, Utilities Engineering Division.

][1.4.6 Calibration Test Reports

****
NOTE: Include this paragraph for NAVFAC SE projects.
****

Submit test results on protective relays via the Contracting Officer to NAVFAC SE; Code 162; Director, Utilities Engineering Division.

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

]1.4.7 DC One-Line Diagram

Submit one-line diagram showing all DC components, interconnecting wiring and over current protective devices.

1.4.8 DC Panel Schedules

Submit panel schedules for each DC panelboard. Schedule must indicate panel ratings, mounting configuration and over current protective device sizes.

[1.4.9 SCADA Interconnection Diagram

Provide a connection diagram for the Supervisory control and data acquisition (SCADA) system. The diagram must show all components along with the required conduit and wire sizes.

]1.5 MAINTENANCE

1.5.1 Additions to Operation and Maintenance Data

In addition to requirements of Data Package 5, include the following on the actual primary unit substations provided.

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, including front view and sectional views with items and devices identified

c. Prices for spare parts and supply list

d. Routine and field acceptance test reports

e. Time-Current-Characteristic (TCC) curves of fuses[and circuit breakers]

[f. Information on metering

] g. Actual nameplate diagram

h. Date of purchase

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be secondary unit substations and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 PRIMARY UNIT SUBSTATIONS

IEEE C37.121, [single-ended][double-ended]arrangement, consisting of [one][two] incoming sections, [one][two] transformer sections, [one][two] transition sections, the number of auxiliary sections, bus-tie sections, and outgoing sections indicated.[Substation must be designed for indoor service.][Substation must be designed for outdoor service with ventilation openings and gasketing provided to ensure a weatherproof assembly under rain, snow, sleet, sand/dust storms, and hurricane conditions.] External doors must have provisions for padlocking.

2.2.1 Incoming Sections

****

NOTE: Choose one of the following three choices for each incoming section: a metal-clad switchgear section, a metal-enclosed switch section, or an air filled terminal chamber.

****

[The][Each] incoming section must consist of[a metal-clad switchgear section][a metal-enclosed switch section][an air filled terminal chamber] for connecting the incoming circuit [directly] [through a [circuit breaker] [[fused] [nonfused] load interrupter switch]]to the transformer. If required for proper connection and alignment, include a transition section with the incoming section. Connection between [circuit breaker][interrupter switch] and transformer must be insulated copper bus or insulated copper cable mounted on porcelain insulators spaced no more than 610 mm 2 feet apart.

2.2.1.1 Conductor Termination

Conductor terminations must be designed for terminating [one][two][_____] single conductor cables per phase and must be arranged for conduits entering from [below][above]. Provide cable terminations of the [modular molded rubber][porcelain insulator] type as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

[2.2.1.2 [Vacuum][or][SF6] Circuit Breaker as Main Protective Device

****

NOTE: When a separately enclosed, pad mounted SF6

switch is provided as the incoming disconnecting/overcurrent protection device for the primary unit substation, use Section 26 13 00 SF6/HIGH-FIREPOINT FLUIDS INSULATED PAD-MOUNTED SWITCHGEAR. Modify Section 26 13 00 for vault-type switches, where applicable.

NOTE: Choose this subparagraph or paragraph LOAD INTERRUPTER SWITCH AS MAIN PROTECTIVE DEVICE.

NOTE: Circuit breakers are more costly than fused switches, but may be needed where switching is frequent, and quick reclosing is required.

The [vacuum][or][SF6] circuit breaker must be an electrically-operated, three-pole, circuit interrupting device rated for [_____] amperes continuous at [_____] kV and [_____] kV BIL. Breaker must be designed for service on a [_____] kV system with a short-circuit capacity of not less than [_____] [amperes symmetrical][MVA]. Rating must be based on IEEE C37.04 and IEEE C37.06. Circuit breaker must be drawout-mounted with position indicator, operation counter, auxiliary switches, and primary and secondary disconnect devices. Circuit breaker must be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism. Provide for manual charging of the mechanism. Circuit breaker control voltage must be [[_____] Vdc][[_____] Vac].[SF6 circuit breakers must be shipped factory filled with SF6 gas conforming to ASTM D2472.]

a. Contacts: Silver-plated, multi-finger, positive pressure, self-aligning type for main drawout contacts.

b. Each drawout breaker must be provided with three-position operation. The connected position and the test/disconnect position must be clearly identified by an indicator on the circuit breaker front panel.

(1) Connected position: Contacts are fully engaged. Breaker must be tripped before it can be racked into or out of this position.

(2) Test/disconnect position: Position must allow for complete testing and operation of the breaker without energizing the primary circuit.

(3) Withdrawn (removed) positions: Places breaker completely out of compartment, ready for removal.

][2.2.1.3 Load Interrupter Switch as Main Protective Device

IEEE C37.20.3. Provide a three-pole, single-throw, deadfront, metal-enclosed, load interrupter switch with manual stored energy operator. Switch must be[fused, with fuses mounted on a single frame][non-fused][in series with [vacuum][or][SF6] interrupters] and designed for easy inspection[and fuse replacement].[SF6 gas must conform to ASTM D2472.] The switch must be operated by a manually charged spring stored energy mechanism which must simultaneously disconnect or connect

ungrounded conductors. The moveable blade of the switch must be deenergized when in the open position. The mechanism must enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus must extend the width of the switch enclosure and must be bolted directly thereto. Connect frame of unit to ground bus. The door must have an inspection window to allow full view of the position of the three switch blades through the closed door. Switch ratings must be:

a. [_____] kV, [_____] kV BIL for service on a [_____] kV system with a fault close rating of not less than [_____] amperes asymmetrical.

b. The switch must be capable of carrying continuously or interrupting [_____] amperes with a momentary rating of [_____] amperes at [_____] kV.

c. Switch must have provision for padlocking in the open and closed positions.

[d. Fuses must be current limiting type rated[[_____] amperes continuous, and [_____] [amperes interrupting capacity].][approximately [_____] percent of the transformer full-load rating and in accordance with the fuse manufacturer's recommendation.]

]]2.2.2 Primary Transition Section

****

NOTE: Transition section should only be specified where absolutely necessary.

****

Provide transition section for insulated copper [cable][bus-bar] connections to the transformer primary terminals. Support [bus][cable] connections between high-voltage [switch][breaker] and transformer primary by porcelain insulators[spaced no more than 610 mm 2 feet apart]. Size and brace [bus][cable] to withstand the specified available fault.

2.2.3 Transformer Sections

****

NOTE: Indicate and specify the type of transformers required for the project.

1. Use less flammable, bio-degradable liquid insulated transformers and locate transformers away from buildings in accordance with UFC 3-600-01, "Fire Protection for Facilities Engineering for Facilities". A thorough analysis should be made by the designer prior to using silicone filled transformers due to the concern over operation of tap changers within the silicone liquid. Bio-degradable is defined as a substance capable of being decomposed by bacteria or other living organisms.

2. Use the following option(s) when additional capacity is required. This involves special coordination with transformer kVA rating, as well as

sizes and ratings of fuses and secondary breakers.

a. If it is anticipated that future load requirements will necessitate increasing the capacity of the transformer, the specification for the transformer should require the provision of components and brackets for future forced air cooling. Forced-air-cooling increases capacity by: 15 percent (750-2000 kVA); 25 percent (2500-5000 kVA).

b. On rare occasions, change "... insulation system rated for a 65 degrees C rise..." to read "...insulation system rated for a 55/65 degrees C rise to allow transformer(s) to have a continuous overload capacity of 12 percent at rated voltage without exceeding 75 degrees C winding temperature rise."

3. Use IEEE C57.12.00, Figure 3(b), voltage designations, such as "13200 V - 4160Y/2400 V".

4. Tap ratings may vary from those indicated, especially in lower kVA ratings.

5. Energy efficient transformers usually have impedance values in the range of 2.95 to 5.75 percent. Perform fault current calculations to determine minimum acceptable transformer impedance. Be sure that specified impedance is available in the size and type transformer required.

6. Delete inapplicable sound levels.

7. Delete last sentence, referring to removable ground strap, if transformer secondary winding is delta type.

****

IEEE C57.12.00. [Less-flammable [bio-degradable]liquid-insulated] [Oil-insulated], two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

2.2.3.1 Transformer Ratings

a. Transformer must be rated [_____] kVA, [_____] kV BIL primary, [_____] kV BIL secondary.

b. Transformer voltage ratings: [_____] V - [_____] V.[For GrdY - GrdY transformers, provide transformer with five-legged core design for third harmonic suppression.]

c. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Provide tap changer, with external, pad-lockable, manual type operating handle, for changing tap setting when the transformer is de-energized.

****

NOTE: Change 85 degrees C to 75 degrees C when

transformers are specifically rated for 55/65 degrees C rise.

****

d. Minimum tested impedance must not be less than [_____] percent at 85 degrees C.

e. Audible sound levels must comply with the following:

kVA	DECIBELS (MAX)
225	55
300	55
500	56
750	58
1000	58
1500	60
2000	61
2500	62
5000	65
7500	67
10000	68

f. Diagrammatic stainless steel or laser-etched anodized aluminum nameplate.

g. Transformer must include ground pads, lifting lugs and provisions for jacking under base. The transformer base construction must be suitable for using rollers or skidding in any direction. Provide transformer top with an access handhole. The transformer must have an insulated low-voltage neutral bushing with lugs for ground cable, and with removable ground strap.

h. Transformer must have the following accessories:

(1) Liquid-level indicator

(2) Pressure-vacuum gage

(3) Liquid temperature indicator

(4) Drain and filter valves

(5) Pressure relief device

[(6) Auxiliary cooling equipment and controls

[(a) Transformer must have provisions for future addition of automatically controlled fans for forced-air-cooling.

][(b) Transformer must be forced-air-cooled. Forced-air-cooling fans must have[automatic temperature control relay][winding temperature indicator with sequence contacts].

]][(7) Transformer Monitoring System

(a) Provide a Transformer Monitoring System (TMS) capable of monitoring primary and secondary voltage, primary and secondary current, winding temperature, transformer fluid temperature, transformer liquid level, transformer sudden pressure, gas in transformer fluid, water in transformer fluid, [Load Tap changer position and Load Tap changer liquid level] as a minimum. The transformer monitoring system must have an LCD display capable of displaying measured values, calculated values, I/O statuses, device status and configuration programming of the system. The TMS must be capable of communicating employing a TIA-485-A interface and utilizing DNP level 3 or Modbus protocols. The TMS must have an event monitor capable of logging up to eight events with a minimum of 32 Mbytes of data storage. The TMS must have a minimum of eight programmable output relays and four analog outputs.

][2.2.3.2 Specified Transformer Efficiency

****

NOTE: Transformer losses and efficiency requirements have been modified into the table included within the specification and the previous Navy loss tables have been deleted.

10 CFR 431, Subpart K is a result of the Energy Policy and Conservation Act (EPACT) of 2005 and is the"minimum" industry standard for distribution transformers manufactured on or after January 1, 2016.

****

Provide transformer efficiency calculations utilizing the actual no-load and load loss values obtained during the routine tests performed on the actual transformer(s) prepared for this project. Reference no-load losses (NLL) at 20 degrees C. Reference load losses (LL) at 55 degrees C and at 50 percent of the nameplate load. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in the "kVA / Efficiency" table below. The table is based on requirements contained within 10 CFR 431, Subpart K. Submit certification, including supporting calculations, from the manufacturer indicating conformance.

kVA	EFFICIENCY (percent)
15	98.65

30	98.83
45	98.92
75	99.03
112.5	99.11
150	99.16
225	99.23
300	99.27
500	99.35
750	99.40
1000	99.43
1500	99.48
2000	99.51
2500	99.53
above 2500	99.54

]2.2.3.3 Insulating Liquid

****

NOTE: On Navy projects use biodegradable less-flammable liquid, unless there is a specific requirement otherwise.

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a. Less-flammable transformer liquids: Must meet the requirements of ASTM D6871, NFPA 70 and be approved by the FM APP GUIDE for Less or Non-Flammable Liquid Insulated Transformers. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

b. Provide a fluid that is a biodegradable, electrical insulating, and cooling liquid classified by UL and approved by FM as "less flammable" with the following properties:

(1) Aquatic biodegradation: EPA 712-C-98-075, 99 percent.

(2) Trout toxicity: The fluid must have passed OECD Test 203 following the methods of EPA 821-R-02-012 and be determined to be non-toxic.

[c. Mineral oil: ASTM D3487, Type II, tested in accordance with ASTM D117. Provide identification of transformer as "non-PCB" and "Type II mineral oil" on the nameplate.

]2.2.3.3.1 Liquid-Filled Transformer Nameplates

Provide nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.2.4 Secondary Transition[and Auxiliary] Section(s)

The secondary transition[and auxiliary] section(s) must have a hinged front panel, a [_____]-ampere, three-phase, [three][four]-wire[insulated] main bus and connections, a ground bus, necessary terminal blocks, wiring and control buses, control power transformer, and cable supports.[In the auxiliary section provide a [_____]-V battery complete with rack and standard accessories, and a battery charger, static type, [without voltage regulation][with automatic charger control], complete with ammeter, voltmeter, and rheostat.]

2.2.4.1 Control Power Transformers

Transformers must be designed for continuous operation at rated kVA 24 hours a day, 365 days a year with normal life expectancy as defined in IEEE C57.96. [Dry-type][Oil insulated], two-winding type, 115 degrees C rise above 40 degrees C maximum ambient designed for mounting in switchgear cubicle or drawer. Transformer must be sized as required to serve the connected load and must have a voltage rating of [_____] kV [three-phase][single-phase], primary, and [120/208] [277/480] [120/240] [120] [_____] V secondary, 60 Hz. Insulation level must be [5KV, 60KV BIL] [15KV, 95KV BIL] [34.5KV, 150KV BIL] [_____].

2.2.4.2 Primary Protection

Provide drawout-mounted, primary current limiting fuses rated for the specified transformer size and the available short-circuit current.

2.2.4.3 Secondary Protection

Provide molded-case circuit breakers or molded-case switch sized as required, mounted in same compartment with transformer and primary fuses to serve the indicated loads.

2.2.5 Metal-Clad Switchgear Outgoing Section

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NOTE: This paragraph may also be used to specify freestanding switchgear not directly connected to a unit substation. This paragraph is not intended to be used for generator control switchgear without extensive modification and coordination with applicable diesel engine generator guide specifications. Specify Category A requirements when switchgear area is subject to access by the unsupervised general public. Category B enclosures must be fence enclosed or in a locked room.

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NOTE: Specify Category A requirements when switchgear area is subject to access by the unsupervised general public. Category B enclosures must be fence enclosed or in a locked room.

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NOTE: To help determine whether metal-clad switchgear or metal-enclosed interrupter switchgear is more appropriate for a project, consider that the primary applications for interrupter switchgear are where there are no instantaneous relaying and where switching is infrequent. Also interrupter switchgear is significantly less costly than metal-clad switchgear.

****

IEEE C37.20.2A for metal-clad medium-voltage [vacuum][SF6] circuit breaker type, insulated for [5][15] kV for use on [_____] kV system. Each steel unit forming part of the switchgear structure must be self-contained and must house [one-high][two-high] breaker or instrument compartments, and a full height center and rear compartment for the buses and outgoing cable connections. For two-high breaker units, provide a removable metal barrier to separate the two cable circuits. Equip individual circuit-breaker compartments with drawout contacts, rails, disconnecting mechanism, and a cell interlock to prevent moving the removable element into or out of the "connected" position while the circuit breaker is closed. Provide a steel door for each breaker compartment. Enclosures must be designed for [indoor][outdoor] location and must conform to the Category [A][B] requirements of Table A1 of Appendix A to IEEE C37.20.2A. Design the structure to allow for future additions. Provide laminated plastic nameplates for each relay, switch, meter, device, and cubicle to identify its function. Provide permanent labels for wiring and terminals corresponding to the designations on approved shop drawings. Mount nameplates on each circuit breaker compartment door.

a. Phase buses and connections: Mount bus structure on insulated supports of high-impact, non-tracking, high-quality insulating material and brace bus to withstand the mechanical forces exerted during short-circuit conditions when connected directly to a source having maximum of [_____] amperes rms symmetrical available. Bus bars must be rated [_____] amperes and must be high conductivity copper having silver plated joints. Make bus bar connections from main buses to the incoming circuit breaker studs. Equip outgoing circuit breaker studs with mechanical clamp type cable connectors for the size of cables shown. Provide cable supports for outgoing cables. Wire secondary circuits, including heater circuits, to terminal blocks. Terminal blocks must be readily accessible for making external connections as required.

b. Ground bus: Provide a copper ground bus sized for full short-circuit capacity. Secure ground bus to each vertical structure and extend ground bus the entire length of switchgear. Include provisions for making the station ground connections.

c. DC bus: Provide an insulated copper bus or wire extending the entire length of switchgear. Bus must be rated 100 amperes at 125 Vdc. Wire must be No. 6 AWG minimum.

d. Each breaker compartment must have provision for mounting up to four sets of ANSI rated current transformers, two on line side and two on load side of each breaker.

2.2.5.1 Circuit Breaker

Each [vacuum][SF6] circuit breaker must be an electrically operated, three-pole, circuit interrupting device rated as indicated at maximum voltage of [_____] kV and [_____] kV BIL. Breaker must be designed for service on a [_____] kV system with a short-circuit capacity of not less than [_____] [amperes symmetrical][MVA]. Rating must be based on IEEE C37.04 and IEEE C37.06. Breaker frame size must be as indicated. Provide draw-out mounted circuit breakers with position indicators, operation counter, auxiliary switches, and primary and secondary disconnect devices. Circuit breaker must be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism. Provide for manual charging of the mechanism and for slow closing of the contacts for inspection or adjustment. Circuit breaker control voltage must be [_____] Vdc.

a. Contacts: Silver-plated, multi-finger, positive pressure, self-aligning type for main drawout contacts.

b. Each drawout breaker must be provided with three-position operation. The connected position and the test/disconnect position must be clearly identified by an indicator on the circuit breaker front panel.

(1) Connected position: Contacts are fully engaged. Breaker must be tripped before it can be racked into or out of this position.

(2) Test/disconnect position: Position must allow for complete testing and operation of the breaker without energizing the primary circuit.

(3) Withdrawn (removed) positions: Places breaker completely out of compartment, ready for removal.

2.2.5.2 Space Only Compartments

Provide fully equipped with busing, control switch, indicating lights, and drawout breaker mounting and connecting straps to accommodate future breakers. Provide compartments with doors.

2.2.5.3 Breaker Lifter

Provide a portable lifter rated for lifting and lowering circuit breakers from two-high cubicles. Portable lifter must have swivel casters in front for ease of movement.

2.2.5.4 Remote Racking Device

Provide an electrically operated remote racking device for installing and removing circuit breakers. The RRD must mount on the circuit breaker compartment door by insertion of mounting pin into the RRD support bushing in the circuit breaker compartment. The RRD output shaft must be capable of activating the racking shaft through a racking port in the circuit breaker compartment door and operate with the door closed or open. Provide a remote operator control with a lanyard type cord that allows the operator to move a minimum of 15 meters 50 feet from the circuit breaker compartment. Include four hours of training for the correct use and operation of RRD.

2.2.6 Protective Relays, Metering, and Control Devices

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NOTE: The only manufacturer to currently have an Authority to Operate (ATO) is Schweitzer Engineering Laboratories. This will require a Justification & Authorization (J&A) be included in the design package that goes to contracting.

****

Relays shall conform to IEEE C37.90. Protective relays shall be microprocessor-based, enclosed in rack-mountable cases with indicating targets and provisions for testing in place by use of test switches. Test switches to fit each type of relay in the equipment shall be provided. Controls, relays, and protective functions shall be provided completely assembled and wired.

All Facility Related Controls Systems (FRCS), which includes at a minimum protective relays and the PAC/RTAC, must meet current Control Systems Platform Enclave/Navy Utilities Monitoring Control Systems (CSPE/NUMCS) Authority to Operate (ATO) requirements.

The following general requirements apply to all protective relays and meters:

a. All protective relays shall be of same manufacturer except for lockout relays.

b. Meters shall display positive power flow when actual primary power flows to switchgear from source circuits identified on drawings.

c. Meters shall display positive power flow when actual primary power flows from switchgear to load circuits identified on drawings.

d. For directional overcurrent relays (Device 67) shall be wired with trip direction away from switchgear bus (exporting power) unless otherwise shown.

e. Current Transformer Mounting and Polarity Marks: Position current transformers in cubicle such that primary current into protected zone results in secondary current into protective relay or meter's polarity terminal.

f. Current transformer secondary circuits shall be wired using 12 AWG minimum, tinned high-stranded SIS wire unless otherwise shown.

g. Voltage transformer secondary circuits shall be wired using 14 AWG minimum, tinned high-stranded SIS wire unless otherwise shown.

h. Control circuits shall be wired using 14 AWG minimum, tinned high-stranded SIS wire unless otherwise shown.

i. Microprocessor based relays shall have connectorized rear terminal blocks. Connectorized terminal blocks shall be arranged by input and output type (i.e. separate terminal blocks for voltage and current inputs).

j. Provide logic in relay for trip coil monitoring.

[2.2.6.1 Line Current Differential Relays (MFR1)

a. Product Description: IEEE C37.90 Microprocessor-based line differential protection relay, IEEE Device numbers as specified herein.

b. Mounting: Rack-mounted in protective relay rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degree C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one high-speed, high-current contact to trip circuit breaker.

(2) Provide output contact with its own test switch. Wire test switch in series with output contact.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Relay failure.

(2) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

e. Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

f. Substation battery ground detection, adjustable.

g. Control and Status Inputs:

(1) Provide status input from a contact on circuit breaker. Contact shall be open when breaker is OPEN and closed when breaker is CLOSED.

h. Current Inputs: Provide individual inputs from current transformers for protected circuit. Route current from current transformer to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

i. Voltage Inputs: Provide three-phase, four-wire voltage inputs from potential transformer circuits shown. Route voltage circuits through non-shorting relay test switches to relay. Voltage input ratings shall be as follows.

(1) Nominal voltage shall be 120 volts phase to phase to match potential transformer secondary ratings.

(2) Continuous voltage rating shall be 300 volts.

(3) Burden shall not exceed 0.10 VA.

j. Protective Functions: Provide following adjustable protection functions and settings.

(1) Line Current Differential (87L)

(2) Phase Instantaneous Overcurrent (50P)

(3) Residual Ground Instantaneous Overcurrent (50G)

(4) Phase Time Overcurrent (51P)

(5) Loss Of Potential (60LOP)

(6) Directional Overcurrent (67)

(7) Residual Ground Time Overcurrent (51G)

(8) Breaker Failure Protection

(9) Breaker Wear Monitor

(10) Station DC Battery Monitor

k. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

(1) Line Differential Channels: The relays shall come equipped with IEEE C37.94 modulated 1300nm single-mode fiber-optic interfaces with type ST connectors.

l. Communications Protocols: The relay shall come equipped with the following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, IEEE C37.118 Synchrophasor data, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability

shall include GOOSE messaging and defined logical node data points.

m. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 2 shall be serial TIA-232 port supporting Mirrored Bits protocol for transfer tripping and shall support IRIG-B signals.

(3) Port 3 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(4) Port 4 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(5) Port 5 shall be dual redundant 100Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

][2.2.6.2 Directional Overcurrent Relays (MFR2)

a. Product Description: IEEE C37.90 Microprocessor-based feeder protection relay configured to provide directional comparison blocking. IEEE Device numbers as specified herein.

b. Mounting: Rack-mounted in protective relay rack for protective relays.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degree C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one high-speed, high-current contact to trip circuit breaker.

(2) Provide output contact with its own test switch. Wire test switch in series with output contact. Refer to "PROTECTIVE RELAY AND METERING TEST SWITCHES" in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Relay failure.

(2) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input from a contact on circuit breaker. Contact shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for protected circuit. Route current from current transformer to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Voltage Inputs: Provide three-phase, four-wire voltage inputs from potential transformer circuits shown. Route voltage circuits through non-shorting relay test switches to relay. Voltage input ratings shall be as follows.

(1) Nominal voltage shall be 120 volts phase to phase to match potential transformer secondary ratings.

(2) Continuous voltage rating shall be 300 volts.

(3) Burden shall not exceed 0.10 VA.

h. Protective Functions: Provide following adjustable protection functions and settings.

(1) Phase Instantaneous Overcurrent (50P)

(2) Ground (Residual) Instantaneous Overcurrent (50G)

(3) Neutral Instantaneous Overcurrent (50N)

(4) Phase Time Overcurrent (51P)

(5) Ground (Residual) Time Overcurrent (51G)

(6) Neutral Time Overcurrent (51N)

(7) Loss of Potential (60LOP)

(8) Directional Phase Time Overcurrent (67P)

(9) Directional Ground (Residual) Time Overcurrent (67G)

(10) Directional Neutral Time Overcurrent (67N)

(11) Breaker Failure Protection

(12) Breaker Wear Monitor

(13) Loss of Potential (60LOP)

(14) Station DC Battery Monitor

i. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

j. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, IEEE C37.118 Synchrophasor data, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

k. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be dual redundant 100Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

(3) Port 2 shall be serial fiber port supporting Mirrored Bits protocol for directional comparison blocking.

(4) Port 3 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(5) Port 4 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

l. Operator Interface

(1) Provide relays with front panel layout including color touch-screen human machine interface, circuit breaker control buttons, and indicators. Touch-screen shall be minimum of 800 by 480 pixels and shall be not less than 5 inches in diagonal.

][2.2.6.3 Non-directional Overcurrent Relays (MFR3)

a. Product Description: IEEE C37.90 Microprocessor-based feeder protection relay, IEEE Device numbers as specified herein.

b. Mounting: Flush mounted device, installed on 480 mm 19 inch mounting plates for 480 mm 19 inch equipment rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degree C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one high-speed, high-current contact to trip circuit breaker.

(2) Provide output contact with its own test switch. Wire test switch in series with output contact. Refer to PROTECTIVE RELAY AND METERING TEST SWITCHES in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Relay failure.

(2) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input from a contact on circuit breaker. Contact shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for protected circuit. Route current from current transformer to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Voltage Inputs: Provide three-phase, four-wire voltage inputs from potential transformer circuits shown. Route voltage circuits through non-shorting relay test switches to relay. Voltage input ratings shall be as follows.

(1) Nominal voltage shall be 120 volts phase to phase to match potential transformer secondary ratings.

(2) Continuous voltage rating shall be 300 volts.

(3) Burden shall not exceed 0.10 VA.

h. Protective Functions: Provide following adjustable protection functions and settings.

(1) Phase Instantaneous Overcurrent (50P)

(2) Ground (Residual) Instantaneous Overcurrent (50G)

(3) Neutral Instantaneous Overcurrent (50N)

(4) Negative-Sequence Overcurrent (50Q)

(5) Phase Time Overcurrent (51P)

(6) Ground (Residual) Time Overcurrent (51G)

(7) Neutral Time Overcurrent (51N)

(8) Station DC Battery Monitor

i. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

j. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, IEEE C37.118 Synchrophasor data, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

k. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be dual redundant 100Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

(3) Port 2 shall be serial fiber port supporting Mirrored Bits protocol for transfer tripping.

(4) Port 3 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(5) Port 4 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

][2.2.6.4 Transformer Differential Relays (MFR4)

Provide high-speed, microprocessor based transformer differential relays. Relays shall be configurable for single-phase and three-phase protection. Bus configurations having more than 6 terminals require additional relays to protect all busses. The relays shall utilize mirrored bits communications for transfer trip functions.

a. Product Description: IEEE C37.90 Microprocessor-based bus differential protection relay, IEEE Device number 87B.

b. Mounting: Flush mounted device, installed on 480 mm 19 inch mounting plates for 480 mm 19 inch equipment rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degrees C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one contact to trip lock-out relay on bus differential trip function. Wire test switch in series with this output contact.

(2) Provide multiple contacts to function as back-up overcurrent protective devices (IEEE 50/51) for sources and loads on protected bus. Circuit breakers on protected bus shall have their own output contacts and relay test switches. Wire test switch in series with output contacts. Refer to PROTECTIVE RELAY AND METERING TEST SWITCHES in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Current transformer open.

(2) Relay failure.

(3) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input of lockout relay and wire to indicate trip condition.

(2) Provide status input from contact on circuit breakers on protected bus. Contacts shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for circuit breakers on protected buses. Route current from current transformers to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Paralleling current transformers is prohibited. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Protective Functions:

(1) Six or more low-impedance current differential circuits per phase (zone of protection).

(2) Relay shall have high sensitivity for internal faults and low sensitivity for external faults.

(3) Open and short circuit current transformer detection and alarm.

(4) Breaker failure detection.

(5) Instantaneous overcurrent protection (Device 50) for protected circuit breakers.

(6) Time-overcurrent protection (Device 51) for protected circuit breakers.

(7) End-zone protection for faults between open circuit breaker and CT.

h. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

i. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

j. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(3) Port 2 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(4) Port 3 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(5) Port 4 not used.

(6) Port 5 shall be dual redundant 100 Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

][2.2.6.5 Synchronism Check Relays (MFR5)

a. Product Description: IEEE C37.90 Microprocessor-based feeder protection relay, IEEE Device numbers as specified herein.

b. Mounting: Flush mounted device, installed on 480 mm 19 inch mounting plates for 480 mm 19 inch equipment rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 deg C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one high-speed, high-current contact to trip circuit breaker.

(2) Provide output contact with its own test switch. Wire test switch in series with output contact. Refer to PROTECTIVE RELAY AND METERING TEST SWITCHES in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Relay failure.

(2) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input from a contact on circuit breaker. Contact shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for protected circuit. Route current from current transformer to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Voltage Inputs: Provide three-phase, four-wire voltage inputs from potential transformer circuits shown. Route voltage circuits through non-shorting relay test switches to relay. Voltage input ratings shall be as follows.

(1) Nominal voltage shall be 120 volts phase to phase to match potential transformer secondary ratings.

(2) Continuous voltage rating shall be 300 volts.

(3) Burden shall not exceed 0.10 VA.

h. Protective Functions: Provide following adjustable protection functions and settings.

(1) Sync-check, IEEE C37.2 device designation 25

(2) Breaker Failure Protection

(3) Breaker Wear Monitor

(4) Undervoltage IEEE C37.2 device designation 27

(5) Overvoltage IEEE C37.2 device designation 59

(6) Loss of Potential, IEEE C37.2 device designation 60LOP

(7) Station DC Battery Monitor

i. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

j. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, IEEE C37.118 Synchrophasor data, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

k. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be dual redundant 100 Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

(3) Port 2 shall be serial fiber port supporting Mirrored Bits

protocol for transfer tripping.

(4) Port 3 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(5) Port 4 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

][2.2.6.6 Bus Differential Relays (MFR6)

Provide high-speed, microprocessor based bus differential relays. Relays shall be configurable for single-phase and three-phase protection. Bus configurations having more than 6 terminals require additional relays to protect all busses. The relays shall utilize mirrored bits communications for transfer trip functions.

a. Product Description: IEEE C37.90 Microprocessor-based bus differential protection relay, IEEE Device number 87B.

b. Mounting: 480 mm 19 inch rack mounted device in equipment rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degree C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one contact to trip lock-out relay on bus differential trip function. Wire test switch in series with this output contact.

(2) Provide multiple contacts to function as back-up overcurrent protective devices (IEEE 50/51) for sources and loads on protected bus. Circuit breakers on protected bus shall have their own output contacts and relay test switches. Wire test switch in series with output contacts. Refer to PROTECTIVE RELAY AND METERING TEST SWITCHES in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Current transformer open.

(2) Relay failure.

(3) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input of lockout relay and wire to indicate trip condition.

(2) Provide status input from contact on circuit breakers on protected bus. Contacts shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for circuit breakers on protected buses. Route current from current transformers to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Paralleling current transformers is prohibited. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Protective Functions:

(1) Six or more low-impedance current differential circuits per phase (zone of protection).

(2) Relay shall have high sensitivity for internal faults and low sensitivity for external faults.

(3) Open and short circuit current transformer detection and alarm.

(4) Breaker failure detection.

(5) Instantaneous overcurrent protection (Device 50) for protected circuit breakers.

(6) Time-overcurrent protection (Device 51) for protected circuit breakers.

(7) End-zone protection for faults between open circuit breaker and CT.

h. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

i. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

j. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(3) Port 2 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(4) Port 3 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(5) Port 4 not used.

(6) Port 5 shall be dual redundant 100Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

][2.2.6.7 Lockout Relays (Device 86)

Provide manually reset lock-out relays with light emitting diode (LED) indicators. Provide green LED to indicate a healthy trip coil circuit. Provide red LED to indicate a trip condition. Provide remote annunciation of the trip coil condition that warns the SCADA operator when trip circuit continuity is lost. Provide a minimum of 8 spare contacts on each relay. Relay shall be wired to trip the all circuit breakers in the protected zone and shall block all tripped circuit breakers from being reclosed until the relay is manually reset.

][2.2.6.8 Auxiliary Control Relays

Provide as required to implement protective functions and interlocking as indicated. Auxiliary relays shall have contacts rated to carry 30 amperes for one minute and 12 amperes continuously. Coils shall be a long-life design with a projected service life of 40 years.

a. Auxiliary relays used for tripping circuit breakers shall be multicontact, high-speed relays operating in one-half cycle or less.

b. Auxiliary relays for functions other than tripping circuit breakers shall be normal-speed relays operating in two cycles or less.

c. Auxiliary timing relays shall be electro-pneumatic relays with contacts rated for at least the load they are controlling.

]2.2.6.9 Instrument Control Switches

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

a. Circuit breaker control switches shall be Heavy-duty type rated for 600 volts, UL listed and CSA certified. Breaker control Switches shall have a miniature pistol-grip type handle and a mechanical target to indicate the last operating position of the switch. Switches shall be hard-wired directly to the related circuit breaker for manual control. Switches shall have spring return action, 3 position with spring return to center, with the adequate number of contacts for the required operation and SCADA monitoring.

b. Red and green position indication LED lights shall be either installed immediately above each circuit breaker switch position or incorporated into the switch itself.

c. Circuit breaker control switches shall include the following positions: 1) "TRIP"; 2)"NAT" (normal after trip)/"NAC" (normal after close); 3) "CLOSE". The control switches shall have a minimum of two trip contacts with one trip contact per deck. Switch contacts shall have a minimum current rating of 30 amperes for one minute and 12 amperes continuously.

2.2.6.10 Protective Relay and Metering Test Switches

a. Product Description: Semi-flush mounted knife blade test switches for protective relays with following features:

(1) Clear cover. Shall allow switches to be in open position when cover is on.

(2) Every relay analog and digital input and output shall pass through a test switch.

(3) Every current transformer circuit shall pass through a shorting test switch.

(4) Every trip circuit shall have a red switch.

(5) All switches shall be black in color except for red trip circuit switch.

b. All switches shall be wired such that source (current transformer, voltage transformer, and other output and input) is wired to bottom terminals. The relay terminals shall be wired to top of test switch.

c. Power to protective relay shall be wired through a relay test switch or wired from a dedicated disconnecting means in cubicle to relay.

2.2.6.11 Pilot and Indicating Lights

Provide light emitting diode type indicating lights. Lights shall be red when the circuit breaker is in the "CLOSED" position and shall be green when the circuit breaker is in the "OPEN" position. Light color shall be visible from a distance not less than the full length of the switchgear and shall be visible at a 175 degree viewing angle. Match control voltage.

2.2.6.12 Instruments

****
NOTE: Select essential instruments and meters. Add to the specification any special metering not listed which is required for a specific project. Use of an Electronic Monitoring System and Electronic Trip Assemblies in the breakers may eliminate the need for many individual electro-mechanical meters. This may also be accomplished on simpler systems by using the electronic watthour meter and identifying the desired special programming features. For NAVFAC SE projects, provide three thermal demand ammeters.
****

a. AC wattmeters: Transformer rated for 120-volt input, 60 Hz, three-phase, four-wire, with scale range coordinated to the ratios of the associated current transformers and potential transformers.[Provide external dropping resistors.]

b. Frequency meters: Rated for 120-volt input, 60 Hz nominal frequency, [_____] to [_____] Hz scale range.

c. Synchroscope: Transformer rated at 120-volt input, 60 Hz, with slow-fast scale.

d. Power-factor meters: Transformer rated 5-ampere, [120][208]-volt input, [_____] scale range for use on [three][four]-wire, three-phase circuits. The accuracy must be plus or minus 0.01.

e. DC ammeters: [Self-contained][Shunt-rated], [0 to [_____] ampere][[_____] to 0 to [_____] ampere] scale range.

f. DC voltmeters: Self-contained, [0 to [_____] volt][[_____] to 0 volt] scale range. Furnish resistors, if required, with the voltmeter.

2.2.6.13 Electronic Watthour Meter

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

Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, [in the outgoing section][as indicated]. Meter must either be programmed at the factory or must be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter must be coordinated to system requirements.

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

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

c. Class: [_____]. Form: [_____]. Accuracy: plus or minus 1.0 percent. Finish: Class II.

d. Kilowatt-hour Register: 5 digit electronic programmable type.

e. Demand Register:

(1) Provide solid state.

(2) Meter reading multiplier: Indicate multiplier on meter face.

(3) Demand interval length: must be programmed for [15][30][60] minutes with rolling demand up to six subintervals per interval.

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

[g. Special Programming Instructions: [_____].

][2.2.6.14 Electro-mechanical Watthour Meters

****

NOTE: On bases that employ Energy Monitoring and Control Systems (EMCS) and monitor each building individually, add the following to this paragraph: "Provide watthour meter with a three-wire, single-pole double-throw, quick-make, quick-break pulse initiator. Coordinate pulse output ratio with main circuit breaker rating."

****

NEMA/ANSI C12.10. Kilowatt-hour meters must be transformer rated, polyphase, 60 Hz, semiflush mounted, drawout or semidrawout switchboard meters for use on a four-wire wye, three-phase system. Kilowatt-hour meters must be[two and one-half][three]-stator.[Totalizing kilowatt-hour meters must be four-stator, two-circuit. For totalizing meters, provide devices and equipment required to provide single point metering of real power and reactive power from two inputs as indicated.] Each meter must have a five-dial pointer type register and must be secondary reading. Register ratio must be selected to provide a meter reading multiplier of even hundreds after applying the product of the current transformer ratio and the potential transformer ratio. Indicate the meter reading multiplier on the meter face. The kilowatt-hour meter must have a [sweep hand][cumulative] type KW demand register with 15-minute interval conforming to NEMA C12.4.

][2.2.6.15 Electric Strip-Chart Recording AC Wattmeter

UL 1437 for [surface][semiflush] mounting. Chart speed must be [_____] mm [_____] inches per [hour][minute] and chart drive motor must be rated [240][120][120/240] V, 60 Hz. The instrument must have a full scale accuracy of one percent.

]2.2.6.16 Instrument Transformers

IEEE C57.13, as applicable.

a. Current transformers: Transformers must be [multi-ratio][or][single ratio] as indicated, 60 Hz, and coordinated to the rating of the associated switchgear, relays, meters, and instruments.

b. Provide shorting blocks to create an intermediate contact point between the meter and the load where it is safe to make wiring alterations. The shorting blocks must be wired such that the negative leads of the current transformers are connected to the same node and tied to ground.

c. Potential transformers: Transformers must be drawout type, 60 Hz, with voltage ratings and ratios coordinated to the ratings of the associated switchgear, relays, meters, and instruments. Potential transformers must be with [one fuse][two fuses] in the primary. Fuses must be current limiting and sized as recommended by the potential transformer manufacturer.

2.2.6.17 Pilot and Indicating Lights

Provide transformer, resistor, or diode type.

2.2.7 Station Batteries and Charger

****
NOTE: For NAVFAC SE projects, specify maintenance-free sealed batteries only.
****

Provide station batteries and charger, suitable for the requirements of the switchgear and [vacuum][SF6] circuit breakers. Batteries must be [_____] V, 60 cells, lead-acid, [pasted plate type][or][sealed, totally absorbed electrolyte type].

a. Pasted plate type batteries: Positive plates must be of the manchester type and negative plates must have a life equal to or greater than the positive plates. Battery containers must be heat and impact resistant clear plastic with electrolyte level lines permanently marked on all four sides. A permanent leakproof seal must be provided between cover and container and around cell posts. Sprayproof vent plugs must be provided in covers. Sufficient sediment space must be provided so that the battery will not have to be cleaned out during its normal life. High porosity separators to provide correct spacing between plates must be provided. Capacity must be calculated by switchgear manufacturer and approved by Contracting Officer before acceptance.

b. Sealed batteries: Provide batteries with leakproof, spillproof electrolyte utilizing highly absorbent material to separate the

positive and negative plates. Battery jars must be hermetically sealed with welded seams. Batteries must be maintenance-free and must not require water to be added. Capacity must be calculated by switchgear manufacturer and approved by Contracting Officer before acceptance.

c. Battery charger must be full-wave rectifier type, utilizing silicon semiconductor devices. Charger must maintain a float charge of 2.15 V per cell and an equalizing charge of 2.33 V per cell. An equalizing charge timer must be provided which operates automatically after an AC power failure of 5 seconds or more. Timer must be adjustable for any time period up to 24 hours. Timer must also be capable of being actuated manually. Adjustable float and equalizing voltage potentiometers must be provided. Charger voltage must be maintained within plus or minus 1/2 percent from no load to full load with AC line variations of plus or minus 10 percent and frequency variations of plus or minus 5 percent. DC voltmeter and ammeter with a minimum 90 mm 3 1/2 inch scale and 2 percent accuracy of full scale must be provided. Output current must be limited to 115 percent of rated output current, even down to short circuit of the DC output terminals. Solid state circuit must have AC and DC transient voltage terminals. AC and DC magnetic circuit breakers must be provided. Circuit breakers must not be overloaded or actuated under any external circuit condition, including recharge of a fully discharged battery and short circuit of the output terminals. Charger must be capable of continuous operation at rated current at an ambient temperature of 40 degrees C. Output DC current capacity must match the requirements of the batteries provided. Provide alarm outputs [Individual Form C contacts] [Single summary Form C contact] as follows:

(1) AC power failure.

(2) DC ground detection.

(3) High DC voltage.

(4) Low DC voltage.

(5) Charger failure.

(6) Battery discharging.

(7) End of discharge.

(8) DC current limit.

(9) Common summary alarm.

d. Secure battery rack such that it can not overturn or be disrupted by lateral forces accompanying a seismic disturbance. Provide steel, three-step racks, painted with two coats of acid resistant paint for mounting batteries. Provide lead-plated copper inter-rack connectors and cell numbers with each rack.

2.2.8 Metal-Enclosed Interrupter Switchgear Outgoing Section

****

NOTE: This paragraph may also be used to specify freestanding switchgear not directly connected to a

unit substation. This paragraph can not be used for generator control switchgear. Specify Category A requirements when switchgear area is subject to access by the unsupervised general public. Category B enclosures must be fence enclosed or in a locked room.

****

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NOTE: To help determine whether metal-clad switchgear or metal-enclosed interrupter switchgear is more appropriate for a project, consider that the primary applications for interrupter switchgear are where there are no instantaneous relaying and where switching is infrequent. Also interrupter switchgear is significantly less costly than metal-clad switchgear.

****

IEEE C37.20.3 for metal-enclosed [air] [vacuum] [SF6] load interrupter type switches, insulated for [5][15][27][_____] kV for use on [_____] kV system. The metal-enclosed switchgear assembly must consist of individual, factory-assembled, freestanding modular units, each with provisions for bolt-together installation. Modules must have uniform dimensions, constructed of rigidly braced 14-gage steel with a durable corrosion-resistant finish. Units must include a removable front panel, capable of being locked, for access to cable connections and fusing, internal venting for air circulation, lifting/mounting provisions and centralized, front facing controls[with mimic bus line diagram] and identification nameplates. Modules must allow incoming/outgoing cable entry from the bottom, sides or rear with adequate access for training and connection of cable using lugs and indoor terminations. Modular units must include necessary provisions for future expansion with removable end covers and extendable high-conductivity copper main and ground bus interconnections. Main bus must be fully insulated and mounted on insulated supports of high-impact, non-tracking, high-quality insulating material. Bus must be braced to withstand the mechanical forces exerted during short-circuit conditions when connected directly to a source having maximum of [_____] amperes rms symmetrical available. Phase bus bars must be rated [_____] amperes. Ground bus must be sized for full short-circuit capacity and must include provisions for external ground connections. Enclosures must be designed for [indoor][outdoor] location and must conform to Category [A][B] requirements of Table A1 of Appendix A to IEEE C37.20.3. Provide permanent labels for wiring and terminals corresponding to the designations on approved shop drawings. A safety glass window must be provided in the door panel in front of each interrupter switch to observe its position.

[2.2.8.1 Air-Insulated Load Interrupter Switches

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NOTE: Choose this paragraph or one of the subparagraphs below, SF6-INSULATED LOAD INTERRUPTER SWITCHES or VACUUM-INSULATED LOAD INTERRUPTER SWITCHES.

****

Load interrupter switches must be three-pole, gang-operated, [fused][non-fused], arranged with hinge end of switch on load side to

provide for "dead blade."[Fuses must be located on hinge side of switch.] Switch handles must be non-removable, operable from front of cubicle. Switch must be equipped with stored-energy, quick-make and quick-break device to operate the switch independent of the handle or power operator speed. Load interrupter switches must be rated at [600][1200] amperes continuous, 61 kA momentary, 38 kA short-time fault closing. Switches must be [manual handle operated "close" and "open"][manual handle operated "close" and remote operated "open" by electrical release device][power operated "close" and "open" utilizing motor charged closing spring mechanism and electrical release device].

][2.2.8.2 SF6-Insulated Load Interrupter Switches

SF6 filled, puffer-type load interrupter switches must be [fused][or][non-fused] as indicated. Switches must incorporate self-aligning, copper-silver plated, wiping-type contacts. SF6 puffer interrupters to minimize arcing during operation; and an internal absorbent to neutralize arc by-products. Switch contacts must be enclosed and sealed in maintenance-free, SF6 filled, molded epoxy insulated case, surrounded by dead-front metallic barriers. Switch operation must be controlled by permanently lubricated quick-make, quick-break spring operator with solid linkage connection to contact operating shaft. Switch operator must be mounted in separate dead-front compartment with access for addition of remote or automatic accessories, and must include removable operating handle with storage provision, positive position indicators, and padlock provisions. SF6 gas must conform to ASTM D2472.[Fused load interrupter switches must be provided with clip-style, mounted air-insulated current limiting fuses and molded epoxy interphase barriers. Provide neon voltage indicators for blown fuse indication.] Load interrupter switch must be rated [_____] continuous, [_____] kA momentary, [_____] kA short-time fault closing.

][2.2.8.3 Vacuum-Insulated Load Interrupter Switches

Circuit interrupting device must be [fused][non-fused], fixed mounted, [manually][electrically] operated, and must be quick-make, quick-break with speed of operation independent of the operator. Electrically operated device must be [120 Vac][125 Vdc]. Spring charging mechanism must not rely on chains or cables.[Motor operator assembly must be a separate device, isolated from high voltage and coupled through a direct drive shaft.] Circuit interrupter must consist of automatic visible blade disconnects in series with vacuum interrupters. Arc interruption must take place within the envelope of the vacuum interrupter. Upon opening, contacts in the vacuum interrupter must separate 12 to 18 milliseconds before disconnect blades open. Total circuit interrupt opening time must not exceed 3.0 cycles after the trip coil is energized at 85 to 100 percent of rated control voltage. Upon closing, disconnect blades must close 9 to 12 milliseconds before contact is made in the vacuum interrupter. Local interrupter switch must be rated [_____] continuous, [_____] kA momentary, [_____] kA short-time fault closing.

][2.2.8.4 Fuses

****
NOTE: Other fuse types may be specified if more appropriate to the project.
****

IEEE C37.41 and IEEE C37.46 as applicable. High-voltage fuses and

non-disconnecting fuse mountings must be accessible only through a separate door mechanically interlocked with the load break switch, to ensure the switch is in the open position when fuses are accessible. Switch must be designed with full height fuse access doors and must have a solid barrier covering the area of the main cross bus and line side of the switch. Metal screen barriers are not acceptable. No energized parts must be within normal reach of the opened doorway. Four single full length interphase barriers must isolate the three phases of the switch from each other and from the enclosures. Fuses must be [current limiting type of self-contained design to limit available fault current stresses on the system and must have interrupting capacity [as indicated][of [_____] amperes symmetrical rms].][boric acid type with provisions for refill units complete with muffler exhaust. Furnish three spare fuse refill units for each switch and fuse assembly.] Fuses must be affixed in position with provisions for removal and replacement from the front of the gear without the use of special tools.

]2.2.9 Insulated Barriers

Where insulated barriers are required by reference standards, provide barriers in accordance with NEMA LI 1, Type GPO-3, 6.35 mm 0.25 inch minimum thickness.

[2.2.10 SF6 Refill Cylinders

****
NOTE: Coordinate with activity to determine if refill cylinders are required. Many activities have an adequate supply of SF6 gas on hand.
****

Provide two SF6 refill cylinders, with a minimum of 2.724 kg 6 pounds of SF6 in each. Include regulator, valves, and hose for connection to the fill valve of the switch.

]2.2.11 Corrosion Protection

****
NOTE: Choose the level of corrosion protection required for the specific project location. Use stainless steel bases for most applications. In less corrosive environments galvanized steel can be included as an alternative to stainless steel. In hostile environments, the additional cost of totally stainless steel tanks and metering may be justified. Manufacturer's standard construction material is acceptable only in noncoastal and noncorrosive environments.
****

Bases frames, and channels of unit substation must be corrosion resistant and must be fabricated of stainless steel[or galvanized steel]. Base must include any part of unit substation that is within 75 mm 3 inches of concrete pad. Paint unit substation, including bases, light gray No. 61 or No. 49.[Paint coating system must comply with IEEE C57.12.28 regardless of base and substation material.] The color notation is specified in ASTM D1535.

2.2.11.1 Stainless Steel

Type 304 or 304L.

[2.2.11.2 Galvanized Steel

ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable. Galvanize after fabrication where practicable.

]2.2.12 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers must be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification must be identical in similar units. External wiring must be color coded consistently for similar terminal boards.

2.2.13 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed white plastic tubing heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide multiple white preprinted polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve must contain multiple characters, must be elliptically shaped to fit the wire securely, and must be keyed, or otherwise arranged, in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Wire markers for factory installed conductors must indicate wire designations corresponding to the schematic drawings. Wire markers on field installed conductors must indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached, as well as the terminal number to which the wire is directly attached (near end/far end marking).

2.2.14 Surge Arresters

Provide one surge arrester for each conductor on circuits where indicated. Surge arresters must conform to IEEE C62.11 for [station class][class indicated] and must be rated [_____] kV.

2.2.15 Neutral Grounding Resistors

****

NOTE: Low Resistance systems use a neutral ground resistor to reduce ground fault current. Low resistance grounding is typically used in systems with voltages exceeding 1000 volts line-to-line. Low resistance grounding limits the magnitude of transient over-voltage thereby reducing equipment damage. In addition, the line-to-ground fault current can be limited to a predetermined value while also providing adequate tripping values for selective coordination.

****

Neutral grounding resistors must be in accordance with IEEE-32. The resistive elements must be low temperature coefficient, resistor grade

stainless steel of sufficient mass to withstand the rated current and prescribed duty. The resistors must be mounted in corrosion resistant support frames, using stainless-steel hardware. The entire resistor assembly must be mounted on insulators rated for the system voltage.

Resistor terminals and interconnections between resistor units must be stainless-steel using stainless steel hardware including lock washers. Connections between resistors and bushings or current transformers must be solid copper copper cables.

Provide NEMA 4X enclosure, type 304 or 316 stainless steel with gray powder coat finish.

a. System Voltage: [4,160V] [12,470V] [13,200V] [13,800V] [_____].

b. Line-To-Neutral Voltage: [2,400V] [7,200V] [7,620V] [8,000V] [_____].

c. Initial Current: [10] [50] [100A] [200A] [400A] [600A] [_____]

d. Duty Cycle: [Continuous] [60] [_____] seconds.

e. Resistance: [_____] Ohms.

2.2.16 Automatic Load Tap Changers

****
NOTE: Coordinate the inclusion of this with the base Public Works Department.
****

Provide automatic Vacuum Reactance Load Tap Changer (VRLTC) on-load tap-changer in the load end of the low-voltage winding. The automatic tap-changing equipment must provide sixteen 5/8-percent taps above rated voltage and sixteen 5/8-percent taps below rated voltage. Accessories must include draining valve, pressure relief device, oil level indicator with analog output for transformer monitoring system, vent for oil filling, oil temperature gauge with analog output for transformer monitoring system, and provisions for upper oil valve. Three-phase, 60 hz, [_____] volt power must be provided for the motor. Single-phase, 60 hz, [_____] volt power must be provided for the heater. Single-phase, 60 hz, [_____] volt power must be provided for controls.

a. Insulating liquid must be Less-flammable liquid-insulated, ASTM D3487, type II, tested in accordance with ASTM D117. Provide identification as "Non-PCB" and oil type on nameplate.

b. Tap-changer tank, flanges, lifting provisions, and hardware must be fabricated of ASTM A240/A240M type 304, 304L or 316 stainless steel. Paint coating system must comply with IEEE C57.12.28.

2.3 SOURCE QUALITY CONTROL

****
NOTE: Use "reserves the right to" on all projects, except those for NAVFAC SE.
****

2.3.1 Equipment Test Schedule

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

a. Test Instrument Calibration

(1) The manufacturer must have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

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

(3) Instrument calibration frequency schedule must not exceed 12 months for both test floor instruments and leased specialty equipment.

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

(5) Calibrating standard must be of higher accuracy than that of the instrument tested.

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

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

[2.3.2 Integral Assembly Test

****
NOTE: Coordinate with paragraph FACTORY TEST REPORTS prior to use of option requiring testing of integral assemblies.
****

Switchgear and substation transformer must be tested as an integral assembly at the transformer manufacturer's test facility. Once acceptance of test results is received, ship switchgear and substation.

]2.3.3 Switchgear Design Tests

IEEE C37.20.2A or IEEE C37.20.3 as applicable. Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification. Required tests must be as follows:

a. Design Test

[(1) Dielectric test

][(2) Rated continuous current test

][(3) Short-time current withstand tests

][(4) Short-circuit current withstand tests

] (5) Mechanical endurance tests

(6) Flame-resistance tests

(7) Rod entry tests

[(8) Rain test for outdoor MV switchgear

]2.3.4 Switchgear Production Tests

IEEE C37.20.2A or IEEE C37.20.3 as applicable. Furnish reports which include results of production tests performed on the actual equipment for this project. Required tests must be as follows:

a. Production Test

(1) Dielectric test

(2) Mechanical operation tests

(3) Grounding of instrument transformer case test

(4) Electrical operation and control-wiring tests

(5) Impulse withstand test.

2.3.5 Load Interrupter Switch Design Tests

IEEE C37.74 and IEEE C37.20.3. Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification. Required tests must be as follows:

a. Design Tests

(1) Dielectric:

(a) Low-frequency withstand

(b) Impulse withstand

(2) Continuous current

(3) Short-time current withstand (2 - second)

(4) Momentary current (10 cycles)

(5) Mechanical endurance

(6) Insulator supports

(a) Flame-resistance

(b) Tracking-resistance

(7) Bus-bar insulation

(a) Dielectric strength

(b) Flame-resistance

(8) Paint qualification

(9) Rain

2.3.6 Load Interrupter Switch Production Tests

IEEE C37.74 as applicable, and IEEE C37.20.3. Furnish reports of production tests performed on the actual equipment for this project. Required tests must be as follows:

a. Production Tests

(1) Dielectric

(2) Mechanical operation

[(3) Grounding of instrument transformer case

][(4) Electrical operation and control wiring

]2.3.7 Transformer Design Tests

In accordance with IEEE C57.12.00 and IEEE C57.12.90. Additionally, IEEE C57.12.80, section 5.1.2 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for[each of] the specified transformer(s). Design tests must have been performed prior to the award of this contract.

a. Tests must be certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a unit-substation transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (ONAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a unit-substation transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer (if specified). Design lightning impulse tests must include both the primary and secondary windings of that transformer.

(1) IEEE C57.12.90 paragraph entitled "Lightning Impulse Test Procedures" and IEEE C57.98.

(2) State test voltage levels.

(3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" for the lifting and moving devices test means a transformer in the same weight range as the transformer specified.

e. Pressure: "Basically the same design" for the pressure test means a unit-substation transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

2.3.8 Transformer Routine and Other Tests

In accordance with IEEE C57.12.00 and IEEE C57.12.90. Routine and other tests must be performed by the manufacturer on[each of] the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence must be as follows:

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

d. Insulation power-factor by manufacturer's recommended test method.

e. No-load losses (NLL) and excitation current

f. Load losses (LL) and impedance voltage

g. Dielectric

(1) Impulse: Per IEEE C57.12.90 paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98. Test the primary winding only.

(a) State test voltage levels

(b) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports.[As an alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand-delivered at the factory witness test.]

(2) Applied voltage

(3) Induced voltage

h. Leak

2.4 HEATERS

Provide 120-volt heaters in each switchgear section. Heaters must be of sufficient capacity to control moisture condensation in the compartments, and must be sized 250 watts minimum. Heaters must be controlled by a thermostat[and humidistat] located inside each section. Thermostats must

be industrial type, high limit, to maintain compartments within the range of 15 to 32 degrees C 60 to 90 degrees F.[Humidistats must have a range of 30 percent to 60 percent relative humidity.] Provide transformer rated to carry 125 percent of heater full load rating. Transformers must have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and must conform to NEMA ST 20. Provide din-rail mounted circuit breakers or fuse block in each switchgear assembly to serve the heaters in that switchgear assembly. The overcurrent protective devices serving the heaters must be in an accessible location with the circuit breaker racked in and the inner door closed. Energize electric heaters in switchgear assemblies while the equipment is in storage or in place prior to being placed in service. Provide method for easy connection of heater to external power source.

[2.5 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

Provide SCADA system including programmable automation controller, substation ethernet switches, GPS clock, fiber optic cable, serial to fiber converters, power supplies, programming, settings, terminal blocks, SCADA interface, relay racks, and additional items shown on the Drawings.

SCADA system shall be installed integral to the primary substation, inside the prefabricated switchgear enclosure. The system shall be fully assembled and all interconnections made at the factory. The system shall be fully programmed, tested and demonstrated during the Factory Witness Tests. The substation manufacturer shall make a laptop available during the testing. Program the laptop to interface with the SCADA system in the same way as the existing SCADA system will be programmed. Demonstrate the data retrieval and control functions including circuit breaker controls, metering, and synchrophasors.

All Facility Related Controls Systems (FRCS), which includes the SCADA System, must meet current Control Systems Platform Enclave/Navy Utilities Monitoring Control Systems (CSPE/NUMCS) Authority to Operate (ATO) requirements.

2.5.1 Programmable Automation Controller (PAC)

a. Product Description: Microprocessor based, substation hardened, programmable automation controller.

b. Mounting: 480 mm 19 inch rack mounted.

c. Power Supply: 125 volts DC.

d. Ethernet Connections: Two 100 BASE-FX fiber optic connections.

e. Input/Output (IO) Board: 8 Outputs, 24 Inputs rated for 125 volts DC.

f. Provide web human machine interface (HMI) license.

g. Client Protocols: SEL, DNP3, Modbus, IEEE C37.118 Synchrophasors.

h. Server Protocols: SEL, DNP3, Modbus.

i. Peer to Peer Protocols: Mirrored Bits.

j. Rear Serial Ports: Twenty-four TIA-232 serial ports per programmable automation controller. Provide additional programmable automation

controllers, each with 24 serial ports, where drawings show more than 24 serial connections into one programmable automation controller.

k. Conformal Coating: Provide conformal coating for outdoor substations within 500 feet of salt water.

2.5.2 Human Machine Interface (HMI) Monitor

Provide multi-touch monitor, complete with accessories including power cord, user manual, remote control, batteries, DVI-D cable, HDMI cable, Display Port cable, drivers, software, and instructions. Monitor shall meet the following requirements:

a. Viewing Screen Size: 680 mm 27 inches minimum; 810 mm 32 inches maximum.

b. Touch Type: Projected Capacitive Touch, with minimum 10 points of simultaneous touch.

c. Inputs: HDMI, DVI-D, DisplayPort. Coordinate with the programmable automation controller.

d. Resolution: 1080P (1920 x 1080) minimum.

e. Power Supply: 125VAC. Include separate DC to AC power inverter, compatible with the HMI display. Inverter shall not distort displayed content, shall not reduce display life, and shall not void display warranty.

f. Operating Temperature: 5-40 degrees C 41-104 degrees F.

g. Operating Humidity: 10-90 percent.

h. Operation: HMI monitor will function as a display and touch-screen type input device only and shall not have on-board programming requirements and shall not introduce more than 0.25 second delay in commands sent to the programmable automation controller.

2.5.3 Substation Ethernet Switches

a. Product Description: Managed, substation hardened Ethernet switch.

b. Environmental Requirements: Meet requirements for harsh environments including IEEE 1613 Class 2 (electric utility substations), IEC 61850 (electric utility substations), IEC 61800-3 (variable speed drive systems), IEC 61000-6-2 (generic industrial), and NEMA TS-2 (traffic control equipment).

(1) Switch shall operate in an environment from minus 40 degrees C to plus 85 degrees C without fans.

(2) Switch shall have conformal coated circuit boards when installed within 500 feet of saltwater.

(3) Switch shall be certified for Class 1, Division 2 hazardous locations.

c. Power Supply: Fully integrated, redundant power supplies rated for 88 to 300 volts DC. Provide screw terminals.

d. Encryption: SSH/SSL 128-bit minimum.

e. Passwords: Provide multi-level user passwords. Provide passwords to the government.

f. Port Security: MAC based port security to enable and disable ports. Provide network access control 802.1x.

g. Ports: Provide single mode gigabit 1000LX SFP uplink ports. Provide 100BASE-FX multimode fiber ports and copper RJ45 Ethernet ports as shown and in accordance with connected device manufacturer's connection requirements.

2.5.4 GPS Clock

a. Product Description: Global positioning satellite clock.

b. High Accuracy: The IRIG-B demodulated output shall be within minus 100 nanoseconds to plus 100 nanoseconds (average) of UTC time.

c. Holdover Accuracy: The clock shall have an accuracy of minus 0.08 ppm to plus 0.08 ppm for 20 minutes (over entire operating temperature range) while clock is not locked to GPS satellite reference.

d. Time Outputs: Clock shall have a minimum of one modulated IRIG-B output and six demodulated IRIG-B outputs programmable to IRIG-B, 1 PPS, or 1k PPS. Demodulated time outputs shall be capable of being programmed for UTC or local time. The clock shall provide IRIG-B connection capability and ASCII time output at one serial port. Provide fiber-optic serial port.

e. IEEE Extended Control Functions: IRIG-B outputs shall be capable of adding extended control functions specified by IEEE C37.118.

f. Daylight Time: The clock shall have automatic daylight-saving time advance/return with presets for North America, Europe, and custom DST-setting capability.

g. Alarm Contact: The alarm contact shall indicate diagnostic self-test failure and be programmable to include loss-of-satellite lock, power supply, and processor as an alarm condition.

h. Display: Front-panel LEDs shall display UTC or local day and time as well as clock operational status.

i. Settings: Settings shall be accomplished through use of easily accessible control (DIP) switches.

j. Software: No proprietary software shall be required to communicate with clock. Standard PC-compatible ASCII terminal emulation programs shall be sufficient to establish communication, provide commands and settings, and download data.

k. Computer Clock-Setting Software: The clock shall support capability to provide date and time to a PC or computer via a communications link using accessory software.

l. Security: Password security shall be provided to control clock

access. Security features shall include a 12-character password length, requiring old password entry before changing to a new password, never showing password on communications ports, and providing a lockout for failed password-entry attempts.

m. Mounting: The clock shall be wall-mounted as indicated.

n. Power Supply: The clock shall have a power supply with an operating range of 18 to 300 Vdc and 85 to 264 Vac.

o. Operating Temperature: The clock shall have an operating range of minus 40 degrees C to plus 80 degrees C with rated accuracy.

p. Robust Hardware: The clock shall meet and be tested for EMI, RFI, shock, vibration, and environmental compliance per IEEE C37.90, IEC 60255-21-3, IEC 61000-4-5, and IEC 60068-2-27.

q. Safety: The clock shall be CE-compliance marked, meeting IEC 61010 standard.

r. Warranty: The clock shall have a minimum warranty period of 10 years.

2.5.5 IRIG-B Distribution Module

Provide IRIG-B distribution module with input connector coordinated with the GPS satellite clock and output connector ports coordinated with the digital clocks and other IRIG-B devices connected to the system. Provide quantity of distribution modules required to connect all IRIG-B devices plus an additional 4 output ports.

2.5.6 Digital Clocks

Provide surface-mounted, digital clocks with IRIG-B inputs. Display numbers shall be not less than 75 mm 3 inches in height and shall be GREEN in color. Enclosure shall be less than 50 mm 2 inches deep, measured from the face of the clock to the back of the enclosure. Provide complete with filtered power supply adapter, rated for input of 125 VDC. Coordinate output rating of the power supply adapter to the clock power input voltage and connection requirements. Coordinate IRIG-B input with the IRIG-B output of the IRIG-B distribution module.

2.5.7 Fiber Optic Cable

Comply with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.5.8 Source Programming Requirement

a. Program programmable automation controller, protective relays, meters, switches, GPS clock, and other programmable devices prior to scheduling Factory Witness Tests. Programming shall include all logical inputs, outputs, ports, protocols, and other such settings required to achieve a fully usable, SCADA-ready application.

b. Furnish and upload all setting files.

2.5.9 Relay Racks

a. Product Description: Equipment enclosures for mounting protective relays, HMI, network switches, GPS clock, relay test switches, bus

differential relays, and lock-out relays.

b. Construction: Main frames and bases of 11 Gage ASTM A240/A240M Type 316 stainless steel. Side and top panels 14 Gage corrosion resistant steel. Rack holes according to ECIA EIA/ECA 310-E Standard with universal spacing. Rack holes threaded for 10-32 fasteners. Provide full length and width rear doors. Front shall be filled with modular, removable steel panels. Arrange panels to accommodate relay heights and widths. Provide panels in unused spaces. Fasteners shall be ASTM A240/A240M Type 316 stainless steel.

c. Equipment Arrangement: Arrange relays and test switches so that the topmost button or switch is no higher than 1800 mm 72 inches above finished floor.

d. Cabling Arrangement: Arrange cables in horizontal and vertical runs parallel and perpendicular to structural members and panels. Fasten cable bundles to steel frame and panels using bolt-on, nylon clamps.

]2.6 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates for each primary unit substation equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription must identify the function and, when applicable, the position. Nameplates must be melamine plastic, 3 mm 0.125 inch thick, white with [black][_____] center core. Surface must be matte finish. Corners must be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 25 by 65 mm one by 2 1/2 inches. Lettering must be a minimum of 6.35 mm 0.25 inch high normal block style.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations must conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

****

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

****

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

3.2.1 Grounding Electrodes

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

3.2.2 Substation Grounding

Provide bare copper cable not smaller than No. 4/0 AWG, not less than 610 mm 24 inches below grade connecting to the indicated ground rods. Substation transformer neutral connections must not be smaller than No. 1/0 AWG. When work, in addition to that indicated or specified, is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" must apply.[Fence and equipment connections must not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 3050 mm 10 feet. Bond each gate section to the fence post through a 3 by 25 mm 1/8 by one inch flexible braided copper strap and clamps.]

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors must be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, paragraph regarding GROUNDING.

3.2.4 Ground Cable Crossing Expansion Joints in Structures and Pavements

Protect from damage by means of approved devices or methods of installation to allow the necessary slack in the cable across the joint to permit movement. Provide stranded or other approved flexible copper cable across such separations.

3.2.5 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

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

3.3.1 Medium-Voltage Switchgear and Load Interrupter Switches

IEEE C37.20.2A and IEEE C37.20.3 as applicable.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 Galvanizing Repair

Repair damage to galvanized coatings caused by handling, transporting, cutting, welding, or bolting. Make repairs in accordance with ASTM A780/A780M, zinc rich paint. Do not heat surfaces that repair paint has been applied to.

3.3.4 Field Fabricated Nameplates

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

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

****

NOTE: Mounting slab connections may have to be given in detail depending on the requirements for the seismic zone in which the equipment is located. Include construction requirements for concrete slab only if slab is not detailed in drawings. Curbs or raised edges may also be required around liquid filled transformers.

****

3.4.1 Exterior Location

Mount [substation][and][switchgear] on concrete slab. Unless otherwise indicated, the slab must be at least 200 mm 8 inches thick, reinforced with a 152 by 152 - MW19 by MW19 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 100 mm 4 inches from the top of the slab. Slab must be placed on a 150 mm 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 100 mm 4 inches above finished grade. Edges above grade must have 15 mm 1/2 inch chamfer. Slab must be of adequate size to project at least 200 mm 8 inches beyond equipment, except that front of slab must be large enough to serve as a platform to withdraw breakers or to operate two-high breaker lifters. Provide conduit turnups and cable entrance space required by the equipment to be mounted[and as indicated]. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm 3 inches above slab surface. Concrete work must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount [substation][and][switchgear] on concrete slab. Unless Otherwise indicated, the slab must be at least 100 mm 4 inches thick. Top of concrete slab must be approximately 100 mm 4 inches above finished floor. Edges above floor must have 15 mm 1/2 inch chamfer. Slab must be of adequate size to project at least 200 mm 8 inches beyond the equipment, except that front of slab must be large enough to serve as a platform to withdraw breakers or to operate two-high breaker lifters. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm 3 inches above slab surface. Concrete work must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.[The [_____] Division, Naval Facilities Engineering Systems Command will witness formal tests after receipt of written certification that preliminary tests have been completed and that system is ready for final test and inspection.]

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NOTE: Thermographic surveying is not required on most projects. NETA recommends that surveys be

performed during periods of maximum possible loading but with not less than 40 percent of rated load on the electrical equipment being inspected. Testing at start-up will therefore not be beneficial except for hard-to-reach areas where solid connections cannot be verified by mechanical methods. Thermographic surveying may be useful if equipment operates under load for a specified period of time, preferably 3 to 6 months, before testing. The additional costs and the additional trip (3 to 6 months after the initial inspection) for the NETA contractor to perform the survey should be considered prior to specifying the requirement.

****

3.5.1.1 Interrupter Switch(es)

a. Visual and Mechanical Inspection

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

(2) Inspect physical and mechanical condition.

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

(4) Verify appropriate anchorage and required area clearances.

(5) Verify appropriate equipment grounding.

(6) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

[(7) Verify that fuse sizes and types correspond to approved shop drawings.

][(8) Verify that each fuse holder has adequate mechanical support.

] (9) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic surveying [is not][is] required.

(10) Test interlocking systems for correct operation and sequencing.

(11) Verify correct phase barrier materials and installation.

(12) Compare switch blade clearances with industry standards.

(13) Inspect all indicating devices for correct operation

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform over-potential tests.

(3) Measure contact-resistance across each switch blade[and fuse holder].

[(4) Measure fuse resistance.

] (5) Verify heater operation.

3.5.1.2 Medium-Voltage Circuit Breakers (Vacuum)

a. Visual and mechanical inspection

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

(2) Inspect physical and mechanical condition.

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

(4) Inspect anchorage, alignment, and grounding.

(5) Perform all mechanical operational tests on both the circuit breaker and its operating mechanism.

(6) Measure critical distances such as contact gap as recommended by manufacturer.

(7) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey [is not][is] required.

(8) Record as-found and as-left operation counter readings.

b. Electrical Tests

(1) Perform a contact-resistance test.

(2) Verify trip, close, trip-free, and antipump function.

(3) Trip circuit breaker by operation of each protective device.

(4) Perform insulation-resistance tests.

(5) Perform vacuum bottle integrity (overpotential) test across each bottle with the breaker in the open position in strict accordance with manufacturer's instructions. Do not exceed maximum voltage stipulated for this test.

3.5.1.3 Medium-Voltage Circuit Breakers (SF6)

a. Visual and mechanical inspection

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

(2) Inspect physical and mechanical condition.

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

(4) Inspect anchorage and grounding.

(5) Inspect and verify adjustments of mechanism in accordance with manufacturer's instructions.

[(6) Inspect and service air compressor in accordance with manufacturer's instructions.

] (7) Test for gas leaks in accordance with manufacturer's instructions.

(8) Verify correct operation of all air and SF6 gas pressure alarms and cutouts.

(9) Slow close/open breaker and check for binding.

(10) Perform time-travel analysis.

(11) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey [is not][is] required.

(

(12) Record as-found and as-left operation counter readings.

b. Electrical Tests

(1) Measure contact resistances.

(2) Perform insulation-resistance tests.

(3) Verify trip, close, trip-free, and antipump functions.

(4) Trip circuit breaker by operation of each protective device.

3.5.1.4 Transformers (Liquid-Filled)

a. Visual and mechanical inspection

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

(2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

[(3) Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.

][(4) Verify operation of all alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay.

] (5) Verify tightness of accessible bolted electrical connection by calibrated torque-wrench method. Thermographic survey [is not][is] required.

(6) Verify correct liquid level in transformer tank.

(7) Perform specific inspections and mechanical tests as recommended by manufacturer.

(8) Verify correct equipment grounding.

(9) Verify that positive gas pressure is maintained on gas blanketed

transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform turns-ratio tests.

(3) Perform insulation power-factor/dissipation-factor tests on windings.

(4) Sample insulating liquid. Sample must be tested for:

(a) Dielectric breakdown voltage

(b) Acid neutralization number

(c) Specific gravity

(d) Interfacial tension

(e) Color

(f) Visual condition

(g) Parts per million water

(h) Measure dissipation factor or power factor.

(5) Perform dissolved gas analysis (DGA).

(6) Test for presence of PCB.

(7) Verify that tap-changer is set at specified ratio.

(8) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.5.1.5 Switchgear Assemblies

a. Visual and Mechanical Inspection

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

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

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

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

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

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

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

] (8) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey [is not][is] required.

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

(10) Clean switchgear.

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

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

(13) Exercise all active components.

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

(15) Verify that vents are clear.

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

(17) Inspect control power transformers.

b. Electrical Tests

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

(2) Perform overpotential tests.

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

(4) Perform control wiring performance test.

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

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

] (7) Verify operation of heaters.

3.5.1.6 Instrument Transformers

a. Visual and Mechanical Inspection

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

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and

secondary circuit.

(5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey [is not][is] required.

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

(7) Verify correct operation of transformer with drawout mechanism and grounding operation. Removal of instruments must be performed in a manner that the secondary circuits of energized current transformers are not opened.

(8) Verify correct primary and secondary fuse sizes for potential transformers.

b. Electrical Tests - Current Transformers

(1) Perform insulation-resistance tests.

(2) Perform polarity tests.

(3) Perform ratio-verification tests.

(4) Perform excitation test on transformers used for relaying applications.

(5) Measure circuit burden at transformer terminals and determine the total burden.

(6) When applicable, perform insulation resistance and dielectric withstand tests on the primary winding with secondary grounded.

(7) CAUTION: Changes of connection, insertion, and removal of instruments, relays, and meters must be performed in such a manner that the secondary circuits of energized current transformers are not opened momentarily.

c. Electrical Tests - Voltage (Potential) Transformers

(1) Perform insulation-resistance tests.

(2) Perform a polarity test on each transformer to verify the polarity marks or H1 - X1 relationships as applicable

(3) Perform a turns ratio test on all tap positions , if applicable.

(4) Measure potential circuit burdens at transformer terminals and determine the total burden.

(5) Measure circuit burden at transformer terminals and determine the total burden.

3.5.1.7 Battery Systems

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved

shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey [is not][is] required.

(4) Measure electrolyte specific gravity and temperature and visually check fill level.

(5) Verify adequacy of battery support racks, mounting, anchorage, and clearances.

b. Electrical tests

(1) Set charger float and equalizing voltage levels.

(2) Verify all charger functions and alarms.

(3) Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.

(4) Perform a capacity load test.

3.5.1.8 Metering and Instrumentation

a. Visual and Mechanical Inspection

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

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

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

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

(3) Verify all instrument multipliers.

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

3.5.1.9 Grounding System

a. Visual and Mechanical Inspection

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

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the

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

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

[3.5.2 Field Dielectric Tests

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NOTE: Field dielectric tests are recommended when new units are added to an existing installation or after major field modifications. If necessary, service the equipment prior to the field test.
****

Perform field dielectric tests on medium-voltage switchgear according to IEEE C37.20.2A or IEEE C37.20.3 as applicable.

]3.5.3 Follow-Up Verification

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NOTE: Use "10" working days and include last bracketed sentence in the paragraph for NAVFAC SE projects.
****

Upon completion of acceptance checks, settings, and tests, the Contractor must show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Circuit breakers must be tripped by operation of each protective device. Test must require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer [5][10] working days in advance of the dates and times for checks, settings, and tests[, to allow the Contracting Officer to notify NAVFAC SE Code 0742; Electrical Engineering Division and Code 162; Director, Utilities Engineering Division].

3.6 TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period will consist of a total of [_____] hours of normal working time and must start after the system is functionally completed but prior to final acceptance tests. The course instruction must cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions must demonstrate all routine maintenance operations.

a. Submit [6][_____] copies of operation and maintenance manuals, within [7][_____] calendar days following the completion of tests and including assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked.

b. Manuals must also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements must also be included. Documents must be bound in a binder marked or identified on the spine and front cover. A table of contents page must be included and marked with pertinent contract information and contents of the manual. Tabs must be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare-parts data. Index sheets must be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers.

c. Submit a digital video recording of the entire training session and three additional copies of the instructions manual within 30 days following the approval of the manuals.

3.7 MANUFACTURER'S FIELD SERVICE

3.7.1 Installation Engineer

After delivery of the equipment, furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of the equipment, assist in the performance of the on site tests, initial operation, and instruct personnel as to the operational and maintenance features of the equipment. Submit a detailed description of the Contractor's proposed procedures for on site tests.

3.7.2 Pre-Energization Services

Calibration, testing, adjustment, and placing into service of the installation must be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience. No part of the electrical system must be energized until all station grounding components have been tested and demonstrated to comply with the specified requirements. The following services must be performed on the equipment listed below. These services must be performed subsequent to testing but prior to the initial energization. The equipment must be inspected to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at station buses and at major equipment must be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations must be inspected to detect possible damage caused during installation. If factory tests were not performed on completed assemblies, tests must be performed after the installation of completed assemblies. Components must be inspected for damage during installation or shipment and to verify that packaging materials have been removed. Components capable of being both manually and electrically operated must be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested must be calibrated, adjusted, and tested in

accordance with the instructions of the equipment manufacturer.

3.8 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation material or operation have been corrected.

-- End of Section --