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USACE / NAVFAC / AFCESA **UFGS-16361N (February 2003)**

Preparing Activity: NAVFAC **Superseding**
UFGS-16361N (March 2001)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 22 December 2004

Latest change indicated by CHG tags.
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DIVISION 16 - ELECTRICAL

SECTION 16361N

PRIMARY UNIT SUBSTATION

02/03

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SECTION 16361N

PRIMARY UNIT SUBSTATION
02/03

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

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents**, including their organization designation and telephone number, is on the Internet.**

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

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
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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 16081 APPARATUS INSPECTION AND TESTING
--Section 16272 THREE-PHASE PAD-MOUNTED TRANSFORMERS
--Section 16273 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS
--Section 16301N OVERHEAD TRANSMISSION AND DISTRIBUTION
--Section 16302N UNDERGROUND TRANSMISSION AND DISTRIBUTION
--Section 16341N SF6 INSULATED PAD-MOUNTED SWITCHGEAR

--Section 16360 SECONDARY UNIT SUBSTATIONS
--Section 16442 SWITCHBOARDS AND SWITCHGEAR
--Section L-16303N UNDERGROUND ELECTRICAL WORK
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****
NOTE: The following information shall 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: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide

specifications.
****

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 C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2004) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 167	(2004) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 653/A 653M	(2004a) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 780	(2001) Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings
ASTM D 117	(2002) Sampling, Test Methods, Specifications for Electrical Insulating Oils of Petroleum Origin
ASTM D 1535	(2001) Specifying Color by the Munsell System
ASTM D 2472	(2000) Sulfur Hexafluoride
ASTM D 3455	(2002) Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin
ASTM D 3487	(2000) Mineral Insulating Oil Used in Electrical Apparatus
ASTM D 877	(2002e1) Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D 92	(2002b) Flash and Fire Points by Cleveland Open Cup Tester

FM GLOBAL (FM)

FM P7825	(2003) Approval Guide

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C12.4	(1984; R1990) Mechanical Demand Registers
IEEE C2	(2002) National Electrical Safety Code
IEEE C37.04	(1999) Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
IEEE C37.20.2	(1999) Metal-Clad Switchgear
IEEE C37.20.3	(2001) Metal-Enclosed Interrupter Switchgear
IEEE C37.41	(2000) Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories
IEEE C37.71	(2001) Three-Phase, Manually Operated Subsurface and Vault Load Interrupting Switches for Alternating-Current Systems
IEEE C37.90	(1989) Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.00	(2000) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.80	(2002) Terminology for Power and Distribution Transformers
IEEE C57.12.90	(1999) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(1993) Requirements for Instrument Transformers
IEEE C57.96	(1999) Loading Dry-Type Distribution and Power Transformers
IEEE C57.98	(1994) Guide for Transformer Impulse Tests
IEEE C62.11	(1999) Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1KV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2003) Acceptance Testing Specifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.1	(2001) Code for Electricity Metering
NEMA C12.10	(1997) Watthour Meters

NEMA C37.06	(2000) AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities**
NEMA C37.121	(1989; R 2000) Switchgear - Unit Substations Requirements
NEMA C37.46	(2000) For High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnection Switches**
NEMA C37.72	(1987) Manually-Operated, Dead-Front Padmounted Switchgear with Load Interrupting Switches and Separable Connectors for Alternating-Current Systems
NEMA C57.12.28	(1999) Pad-Mounted Equipment - Enclosure Integrity
NEMA LI 1	(1998) Industrial Laminated Thermosetting Products
NEMA ST 20	(1992; R 1997) Dry-Type Transformers for General Applications
NEMA TP 1	(2002) Guide for Determining Energy Efficiency for Distribution Transformers

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1437	(1998) Electrical Analog Instruments - Panel Board Types
UL 467	(1993; Rev thru Feb 2001) Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

****

NOTE: Include Section 16081 APPARATUS INSPECTION AND TESTING on all projects involving medium voltage and specialized power distribution equipment

****

Section 16050N BASIC ELECTRICAL MATERIALS AND METHODS and Section 16081 APPARATUS INSPECTION AND TESTING apply to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

****

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary

factors in determining if a submittal for the item should be required.

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

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

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

****

NOTE: Include the bracketed options on "CI44 and 074 review" for LANTNAVFACENGCOM and SOUTHNAVFACENGCOM projects respectively. For other projects, submittal review shall be performed by the designer of record. If submittal review by LANTNAVFACENGCOM or SOUTHNAVFACENGCOM is specifically desired, the responsible Government agency must coordinate with the respective Code CI44 or 074 during the design process. Add appropriate information in Section 01330, "Submittal Procedures" to coordinate with the special requirements.

****

[Submit in accordance with paragraph entitled "Coordinated Submittal Reviews" herein].

1.3.1 Coordinated Submittal Reviews

a. Submit transformer submittals to Code [CI44, Atlantic][074, Southern] Division, Naval Facilities Engineering 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 surveillance and to insure alignment of equipment and coordination for interconnections.

SD-02 Shop Drawings

Unit substation drawings; G

[Transformer drawings [(to Code [CI44][074])]; G]

SD-03 Product Data

****

NOTE: Use bracketed options referring to Codes CI44 and 074 for LANTNAVFACENGCOM and SOUTHNAVFACENGCOM 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 [CI44][074])]; G]

Submittal shall 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 SOUTHNAVFACENGCOM projects.

****

[Calibration test reports; G]

Submit report of results of acceptance checks and tests specified by paragraph entitled "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-07 Certificates

****

NOTE: Use "Tested transformer losses" for other than LANTNAVFACENGCOM and SOUTHNAVFACENGCOM projects. Use "Transformer losses" for LANTNAVFACENGCOM projects. Use "Transformer loss calculations" for SOUTHNAVFACENGCOM projects.

****

[Tested Transformer Losses; G]

[Transformer losses; G]

[Transformer loss calculations; G]

SD-09 Manufacturer's Field Reports

****

NOTE: Include following option if "less-flammable transformer liquid" is chosen.

****

[Silicone compatibility tests[(to code [CI44] [074])]; G]

****

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 [CI44][074]]; G

Transformer routine and other tests[(to code [CI44][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 01781 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

****

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

[Calibration schedule; G]

[Formal request for settings; G]

Equipment test schedule[(to Code [CI44][074])]; G

1.4 QUALITY ASSURANCE

1.4.1 Battery Power Calculations

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

[1.4.2 Transformer Losses

****
NOTE: Use this paragraph for LANTNAVFACENGCOM projects only.
****

Submit certification from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Losses".

]1.4.3 Unit Substation Drawings

Drawings shall 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 11 x 17 inches 279 x 431 mm 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 shall be used by the designer of record to verify fuse size and to[provide breaker settings that will] ensure protection and coordination are achieved.

[1.4.4 Transformer Drawings

****
NOTE: Include bracketed option for separate transformer drawings on LANTNAVFACENGCOM and SOUTHNAVFACENGCOM projects only.
****

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

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

b. ANSI nameplate data

][1.4.5 Calibration Schedule

****
NOTE: Include "Calibration schedule" and "Formal request for settings" for SOUTHNAVFACENGCOM 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:

SOUTHNAVFACENGCOM, Code 05, Construction Department

SOUTHNAVFACENGCOM; Code 162; Director, Utilities Engineering Division

][1.4.6 Formal Request for Settings

****
NOTE: The "30" days in brackets below may be extended for projects involving major electrical distribution work. Consult with SOUTHNAVFACENGCOM 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 SOUTHNAVFACENGCOM; Code 162; Director, Utilities Engineering Division.

b. The equipment requiring protection and coordination shall 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:

SOUTHNAVFACENGCOM; Code 162; Director, Utilities Engineering Division.

][1.4.7 Calibration Test Reports

****
NOTE: Include this paragraph for SOUTHNAVFACENGCOM projects.
****

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

Submit operation and maintenance data in accordance with Section 01781 OPERATION AND MAINTENANCE DATA.

]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

****
NOTE: For LANTNAVFACENGCOM projects, change Section 16302N, "Underground Transmission and Distribution" to Section 16303N, "Underground Electrical Work" (typical throughout this specification).
****

Products and materials not considered to be secondary unit substations and related accessories are specified in Section 16302N UNDERGROUND TRANSMISSION AND DISTRIBUTION, and Section 16402 INTERIOR DISTRIBUTION SYSTEM.

2.2 PRIMARY UNIT SUBSTATIONS

NEMA 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 shall be designed for indoor service.][Substation shall be designed for outdoor service with ventilation openings and gasketing provided to ensure a weatherproof assembly under rain, snow, sleet, and hurricane conditions.] External doors shall 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 shall 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 shall 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 shall be designed for terminating [one][two][_____] single conductor cables per phase and shall be arranged for conduits entering from [below][above]. Provide cable terminations of the [modular molded rubber][porcelain insulator] type as specified in Section 16302N UNDERGROUND TRANSMISSION AND 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 16341N, "Pad-Mounted SF6 Insulated Interrupter Switches". Modify Section 16341N for vault-type switches, where applicable.
****

****
NOTE: Choose this subparagraph or "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 shall be an electrically-operated, three-pole, circuit interrupting device rated for [_____] amperes continuous at [_____] kV and [_____] kV BIL. Breaker shall be designed for service on a [_____] kV system with a short-circuit capacity of not less than [_____] [amperes symmetrical][MVA]. Rating shall be based on IEEE C37.04 and NEMA C37.06. Circuit breaker shall be drawout-mounted with position indicator, operation counter, auxiliary switches, and primary and secondary disconnect devices. Circuit breaker shall 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 shall be [[_____] Vdc][[_____] Vac].[SF6 circuit breakers shall be shipped factory filled with SF6 gas conforming to ASTM D 2472.]

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

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

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

    2. Test/disconnect position: Position shall 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 shall 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 shall conform to ASTM D 2472.] The switch shall be operated by a manually charged spring stored energy mechanism which shall simultaneously disconnect or connect ungrounded conductors. The moveable blade of the switch shall be deenergized when in the open position. The mechanism shall 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 shall extend the width of the switch enclosure and shall be bolted directly thereto. Connect frame of unit to ground bus. The door shall have an inspection window to allow full view of the position of the three switch blades through the closed door. Switch ratings shall 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 shall be capable of carrying continuously or interrupting [_____] amperes with a momentary rating of [_____] amperes at [_____] kV.

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

d. [Fuses shall 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 mineral oil filled transformers and locate transformers at least 7.6 meters 25 feet from buildings wherever possible. Where adequate distance from structures cannot be attained, consult NAVFAC design manuals and MIL-HDBK-1008, "Fire Protection for Facilities Engineering, Design, and Construction." Caution should be used in specifying less-flammable liquid filled transformers. 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.

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. [Oil-insulated][Less-flammable liquid-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 shall 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 shall not be less than [_____] percent at 85 degrees C.

e. Audible sound levels shall 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

kVA	DECIBELS (MAX)
10000	68

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

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

h. Transformer shall 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 shall have provisions for future addition of automatically controlled fans for forced-air-cooling.]

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

[2.2.3.2 Specified Transformer Efficiency

****

NOTE: On other than LANTNAVFACENGCOM and SOUTHNAVFACENGCOM projects, use "Specified Transformer Efficiency". Delete "Specified Transformer Losses", "Transformer Loss Calculations", and "Deduct Clause".

Efficiency shall be specified based on NEMA TP 1 until actual loss values can be coordinated with industry using life cycle cost economics.

****

Minimum efficiency, based on test results, shall not be less than NEMA Class 1 efficiency as defined by NEMA TP 1.

a. Tested transformer losses: Submit certification from the manufacturer, with the submitted catalog data, to show conformance with the specified efficiency requirements. The values used to determine the actual efficiency shall be the tested no-load losses (NLL) (in watts) at a reference temperature of 20 degrees C and the tested load losses (LL) (in watts) at a reference temperature of 85 degrees C. If the efficiency based on the aforementioned test results, is less than the

NEMA Class 1 efficiency, the transformer is unacceptable. Transformer efficiency values at both full load and at one-half full load shall be included on the routine test report.

][2.2.3.3   Specified Transformer Losses

****

NOTE: On LANTNAVFACENGCOM projects, use "Specified Transformer Losses". Delete "Specified Transformer Efficiency", "Transformer Loss Calculations", and "Deduct Clause". The appropriate NLL and LL values for each transformer will be provided by Code CI44 at the 100 percent review. Until that time, leave the following bracketed values blank.

****

No-load losses (NLL shall be [____] watts at 20 degrees C, and load losses (LL) shall be [_____] watts at 85 degrees C. The values for the specified losses shall be used for comparison with the losses determined during the routine tests. If the routine test values exceed the specified no-load losses by more than 10 percent, or the total losses exceed the specified total losses (sum of no-load and load losses) by more than 6 percent, the transformer is unacceptable.

****

NOTE: On SOUTHNAVFACENGCOM projects, use "Transformer Loss Calculations" and "Deduct Clause". Delete "Specified Transformer Efficiency" and "Specified Transformer Losses".

TRANSFORMER LOSSES (WATTS)

kVA	**1000**	**1500**	**2000**	**2500**
NLL	**1250**	**1725**	**2100**	**2775**
LL	**6050**	**7300**	**8425**	**12000**

****

****

Specify values for the variables "A", "B", & "C" using Transformer Losses (Watts) table above, Table I below, and C equals A(NLL) plus B(LL).

TABLE I

ACTIVITY	**LOSS FACTORS**	
NAS KEY WEST	**A = 8.36**	**B = 2.95**
CHARLESTON AFB	**A = 3.79**	**B = 1.91**
GLAKES COMPLEX	**A = 4.89**	**B = 2.14**
DFSP CHARLESTON	**A = 4.54**	**B = 2.36**
NAS CORPUS CHRISTI	**A = 3.98**	**B = 2.10**
MCAS BEAUFORT	**A = 4.54**	**B = 2.36**
NAS KINGSVILLE	**A = 3.98**	**B = 2.10**
MCRD PARRIS ISLAND	**A = 4.54**	**B = 2.36**
NS INGLESIDE	**A = 3.98**	**B = 2.10**
NH BEAUFORT	**A = 4.54**	**B = 2.36**
NAS MERIDIAN	**A = 4.65**	**B = 2.19**
NH CHARLESTON	**A = 4.54**	**B = 2.36**

TABLE I

ACTIVITY	LOSS FACTORS	
CAPE CANAVERAL	A = 6.25	B = 1.78
NISE	A = 4.54	B = 2.36
MCLB ALBANY	A = 5.26	B = 1.50
NWS CHARLESTON	A = 4.54	B = 2.36
NAS ATLANTA	A = 5.26	B = 1.50
NS PASCAGOULA	A = 5.30	B = 1.51
NSB, KINGS BAY	A = 5.26	B = 1.50
BARKSDALE AFB	A = 3.59	B = 1.44
CSS PANAMA CITY	A = 4.23	B = 1.96
NAS FORT WORTH	A = 3.70	B = 1.70
NAS PENSACOLA	A = 4.23	B = 1.96
NAS MEMPHIS	A = 3.93	B = 2.09
NAS SAUFLEY	A = 4.23	B = 1.96
ANDROS ISLAND	A = 3.56	B = 1.84
NAS WHITING FIELD	A = 4.23	B = 1.96
ASCENSION ISLAND	A = 3.56	B = 1.84
NTTC CORRY	A = 4.23	B = 1.96
DETROIT	A = 3.56	B = 1.84
BLOUT ISLAND	A = 4.72	B = 1.89
DFSP ALASKA	A = 3.56	B = 1.84
NAS JACKSONVILLE	A = 4.72	B = 1.89
EGLIN AFB	A = 3.56	B = 1.84
NS MAYPORT	A = 4.72	B = 1.89
INDIAN NAWC	A = 3.56	B = 1.84
NAS NEW ORLEANS	A = 3.23	B = 2.07
NASC LOUISVILLE	A = 3.56	B = 1.84
SA NOLA WEST BAN	A = 3.23	B = 2.07
NPC FRINDLEY	A = 3.56	B = 1.84
KEESLER AFB	A = 4.03	B = 1.64
NWS CRANE	A = 3.02	B = 1.55
NCBC GULFPORT	A = 4.03	B = 1.64
POPE AFB	A = 3.56	B = 1.84
STENNIS SPC	A = 4.03	B = 1.64
SELFRIDGE ANG	A = 3.56	B = 1.84
NSA NOLA EAST BAN	A = 5.10	B = 1.97
SEY. JOHNSON AFB	A = 3.56	B = 1.84
ORLANDO COMPLEX	A = 4.62	B = 1.84
SHAW AFB	A = 3.56	B = 1.84
TINKER AFB	A = 3.56	B = 1.84

****

][2.2.3.4 Transformer Loss Calculations

a. "A" and "B" are given loss factors. A equals [_____]; B equals [_____]

b. "C" is the cost of losses. C equals $ [_____]

c. "NLL" and "LL" are the transformer no-load losses (watts) at 20 degrees C, and load-losses (watts) at 85 degrees C, respectively.

][2.2.3.5 Deduct Clause

After routine test results are available, Contractor shall perform actual transformer loss calculations (D) using test result values for NLL and LL, and values specified above for A and B. Submit calculations for each transformer with the routine test submittal. Calculate using equation: "D equals A(NLL) plus B(LL)".

a. If D is less than or equal to C: No adjustment will be made to contract price.

b. If D is greater than C: A unilateral contract modification will be issued in the amount of difference between C and D.

c. If D is greater than 1.25(C): The transformer is unacceptable.

]2.2.3.6 Insulating Liquids

[a. Mineral oil: ASTM D 3487, Type II, tested in accordance with ASTM D 117. Provide identification of transformer as "non-PCB" on the nameplate.]

[b. Less-flammable transformer liquids: NFPA 70 and FM P7825 for less-flammable liquids having a fire point not less than 300 degrees C tested in accordance with ASTM D 92 and a dielectric strength not less than 33 kV tested in accordance with ASTM D 877. Do not provide askarel or insulating liquids containing polychlorinated biphenyls (PCB's), tetrachloroethylene (perchloroethylene), chlorine compounds, and halogenated compounds.

[1. Silicone compatibility tests: When silicone is used as a less-flammable transformer liquid, compatibility of silicone with seals and gasketing materials in oil-immersed type tap changers shall be determined by compatibility tests conducted in accordance with ASTM D 3455. Test results shall show no evidence of shrinkage, swelling, or absorption caused by the liquid.]]

2.2.4 Secondary Transition[and Auxiliary] Section(s)

The secondary transition[and auxiliary] section(s) shall 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 shall 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, two-winding type, 115 degrees C rise above 40 degrees C maximum ambient designed for mounting in switchgear cubicle or drawer. Transformer shall be sized as required to serve the connected load and shall have a voltage rating of [_____] kV three-phase, delta primary, and [120/208][277/480] V wye secondary, 60 Hz.

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: 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.

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IEEE C37.20.2 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 shall be self-contained and shall 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 shall be designed for [indoor][outdoor] location and shall conform to the Category [A][B] requirements of Table A1 of Appendix A to IEEE C37.20.2. 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 shall be rated [_____] amperes and shall 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 shall 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 shall be rated 100 amperes at 125 Vdc. Wire shall be No. 6 AWG minimum.

d. Each breaker compartment shall 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 shall be an electrically operated, three-pole, circuit interrupting device rated as indicated at maximum voltage of [_____] kV and [_____] kV BIL. Breaker shall be designed for service on a [_____] kV system with a short-circuit capacity of not less than [_____] [amperes symmetrical][MVA]. Rating shall be based on IEEE C37.04 and NEMA C37.06. Breaker frame size shall be as indicated. Circuit breaker shall be drawout-mounted with position indicator, operation counter, auxiliary switches, and primary and secondary disconnect devices. Circuit breaker shall 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 shall be [_____] Vdc.

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

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

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

    2. Test/disconnect position: Position shall 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 shall have swivel casters in front for ease of movement.

2.2.6   Protective Relays, Metering, and Control Devices

2.2.6.1   Relays

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NOTE: The definition and application of device function numbers used in electrical substations and switchgear are found in ANSI C37.2, "IEEE Standard Electrical Power System Device Function Numbers." For description and application of commonly used relays, refer to MIL-HDBK-1004/3, "Switchgear and Relaying." This guide specification does not cover all possible relay applications. Choose only the relay types applicable to the specific project.

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Relays shall conform to IEEE C37.90. Protective relays shall be induction type or solid-state type enclosed in rectangular, semiflush, switchboard-type drawout cases with indicating targets and provisions for testing in place by use of manufacturer's standard test blocks or test switches. One complete set of test blocks or test switches to fit each type of relay in the equipment shall be provided. Auxiliary and lockout relays are not required to have drawout cases or test provisions. Controls, relays, and protective functions shall be provided completely assembled and wired.

a. Phase overcurrent relays (device [50/]51): Provide [_____] sets of three time overcurrent relays responding to phase currents wired to trip associated circuit breakers upon the occurrence of a current above the tap setting of the relays. Each relay shall have [very][extremely] inverse time characteristics with a tap range of [_____] to [_____] amperes.[Each relay shall be equipped with an instantaneous overcurrent unit having a pickup value over the range of [_____] to [_____] amperes.][Relays shall be Type [_____].]

b. Ground overcurrent relays (device [50/]51N): Provide a time overcurrent relay responding to ground (residual) current, wired to trip the associated circuit breaker upon occurrence of ground current above the tap setting of the relay. Relay shall have [very][extremely] inverse time characteristics with a tap range of [_____] to [_____] amperes. Relay shall be equipped with an instantaneous overcurrent unit having a pickup value adjustable over the range of [_____] to [_____] amperes.[Relays shall be Type [_____].]

c. Ground overcurrent relays (device 51N): Provide a time overcurrent relay responding to ground (residual) current, wired to trip the associated circuit breaker upon occurrence of ground current above the tap setting of the relay. Relay shall have [very][extremely] inverse time characteristics with a tap range of [_____] to [_____] amperes.[Relay shall be equipped with an instantaneous overcurrent unit having a pickup value adjustable over the range of [_____] to [_____] amperes.][Relays shall be Type [_____].]

d. Directional phase overcurrent relays (device 67): Provide [_____] sets of three directionally controlled time overcurrent relays sensing phase current, wired to trip associated circuit breakers upon a current exceeding the tap setting in the direction indicated. Relays shall have a voltage polarized directional unit and an inverse time characteristic overcurrent unit. Overcurrent unit shall have a tap range of [_____] to [_____] amperes.[Relays shall be Type [_____].]

e. Directional ground overcurrent relays (device 67N): Provide directionally controlled time overcurrent relays sensing ground (residual) current. Relays shall be wired to trip the associated circuit breaker upon a current exceeding the tap setting in the direction indicated. Relays shall have a current and voltage polarized directional unit and an inverse time characteristic overcurrent unit. Relays shall be voltage polarized. Auxiliary potential transformers shall be provided to obtain polarizing voltage. Overcurrent unit shall have a tap range of [_____] to [_____] amperes.[Relays shall be Type [_____].]

f. Lockout relays (device 86): Provide hand reset, electrically tripped, high-speed auxiliary relays where indicated. Relays shall be tripped by the indicated devices and shall be wired to trip the associated circuit breaker and prohibit closing of the circuit breaker by local and remote controls until the lockout relay has been reset by hand to its normal position. Each relay shall be provided with the number of contacts required to perform the indicated function and, in addition, shall have a minimum of two spare normally closed contacts and two spare normally open contacts.

g. Bus differential relays (device 87B): Provide a set of three high-speed, high-impedance, single-phase bus differential relays, wired to trip the circuit breakers connected to the protected bus upon occurrence of a fault within the zone of protection. Relays shall not trip the circuit breakers on through current to a fault outside the zone of protection. Current signals shall be obtained from dedicated current transformers. Bus differential relay shall include a voltage-operated unit which shall operate in three to six cycles for low-magnitude faults and a current-operated unit which shall operate in one to three cycles on moderate to severe faults. Relay shall include a thyrite voltage-limiting unit. Voltage-operated unit shall have an adjustment range of 75 to 500 V. Current-operated unit shall have an adjustment range of 2 to 50 amperes.

[h. Trip blocking test switches: Trip blocking test switches shall be provided to block tripping of 34.5-kV circuit breakers from the bus differential lockout relay. Trip blocking test switches shall be back-connected knife switches in a semiflush panel-mounted insulating case with removable clear glass or acrylic cover. Knife switches shall be rated for at least 125 Vdc and 30 amperes. Knife switches shall have an insulated operating knob.]

[i. Transformer differential relays (device 87T): Provide a set of three high-speed, percentage differential relays for protection of three-phase, delta-wye, two-winding transformer. Relays shall sense phase currents from the transformer primary current transformers and transformer secondary breaker current transformers. Relays shall trip the primary circuit breakers and the transformer secondary breakers. Relays shall have a sensitive differential unit to detect faults within the protected zone. Relays shall have a harmonic restraint unit to prevent tripping on transformer inrush current and two restraint transformers to prevent tripping on through-current to a fault outside the zone. Relays shall have a sensitivity of 0.35 times the tap value. Relays shall have ratio taps in the range of 2.9 to 8.7 amperes. Relays shall be Type [_____].]

[j. Fault pressure relay (device 63): Provide a fault pressure relay sensitive to rate of rise of transformer tank pressure to detect internal faults in transformer windings. Fault pressure relay shall be wired to a compatible auxiliary seal-in relay (Device 63X), which shall trip primary circuit breakers and transformer secondary breakers of the associated transformer via a lockout relay. Fault pressure relay shall be transformer mounted and auxiliary relay shall be panel mounted in a semiflush case. Auxiliary relay shall have trip-indicating targets.]

k. Thermal relay (device 49): Provide a winding thermal relay, with associated accessories. Equipment shall indicate the winding temperature of the transformer, provide automatic cooling fan control, and shall have one spare single-pole, double-throw contact for remote indication of overtemperature for connection to a future Supervisory Control and Data Acquisition (SCADA) System.

l. 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.

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

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

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

2.2.6.2 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 SOUTHNAVFACENGCOM projects, provide three thermal demand ammeters.

****

ANSI C39.1 for electrical indicating switchboard instruments, with one percent accuracy class, antiparallax pointer, and glare-free face with scales as indicated and coordinated to the ratios of the current and potential transformers provided. AC ammeters and voltmeters shall be a minimum of [50][115] mm [2][4 1/2] inches square, with 4.36 rad 250 degree scale. Provide single-phase indicating instruments with flush-mounted transfer switches for reading three phases.

a. AC ammeters: Transformer rated, 5-ampere input, 60 Hz.

b. AC voltmeters: Transformer rated, 150-volt input, 60 Hz.[Provide external dropping resistors.]

c. 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.]

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

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

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

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

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

2.2.6.3 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.

2.2.6.4 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 shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter shall be coordinated to system requirements.

****
NOTE: When Section 15910, "Direct Digital Control Systems" is used, coordinate meter requirements. Determine the appropriate class and form designations.
****

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 15910N DIRECT DIGITAL CONTROL SYSTEMS].

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

c. Class: [__]. Form: [___]. Accuracy: +/- 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: shall 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: [____].]

2.2.6.5 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 C12.10. Kilowatt-hour meters shall 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 shall be [two and one-half][three]-stator.[Totalizing kilowatt-hour meters shall 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 shall have a five-dial pointer type register and shall be secondary reading. Register ratio shall 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 shall have a [sweep hand][cumulative] type KW demand register with 15-minute interval conforming to IEEE C12.4.

2.2.6.6 Electric Strip-Chart Recording AC Wattmeter

UL 1437 for [surface][semiflush] mounting. Chart speed shall be [_____] mm [_____] inches per [hour][minute] and chart drive motor shall be rated

[240][120][120/240] V, 60 Hz. The instrument shall have a full scale accuracy of one percent.

2.2.6.7 Instrument Transformers

IEEE C57.13, as applicable.

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

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

2.2.6.8 Heaters

Provide 120-volt heaters in each switchgear section. Heaters shall be of sufficient capacity to control moisture condensation in the compartments, and shall be sized 250 watts minimum. Heaters shall be controlled by a thermostat[and humidistat] located inside each section. Thermostats shall be industrial type, high limit, to maintain compartments within the range of 15 to 32 degrees C 60 to 90 degrees F.[Humidistats shall have a range of 30 percent to 60 percent relative humidity.] Provide transformer rated to carry 125 percent of heater full load rating. Transformers shall have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and shall conform to NEMA ST 20. Provide panelboard and circuit breakers in each switchgear assembly to serve the heaters in that switchgear assembly. 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.

2.2.6.9 Pilot and Indicating Lights

Provide transformer, resistor, or diode type.

2.2.7 Station Batteries and Charger

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NOTE: For SOUTHNAVFACENGCOM 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 shall be [_____] V, 60 cells, lead-acid, [pasted plate type][or][sealed, totally absorbed electrolyte type].

a. Pasted plate type batteries: Positive plates shall be of the manchester type and negative plates shall have a life equal to or greater than the positive plates. Battery containers shall be heat and impact resistant clear plastic with electrolyte level lines permanently marked on all four sides. A permanent leakproof seal shall be provided between cover and container and around cell posts. Sprayproof vent plugs shall be provided in covers. Sufficient sediment space shall 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 shall be provided. Capacity shall 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 shall be hermetically sealed with welded seams. Batteries shall be maintenance-free and shall not require water to be added. Capacity shall be calculated by switchgear manufacturer and approved by Contracting Officer before acceptance.

c. Battery charger shall be full-wave rectifier type, utilizing silicon semiconductor devices. Charger shall maintain a float charge of 2.15 V per cell and an equalizing charge of 2.33 V per cell. An equalizing charge timer shall be provided which operates automatically after an AC power failure of 5 seconds or more. Timer shall be adjustable for any time period up to 24 hours. Timer shall also be capable of being actuated manually. Adjustable float and equalizing voltage potentiometers shall be provided. Charger voltage shall 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 shall be provided. Output current shall be limited to 115 percent of rated output current, even down to short circuit of the DC output terminals. Solid state circuit shall have AC and DC transient voltage terminals. AC and DC magnetic circuit breakers shall be provided. Circuit breakers shall 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 shall be capable of continuous operation at rated current at an ambient temperature of 40 degrees C. Output DC current capacity shall match the requirements of the batteries provided.

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

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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.

****

****

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 shall consist of individual, factory-assembled, freestanding modular units, each with provisions for bolt-together installation. Modules shall have uniform dimensions, constructed of rigidly braced 14-gage steel with a durable corrosion-resistant finish. Units shall 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 shall 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 shall include necessary provisions for future expansion with removable end covers and extendable high-conductivity copper main and ground bus interconnections. Main bus shall be fully insulated and mounted on insulated supports of high-impact, non-tracking, high-quality insulating material. Bus shall 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 shall be rated [_____] amperes. Ground bus shall be sized for full short-circuit capacity and shall include provisions for external ground connections. Enclosures shall be designed for [indoor][outdoor] location and shall 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 shall 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

****
NOTE: Choose this paragraph or one of the subparagraphs below entitled, "SF6-Insulated Load Interrupter Switches" or "Vacuum-Insulated Load Interrupter Switches."
****

Load interrupter switches shall be three-pole, gang-operated, [fused][non-fused], arranged with hinge end of switch on load side to provide for "dead blade."[Fuses shall be located on hinge side of switch.] Switch handles shall be non-removable, operable from front of cubicle. Switch shall 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 shall be rated at [600][1200] amperes continuous, 61 kA momentary, 38 kA short-time fault closing. Switches shall 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 shall be [fused][or][non-fused] as indicated. Switches shall 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 shall be enclosed and sealed in maintenance-free, SF6 filled, molded epoxy insulated case, surrounded by dead-front metallic barriers. Switch operation shall be controlled by permanently lubricated quick-make, quick-break spring operator with solid linkage connection to contact operating shaft. Switch operator shall be mounted in separate dead-front compartment with access for addition of remote or automatic accessories, and shall include removable operating handle with storage provision, positive position indicators, and padlock provisions. SF6 gas shall conform to ASTM D 2472.[Fused load interrupter switches shall 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 shall be rated [_____] continuous, [_____] kA momentary, [_____] kA short-time fault closing.

][2.2.8.3   Vacuum-Insulated Load Interrupter Switches

Circuit interrupting device shall be [fused][non-fused], fixed mounted, [manually][electrically] operated, and shall be quick-make, quick-break with speed of operation independent of the operator. Electrically operated device shall be [120 Vac][125 Vdc]. Spring charging mechanism shall not rely on chains or cables.[Motor operator assembly shall be a separate device, isolated from high voltage and coupled through a direct drive shaft.] Circuit interrupter shall consist of automatic visible blade disconnects in series with vacuum interrupters. Arc interruption shall take place within the envelope of the vacuum interrupter. Upon opening, contacts in the vacuum interrupter shall separate 12 to 18 milliseconds before disconnect blades open. Total circuit interrupt opening time shall not exceed 3.0 cycles after the trip coil is energized at 85 to 100 percent of rated control voltage. Upon closing, disconnect blades shall close 9 to 12 milliseconds before contact is made in the vacuum interrupter. Local interrupter switch shall 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 NEMA C37.46 as applicable. High-voltage fuses and non-disconnecting fuse mountings shall 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 shall be designed with full height fuse access doors and shall 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 shall be within normal reach of the opened doorway. Four single full length interphase barriers shall isolate the three phases of the switch from each other and from the enclosures. Fuses shall be [current limiting type of self-contained design to limit available fault current stresses on the system and shall 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 shall 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 shall be corrosion resistant and shall be fabricated of stainless steel[or galvanized steel]. Base shall 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 shall comply with NEMA C57.12.28 regardless of base and substation material.] The color notation is specified in ASTM D 1535.

2.2.11.1 Stainless Steel

ASTM A 167, Type 304 or 304L.

[2.2.11.2 Galvanized Steel

ASTM A 123/A 123M, ASTM A 653/A 653M G90 coating, and ASTM A 153/A 153M, 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 shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units. External wiring shall 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 shall contain a single letter or number, shall be elliptically shaped to fit the wire securely, and shall 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 shall indicate wire designations corresponding to the schematic drawings. Wire markers on field installed conductors shall 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 shall conform to IEEE C62.11 for [station class][class indicated] and shall be rated [_____] kV.

2.3 SOURCE QUALITY CONTROL

****

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

****

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 shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

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

4. Dated calibration labels shall be visible on all test equipment.

5. Calibrating standard shall 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 shall 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 C37.20.2 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 shall 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 C37.20.2 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 shall 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 C37.71 or NEMA C37.72 as applicable, 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 shall 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 C37.71 or NEMA C37.72 as applicable, and IEEE C37.20.3. Furnish reports of production tests performed on the actual equipment for this project. Required tests shall 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 shall have been performed prior to the award of this contract.

a. Tests shall 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 shall 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 shall 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 shall 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

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall 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 shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 16302N UNDERGROUND TRANSMISSION AND 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 shall 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" shall apply.[Fence and equipment connections shall 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 shall be installed as specified in Section 16302N UNDERGROUND TRANSMISSION AND DISTRIBUTION, paragraph entitled "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 C37.20.2 and IEEE C37.20.3 as applicable.

3.3.2 Meters and Instrument Transformers

NEMA 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 A 780, zinc rich paint. Do not heat surfaces that repair paint has been applied to.

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 shall be at least 200 mm 8 inches thick, reinforced with a 152 x 152 - MW19 x MW19 6 x 6 - W2.9 x W2.9 mesh, placed uniformly 100 mm 4 inches from the top of the slab. Slab shall be placed on a 150 mm 6 inch thick, well-compacted gravel base. Top of concrete slab shall be approximately 100 mm 4 inches above finished grade. Edges above grade shall have 15 mm 1/2 inch chamfer. Slab shall be of adequate size to project at least 200 mm 8 inches beyond equipment, except that front of slab shall 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 shall be as specified in Section 03300N CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount[substation][and][switchgear] on concrete slab. Unless Otherwise indicated, the slab shall be at least 100 mm 4 inches thick. Top of concrete slab shall be approximately 100 mm 4 inches above finished floor. Edges above floor shall have 15 mm 1/2 inch chamfer. Slab shall be of adequate size to project at least 200 mm 8 inches beyond the equipment, except that front of slab shall 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 shall be as specified in Section 03300N 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 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.]

****
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.

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 shall 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.

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 shall 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 shall 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.

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

****
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 C37.20.2 or IEEE C37.20.3 as applicable.

]3.5.3 Follow-Up Verification

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

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device. Test shall 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 SOUTHNAVFACENGCOM Code 0742; Electrical Engineering Division and Code 162; Director, Utilities Engineering Division].

-- End of Section --