Preparing Activity: NAVFAC Superseding
UFGS-26 11 16 (February 2010)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
****

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11/21

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SECTION 26 11 16

SECONDARY UNIT SUBSTATIONS
11/21

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NOTE:

1. This guide specification covers the requirements for three phase secondary unit substations for step-down operation at primary voltages of 601 volts through 38 kilovolts, and secondary voltages, of 600 volts or less.

2. When feasible, provide a separate liquid-filled pad-mounted transformer outside of the facility and a separately erected switchboard/switchgear assembly inside the respective facility in lieu of a secondary unit substation. For NAVFAC LANT projects, do not use secondary unit substations with secondary current greater than 5000 amperes.

3. For NAVFAC LANT projects, where the available fault current is less than 12,000 amperes rms symmetrical, provide pad-mounted switchgear with a fault interrupting switch-way as the transformer primary protection device in lieu of a load interrupting switch. Clearly indicate requirements for identifying signage at switch-ways and at the transformer.

USE THE FOLLOWING RELATED GUIDE SPECIFICATIONS FOR POWER DISTRIBUTION EQUIPMENT:

--Section 26 08 00 APPARATUS INSPECTION AND TESTING
--Section 26 12 19.10 THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS
--Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS
--Section 26 11 14.00 10 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION
--Section 26 13 00 SF6/HIGH-FIREPOINT FLUIDS INSULATED PAD-MOUNTED SWITCHGEAR
--Section 26 11 13.00 20 PRIMARY UNIT SUBSTATION
--Section 26 22 00.00 10 480-VOLT STATION SERVICE

SWITCHGEAR AND TRANSFORMERS
--Section 26 23 00 LOW VOLTAGE SWITCHGEAR
--Section 26 24 13 SWITCHBOARDS
--Section 26 28 00.00 10 MOTOR CONTROL CENTERS, SWITCHBOARDS AND PANELBOARDS
--Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION
--Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION

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

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

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

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NOTE: This section utilizes the following energy cost and loss value tables. Graphics/Tables files contain all graphics/tables for the specification.

NOTE: To download UFGS Forms, Graphics, and Tables, go to: https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables

Do not include list of tables, or tables themselves, in project specifications. Use tables to obtain values required in PART 2 of the specification.

For NAVFAC SE facilities use table US-2.

TABLE NUMBER	TITLE
US-1	Transformer Loss & Impedance Data - for Energy Cost (EC) Less Than or Equal to $0.04 (2 pages)
US-2	Transformer Loss & Impedance Data - for Energy Cost (EC) Greater Than $0.04 and Less Than or Equal to $0.08 (2 pages)
US-3	Transformer Loss & Impedance Data - for Energy Cost (EC) Greater Than $0.08 and Less Than or Equal to $0.12 (2 pages)
EC-1	Energy costs at NAVFAC LANT Activities (2 pages)

****

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NOTE: The following information shall be shown on the project drawings:

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

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

3. Grounding Plan.

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

5. 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.

6. Special conditions, such as altitude, temperature and humidity, exposure to fumes, vapors, dust, and gases; and seismic requirements.

****

PART 1 GENERAL

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

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

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

****

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

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 318M	(2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering
ANSI Z540.1	(1994; R 2002) Calibration Laboratories and Measuring and Test Equipment - General Requirements

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A653/A653M	(2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM D117	(2018) Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Liquids
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System
ASTM D2472	(2000; R 2014) Standard Specification for Sulphur Hexafluoride
ASTM D3487	(2016; E2017) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D6871	(2017) Standard Specification for Natural (Vegetable Oil) Ester Fluids Used in Electrical Apparatus

FM GLOBAL (FM)

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
IEEE C37.90	(2005; R 2011) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C37.121	(2012) American National Standard for Switchgear-Unit Substations - Requirements
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.01	(2020) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.12.50	(1981; R 1998) Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Volt 601 to 34,500 Volts
IEEE C57.12.51	(2019) IEEE Guide for Mechanical Interchangeability of Ventilated Dry-Type Transformers
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating

	Transformers
IEEE C57.12.91	(2011) Standard Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C57.124	(1991; R 2002) Recommended Practice for the Detection of Partial Discharge and the Measurement of Apparent Charge in Dry-Type Transformers
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO ISO/IEC 17025	(2017) General Requirements for the Competence of Testing and Calibration Laboratories

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.4	(1984; R 2011) Registers - Mechanical Demand
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation

	Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

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

****

Section 26 08 00 APPARATUS INSPECTION AND TESTING, Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS, and 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, must be as defined in IEEE 100.

1.4 SUBMITTALS

****

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

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

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

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

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Include the bracketed paragraph for Navy projects for NAVFAC SE or NAVFAC LANT.

****

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

[In addition, submit in accordance with paragraph COORDINATED SUBMITTAL REVIEWS herein.

]1.4.1 Coordinated Submittal Reviews

****

NOTE: Include bracketed items "a" and "b" for NAVFAC LANT and NAVFAC SE projects. Choose the bracketed option "DC44" or "CI46" for NAVFAC LANT projects, and "074" for NAVFAC SE projects. For other projects, submittal review shall be performed by the designer of record. If submittal review by NAVFAC LANT or NAVFAC SE is specifically desired, the responsible Government agency must coordinate with the respective Code DC44, CI46, or 074 during the design process. Add appropriate information in Section 01 33 00 SUBMITTAL PROCEDURES to coordinate with the special requirements. For NAVFAC LANT, submit liquid-filled transformers to DC44 and dry-type transformers to CI46.

****

[a. Submit transformer submittals to Code [[DC44][CI46], Atlantic] [074, Southern] Division, Naval Facilities Engineering Systems Command for approval. In addition, submit one set of the remaining substation components for surveillance.

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

] SD-02 Shop Drawings

Unit Substation Drawings; G[, [_____]]

[Transformer Drawings (to Code [[DC44][CI46]] [074]); G[, [_____]]

] Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams must identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings must indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals must include the nameplate data, size, and capacity. Submittals must also include applicable federal, military, industry, and technical society publication references.

SD-03 Product Data

[Fuse Curves; G[, [_____]]

] **********
NOTE: Use bracketed options referring to Codes DC44 or CI46 for NAVFAC LANT and to Code 074 for NAVFAC SE projects. 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. For NAVFAC LANT submit liquid-filled transformers to DC44 and dry-type to CI46.
****

Secondary Unit Substation[Excluding Transformer Data]; G[, [_____]]

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

][Unit Substation Transformer (Dry-type) (to Code [CI46][074]); G[, [_____]]

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

SD-06 Test Reports

Acceptance Checks and Tests; G[, [_____]]

SD-07 Certificates

Paint Coating System; G[, [_____]]

Transformer Efficiencies; G[, [_____]]

SD-09 Manufacturer's Field Reports

Load Interrupter Switch Production Tests; G[, [_____]]

Unit Substation Transformer Design Tests (Liquid-filled)[(to Code [DC44][074])]; G[, [_____]]

Unit Substation Transformer Routine and Other Tests (Liquid-filled)

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

****
NOTE: For dry-type transformers, use the following bracketed options. Delete the previous three options for liquid filled transformers along with their associated subparagraphs in the paragraph SOURCE QUALITY CONTROL.
****

[Unit Substation Transformer Design Tests (Dry-type)[(to Code [CI46][074])]; G[, [_____]]

][Unit Substation Transformer Routine and Other Tests (Dry-type)[(to Code [CI46][074])]; G[, [_____]]

] SD-10 Operation and Maintenance Data

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

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals; G[, [_____]]

Equipment Test Schedule[(to Code [[DC44 for Liquid-filled Units][CI46 for Dry-type Units]] [074])]; G[, [_____]]

1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

1.5.1.1 Unit Substation Drawings

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

a. An outline drawing, with dimensional plan view, elevation, foundation plan and side views showing incoming, transformer, and outgoing sections.[Include [switchboard][switchgear] information from Section[26 28 00.00 10 MOTOR CONTROL CENTERS, SWITCHBOARDS AND PANELBOARDS][26 23 00 LOW-VOLTAGE SWITCHGEAR][26 24 13 SWITCHBOARDS] as part of the total unit substation.]

b. One-line diagram showing all components and their ratings.

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

d. Three-line diagram showing bus configuration, bus rating and overcurrent protective devices.

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

][f. Time-current characteristic fuse curves (on full size logarithmic paper) for the load interrupter switch fuse.

]1.5.1.2 Transformer Drawings

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

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

b. ANSI nameplate data.

1.5.2 Paint Coating System

Submit IEEE C57.12.29 coating system performance requirement tests. When interrupter switchgear and transformer are provided by two different manufacturers, each one must provide certification.

1.5.3 Transformer Efficiencies

****
NOTE: Use this paragraph for oil-filled transformers. Also use this paragraph for dry-type transformers on NAVFAC LANT projects.
****

Submit certification from the manufacturer indicating conformance with the paragraph SPECIFIED TRANSFORMER EFFICIENCIES".

1.5.4 Substation Product Data

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

1.5.5 Test Reports

Submit report of acceptance test results as specified by paragraph FIELD QUALITY CONTROL.

1.5.6 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.7 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.7.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.7.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site must not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Assembled Operation and Maintenance Manuals

Manuals must be assembled in durable, hard covered, water resistant binders. The manual must be assembled and indexed in the order noted in a table of contents. The contents of the assembled operation and maintenance manuals must be as follows:

a. Manufacturer's O&M information required by the paragraph, SD-10 OPERATION AND MAINTENANCE DATA.

b. Catalog data required by the paragraph, SD-03 PRODUCT DATA.

c. Drawing required by the paragraph, SD-02 SHOP DRAWINGS.

d. Price for spare parts and supply list

e. Routine and field acceptance test reports

1.6.2 Operation and Maintenance Data

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

1.7 WARRANTY

The equipment items must be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

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

2.2 SECONDARY UNIT SUBSTATION

Secondary Unit substations must comply with IEEE C37.121 regardless of the kVA rating specified. Substation must consist of [one][_____] incoming section[s], [one][_____] transformer section[s], and [one][_____] outgoing section[s].[Substation must be designed for outdoor service with ventilation openings and gasketing provided to ensure a weatherproof

assembly under rain, snow, sleet, and hurricane conditions.] Substations must be subassembled and coordinated by one manufacturer and must be shipped in complete sections ready for connection at the site. Where practicable, substation must be shipped as one unit. External doors must have provisions for padlocking. Bus bars and conductors must be copper.

2.2.1 Incoming Section[s]

The incoming section must consist of [a metal-enclosed interrupter switchgear section] [an air-filled terminal chamber] for connecting the incoming circuit [directly] [through a [fused] [non-fused] load interrupter switch] [vacuum circuit breaker] to the transformer. Circuit breaker and switch operating mechanisms must be serviceable items and be accessible from the front. Protective relays, controls, current transformer, voltage transformer and miscellaneous accessories shall be located in low voltage compartments. Operation of the switchgear must not be affected by opening the low voltage compartment doors. If required for proper connection and alignment, include a transition section with the incoming section.

2.2.1.1 Incoming Section Enclosure

****
NOTE: If medium voltage breakers are required for the main protective device, add information from Section 26 11 13.00 20 PRIMARY UNIT SUBSTATION for Navy projects and Section 26 11 14.00 10 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION for other projects.
****

The incoming section enclosure must be NEMA ICS 6 Type [3R][1][_____][as indicated][, fabricated entirely of type 304 or 304L stainless steel].[Bases, frames and channels of enclosure must be corrosion resistant and must be fabricated of [type 304 or 304L stainless steel][or][galvanized steel]. Base must include any part of enclosure that is within 75 mm 3 inches of concrete pad.][Galvanized steel must be ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable.] Paint enclosure, including bases, ASTM D1535 light gray No. 61 or No. 49. Paint coating system must comply with IEEE C57.12.29.

2.2.1.2 Cable Terminations

****
NOTE: Select insulated high-voltage connectors only when connecting directly to a dead-front transformer without using a load interrupter switch.
****

[Provide medium voltage cable terminations as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

][IEEE 386. Insulated High-Voltage Connectors. Connectors must have steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

****
NOTE: Coordinate with connector and bushings specified in transformer section. If available

fault is greater than 10,000 rms symmetrical amperes or if cable size is greater than No. 4/0 AWG, do not use 200 ampere loadbreak connectors.
****

[a. 200 ampere loadbreak connector ratings: Voltage: [15kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL]. Short time rating: 10,000 rms symmetrical Amperes.

] **********
NOTE: For NAVFAC LANT projects, provide 600 ampere connectors with 200 ampere bushing interface.
****

[b. 600 ampere deadbreak connector ratings: Voltage: [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL]. Short time rating: 40,000 rms symmetrical amperes.[Connectors must have 200 ampere bushing interface[for surge arresters][as indicated].]

] **********
NOTE: Include the following paragraph only when the activity requires additional grounding elbows and feed-thru inserts.
****

[c. Provide one set of three grounding elbows[and one set of three feed-thru inserts] for each secondary unit substation. Grounding elbows and feed-thru inserts must be delivered to the contracting officer.

]]2.2.1.3 Surge Arresters

****
NOTE: Surge arresters should be located at both the riser pole (where applicable) and at the equipment. Specify surge arrestors at the riser pole in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Dead front surge arresters are only available as distribution class. Substations utilizing station class arresters are covered by Section 26 11 13.00 20 PRIMARY UNIT SUBSTATION for Navy projects and Section 26 11 14.00 10 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION for other projects.
****

IEEE C62.11, rated [3][6][9][10][12][15][_____][kV][as indicated][, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap, suitable for plugging into inserts]. Arresters must be [intermediate] [distribution] class. Arresters for use at elevations in excess of 6000 feet above mean sea level must be specifically rated for that purpose. Arresters must be equipped with mounting brackets suitable for the indicated installations.

2.2.1.4 Load Interrupter Switch

****
NOTE: Verify UL listing is available for specified equipment before including bracketed option. UL listing may not be available for equipment operating

above 15 kV.
****

IEEE C37.20.3. Provide a three-pole, single-throw, deadfront, metal-enclosed, load interrupter switch with manual stored energy operator. Switch must be[fused, with fuses mounted on a single frame][non-fused][in series with [vacuum][or][SF6] interrupters] and designed for easy inspection[and fuse replacement].[SF6 gas must conform to ASTM D2472.] The switch must be operated by a manually charged spring stored energy mechanism which must simultaneously disconnect or connect ungrounded conductors. The moveable blade of the switch must be de-energized when in the open position. The mechanism must enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus must extend the width of the switch enclosure and must be bolted directly thereto. Connect frame of unit to ground bus. The door must have an inspection window to allow full view of the position of the three switch blades through the closed door. Switch ratings must be:

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

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

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

d. Fuses must be current limiting type rated [_____] amperes continuous, and [_____] amperes interrupting capacity.

e. SF6 gas interrupter switch must have three distinct positions of closed, opened and ground (earthed). The switch must have visible indicator to provide positive indication of its status.

[2.2.1.5 Primary Protective Device Connection

Connections between the primary protective device and transformer must be [cable][bus] mounted on porcelain insulators, and sized and braced to withstand the specified short-circuit and short-time currents.

]2.2.1.6 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 D2472.[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.

2.2.1.7 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.

2.2.1.8 Remote Racking Device

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

[2.2.1.9 Protective Relays

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

a. Relay Mounting:

(1) Each relay shall be mounted in a draw-out case with a two-stage quick-release operation.

(2) Removal of the relay from the case shall disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected.

(3) When the relay is inserted into the case, control power connections shall be made before the trip circuits are activated.

(4) Include a self-shorting contact on the case terminal block for a1arm indication and tripping of circuit breaker upon removal of the relay from the case.

b. Equip each relay system with a communications module to transmit the following data.

(1) Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.

(2) Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote open-close mode.

c. Relay must be equipped with the following ANSI devices:

(1) 24 Volts per Hertz

(2) 25 Synchrocheck

(3) 27X Auxiliary Undervoltage

(4) 27P Phase Undervoltage

(5) 32 Directional Power

(6) 49 Hottest Spot Temperature, Aging Factor, Loss of Life

(7) 50/87 Instantaneous Differential Overcurrent

(8) 50BF Breaker Failure

(9) 50G Ground Instantaneous Overcurrent

(10) 50N Neutral Instantaneous Overcurrent

(11) 50P Phase Instantaneous Overcurrent

(12) 50_2 Negative Sequence Instantaneous Overcurrent

(13) 51G Ground Time Overcurrent

(14) 51N Neutral Time Overcurrent

(15) 51_2 Negative Sequence Time Overcurrent

(16) 55 Power Factor

(17) 59N Neutral Overvoltage

(18) 59P Phase Overvoltage

(19) 59X Auxiliary Overvoltage

(20) 59_2 Negative Sequence Overvoltage

(21) 67G Ground Directional Element

(22) 67N Neutral Directional Element

(23) 67P Phase Directional Element

(24) 81O Overfrequency

(25) 81U Underfrequency

(26) 81R Frequency Rate of Change

(27) 87G Restricted Ground Fault (RGF)

(28) 87T Transformer differential

]2.2.2 Transformer (Liquid-Filled) Section[s]

****

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

1. Previously the use of mineral oil filled transformers were recommended wherever possible. The recent availability of biodegradable less-flammable transformer liquids may have altered that recommendation. For NAVFAC LANT, choose less-flammable transformer liquids as specified below for all projects unless there is a specific requirement to do otherwise. Where adequate distance from structures cannot be attained, consult NAVFAC design manuals and UFC 3-600-01, "Fire Protection Engineering For Facilities." Silicon-filled and R-temp filled transformers shall not be used for less-flammable requirements.

2. Use dry type transformers in unique applications only where their use can be thoroughly justified. Identify the intent to utilize dry type units in the basis of design and obtain approval from the applicable reviewing engineering field division. Dry type transformers, available in a variety of styles (including Cast Coil, Cast / Encapsulated Coil, Vacuum Pressure Encapsulated (VPE), Vacuum Pressure Impregnated (VPI) and Sealed) are normally less efficient and more expensive than oil filled transformers. There are, however, certain applications which warrant their use. This specification is limited to a choice of cast coil and vacuum pressure insulated (VPI) types of transformers which are available from at least three major manufacturers. Cast coil transformers (primary and secondary individually cast in epoxy) are recommended for use when planning de-energization of transformer for extended periods of time, when located outdoors, or in an extremely corrosive chemical environment. VPI transformers are recommended when used in a clean, limited space, indoor environment for continuous service.

3. Use the following option(s) when additional

capacity is required. This involves special coordination with transformer KVA ratings, 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 and mechanical circulation for the coolant fluid.

b. On rare occasions, for liquid-filled transformers, 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 65 degrees C winding temperature rise."

4. Use IEEE C57.12.00, Table 11(b), "Designation of voltage ratings of three-phase windings", such as "4160 V - 480Y / 277 V."

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

6. Dry-type transformers below 750 kVA usually have impedance values in the range of 2.5 to 5.0 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.

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

8. Choose stainless steel fabrication where environmental conditions are not suitable for mild steel or where a higher level of corrosion protection is desired (i.e. directly on waterfront).

9. Ship to Shore Power Substations must be specified with the appropriate output voltage, refer to UFC 4-150-02 for ship voltages. Specify transformers with a total of six 2.5 percent full capacity taps, two above and four below the nominal voltage.

****

IEEE C57.12.29. [Mineral oil liquid-filled][Less-flammable, bio-degradable liquid-filled]. Transformer[base][, including the tank, radiators, flanges, base, lifting provisions, and hardware,] must be fabricated of type 304, 304L, or 316 stainless steel.[Transformer base must include any part of the transformer that is within 75 mm 3 inches of concrete pad.] Paint coating system must comply with IEEE C57.12.29.

2.2.2.1 Transformer Ratings

a. Cooling Class: [ONAN-Liquid-filled, self-cooled][ONAN/ONAF-Liquid-filled, self-cooled/forced air cooled][_____].

b. Frequency: [50][60] Hz.

c. Phases: Three phase.

d. Rated Kilovolt Amperes: [_____] kVA

e. Voltage Rating: [_____] v - [_____] V.[For GrdY - GrdY transformers, provide transformer with five-legged core design for third harmonic suppression.]

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

g. Insulation Level: [60][95][150][_____] kV BIL

h. Temperature Rise: 65 degree C average winding temperature rise above a 30 degree ambient.

****

NOTE: Delete kVA ranges and sound levels for kVA ratings not used in the job.

****

i. Audible Sound Levels: Audible sound levels must comply with the following:

kVA Range	DECIBELS (MAX)
225-300	55
301-500	56
501-700	57
701-1000	58
1001-1500	60
1501-2000	61
2001-2500	62
2501-3000	63
3001-4000	64

2.2.2.2 Transformer Accessories

The transformer must have the following accessories:

a. [Four][_____] 2.5 percent full capacity taps, [two][_____] above and

[two][_____] below rated primary voltage.

b. Tap changer, with external, pad-lockable, manual type operating handle, for changing tap setting when transformer is de-energized.

[c. Dead-front high-voltage bushings; IEEE 386. [15 kV, 95 kV BIL][25kV, 125 kV BIL][35 kV, 150 kV BIL]. Provide [200 ampere bushing wells with bushing well inserts][600 ampere one piece deadbreak apparatus bushings].

] **********
NOTE: Include standoff bushings only when the Activity requires the additional items.
****

[d. Parking stands: Provide a parking stand near each dead-front bushing.[Provide insulated standoff bushings for parking of energized load-break connectors on each parking stands.]

] e. Insulated low-voltage neutral bushing with lugs for ground cable and removable ground strap.

f. Ground pads.

g. Liquid-level indicator.

h. Pressure-vacuum gage.

i. Liquid temperature indicator.

j. Drain and filter valves.

k. Pressure relief device, top mounted.

l. Diagrammatic stainless steel or laser-etched anodized aluminum nameplate in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

m. Transformer base with provisions for jacking and for rolling in either direction.

n. Lifting provisions.

o. Bolted transformer top or welded top with bolted handhole access.

[p. Auxiliary cooling equipment and controls.

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

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

]]2.2.2.3 Specified Transformer Efficiencies

****
NOTE: Transformer losses and efficiency requirements have been modified into the table

included within the specification and the previous Navy loss tables have been deleted.

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

****

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

KVA	EFFICIENCY (percent)
15	98.65
30	98.83
45	98.92
75	99.03
112.5	99.11
150	99.16
225	99.23
300	99.27
500	99.35
750	99.40
1000	99.43
1500	99.48
2000	99.51
2500	99.53
above 2500	99.54

2.2.2.4 Insulating Liquid

****

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

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

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

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

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

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

][2.2.2.4.1 Liquid-Filled Transformer Nameplates

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

][2.2.3 Transformer (Dry-Type) Section[s]

****
NOTE: Delete the paragraphs on Dry-Type Transformers when Liquid-Filled Transformers are used.
****

IEEE C57.12.01, and [IEEE C57.12.50 for dry-type transformers rated up to 500 kVA][IEEE C57.12.51 for dry-type transformers rated 501 kVA and larger]. Transformer[base][, including the enclosure, flanges, base, lifting provisions, and hardware,] must be fabricated of type 304 or 304L stainless steel.[Transformer base must include any part of the transformer that is within 75 mm 3 inches of concrete pad.] Paint coating system must comply with IEEE C57.12.29. Windings must be copper.

****
NOTE: Select either cast coil or VPI transformer.
****

[Provide a cast coil type transformer with primary and secondary windings individually cast in epoxy. Resin-encapsulated windings are not acceptable. Transformer[s] must have an insulation system rated 185 degrees C, with an 80 degree C average winding temperature rise above a 40 degrees C maximum ambient.

][Provide a vacuum pressure impregnated (VPI) type transformer with an insulation system rated 220 degrees C, and with an 80 degree C average winding temperature rise above a 40 degrees C maximum ambient.

]2.2.3.1 Transformer Ratings

****

NOTE: Use 95 kV BIL for 15 kV systems in lieu of the 60 kV BIL allowed by the referenced standards. 10 kV BIL is the standard secondary rating for up to 600 volts. 30 kV BIL is an optional secondary rating that can be specified when required. Perform fault current calculations to verify that the distribution equipment is coordinated with the impedance specified.

****

a. Transformer must be rated [_____] kVA, [95][60][_____] kV BIL Primary and 10 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. Locate tap adjustments on the face of the high voltage coil. Adjustments must be accessible by removing the front panel and must be made when the transformer is de-energized.

d. Minimum tested impedance must not be less than [_____] percent at 80 degrees C.

****

NOTE: Edit kVA and sound levels for those used in job - delete those not used.

****

e. Audible sound levels must comply with the following:

kVA	DECIBELS (MAX)
225	58
300	58
500	60
700	64
1000	64
1500	65
2000	66
2500	68

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

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

h. Dry type transformer must have the following accessories.

(1) Winding temperature indicator

[(2) Auxiliary cooling equipment and controls

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

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

]]]2.2.4 Outgoing Section

[The outgoing section must consist of a full height air terminal compartment for physical protection of and connection point for the secondary conductors between the transformer and the [switchboard][_____] located [in the building][_____].

][The outgoing section must consist of a full height air terminal compartment. This compartment must contain the indicated metering,[instruments,][and][control power transformers] and must be the connection point for the secondary conductors between the transformer and the [switchboard][_____] located [in the building][_____]. Provide one three point latching hinged door, either full height or on the upper half of the outgoing section to provide access to metering. The upper section must contain the current transformers and a watthour meter mounted to a dead front interior barrier as defined below. If using upper half section door only, the lower section must be bolt on type and contain bus bars and lugs to terminate the service entrance conductors. Provide insulated barriers between the upper and lower sections to permit the bus bars to pass between the sections. Provide locking access handle to eliminate unauthorized access.

][The outgoing section must consist of a secondary transition section for connecting to a low-voltage [switchboard][switchgear section]. The [switchboard][switchgear] must be as specified in Section[26 28 00.00 10 MOTOR CONTROL CENTERS, SWITCHBOARDS AND PANELBOARDS][26 22 00.00 10 480-VOLT STATION SERVICE SWITCHGEAR AND TRANSFORMERS][26 23 00 LOW VOLTAGE SWITCHGEAR][26 24 13 SWITCHBOARDS]. Connections between the transformer secondary bushings and the outgoing section transition bus must be flexible braid bus. The secondary transition section must have a hinged front panel.

]2.2.4.1 Outgoing Section Enclosure

Provide outgoing section enclosure in accordance with the requirements in paragraph INCOMING SECTION ENCLOSURE.

[2.2.5 Watthour and Digital Meters

2.2.5.1 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 electromechanical meters.
****

NEMA/ANSI C12.10. Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, as indicated. Meter must either be programmed at the factory or must be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter must be coordinated to system requirements.

****
NOTE: Form 9S, in text below, is for three-phase, four-wire wye systems, for other system configurations, designer shall determine the appropriate form designation.
****

a. Design: Provide meter designed for use on a 3-phase, 4-wire, [208Y/120][480Y/277] volt system with 3 current transformers. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS)[as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC].

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

c. Class 20. Form: [9S][_____]. Accuracy: plus or minus 1.0 percent. Finish: Class II.

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

e. Demand Register:

(1) Provide solid state.

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

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

[2.2.5.2 Electro-Mechanical Watthour Meters

NEMA/ANSI C12.10. Kilowatt-hour meters must be [two][three][four]-stator, transformer rated, polyphase, 60 hertz, [surface][semiflush] mounted, [drawout][semi drawout] switchboard meters [120 volt for use on a four-wire wye, three phase, 208Y/120 Volt system][240 volt for use on a four-wire wye, three-phase 480Y/277 volt system]. Meter must have a five-dial pointer type register.[The kilowatt-hour meter must have a [sweep-hand][cumulative] type kilowatt demand register with [15][30][60]-minute interval conforming to NEMA C12.4.] Provide correct multiplier on face of meter.

][2.2.5.3 Digital Meters

****
NOTE: Digital metering incorporates the latest technology and provides additional information, often without additional cost. A control power transformer (115 V or 130 V) is normally required with this type of metering.
****

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meters enclosed in sealed cases with a simultaneous three line display. Meters must have 16 mm 0.56 inch, minimum, LED's.[Watthour meter must have a single line display with 16 mm 0.56 inch, minimum, LED's.] The meters must accept[input from standard 5A secondary instrument transformers][and][direct voltage monitoring range to [300][600] volts, phase to phase to phase]. Programming must be via a front panel display and a communication interface with a computer. Password secured programming must be stored in non-volatile EEPROM memory. Digital communications must be Modbus [ASCII][RTU] protocol via an [RS232C][RS485] serial port[and an independently addressable [RS232C][RS485] serial port]. The meter must calculate and store average max/min demand values for all readings based on a user selectable sliding window averaging period. The meter must have programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.[Meter must provide THD measurement to the thirty-first order.][Historical trend logging capability must include ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. The unit must also store and time stamp up to 100 programmable triggered conditions.][Event waveform recording must be triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Waveforms must be stored for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.]

[a. Multi-Function Meter: Meter must simultaneously display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, kVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under kVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. The meter must have a Form C KYZ pulse output relay.

][b. Power Meter: Meter must simultaneously display Watts, VARs, and selected kVA/PF. Detected alarm conditions include over/under kVA, over/under PF, over/under VARs, over/under reverse power.

][c. Volt Meter: Meter must be selectable between simultaneous display of the three phases of phase to neutral voltages and simultaneous display of the three phases of the phase to phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, and over percent THD.

][d. Ammeter: Meter must simultaneously display phase A, B, and C current. Detected alarm conditions include over/under current, and over percent THD.

][e. Digital Watthour Meter: Meter must have a single selectable display for watts, total kilowatt hours (kWh) and watt demand (Wd). The meter must have a Form C KYZ pulse output relay.

]]][2.2.6 Instruments

****
NOTE: On projects where voltage or amperage readings are required, use of the digital metering equipment versus individual ammeters and voltmeters may be justified due to technological advances and reduced costs of electronic equipment.
****

Electrical indicating switchboard style instruments, with 2 percent accuracy. The ac ammeters and voltmeters must be minimum of 50.8 mm 2 inches square, with 4.36 rad 250 degree scale. Provide single phase indicating instruments with flush-mounted transfer switches for reading three phases.

[2.2.6.1 Ac Ammeters

[Self-contained][Transformers rated, 5-ampere input, for use with a [_____] to 5-ampere current transformer ratio], 0 to [_____]-ampere scale range, 60 hertz.

][2.2.6.2 Ac Voltmeters

Self-contained.

][2.2.6.3 Instrument Control Switches

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

]][2.2.7 Current Transformers

****
NOTE: Select the appropriate current transformer (CT) ratio, continuous-thermal-current rating factor (RF) at 30 degrees C and ANSI Metering Accuracy Class values based on the CT ratio which is just below the rating of the main protective device.

Select an ANSI Metering Accuracy Class in accordance with the following table:

CT Ratio	RF	Accuracy Class
200/5	4.0	0.3 thru B-0.1
300/5	3.0	0.3 thru B-0.2
400/5	4.0	0.3 thru B-0.2

600/5	**3.0**	**0.3 thru B-0.5**
800/5	**2.0**	**0.3 thru B-0.5**
1200/5	**1.5**	**0.3 thru B-0.5**
1500/5	**1.5**	**0.3 thru B-0.9**
2000/5	**1.5**	**0.3 thru B-1.8**
2500/5	**1.5**	**0.3 thru B-1.8**
3000/5	**1.5**	**0.3 thru B-1.8**
3500/5	**1.5**	**0.3 thru B-1.8**
4000/5	**1.5**	**0.3 thru B-1.8**
5000/5	**1.5**	**0.3 thru B-1.8**

****

IEEE C57.13. Transformers must be single ratio, 60 hertz, [_____] to 5-ampere ratio, [_____] rating factor, with a metering accuracy class of 0.3 through [_____].

][2.2.8 Control Power Transformers

Transformer must conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

][2.2.9 Meter Fusing

Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to voltage sensing meters. Size fuses as recommended by the meter manufacturer.

]2.2.10 Heaters

Provide 120-volt heaters in[incoming section,][dry-type transformer section,][and][outgoing section]. Heaters must be of sufficient capacity to control moisture condensation in the compartments, must be 250 watts minimum, and must be controlled by a thermostat[and humidistat] located in each section. Thermostat must be industrial type, high limit, to maintain compartments within the range of 15.5 to 32.2 degrees C 60 to 90 degrees F.[Humidistat must have a range of 30 to 60 percent relative humidity.] If heater voltage is different than substation equipment voltage, provide transformer rated to carry 125 percent of heater full load rating. Transformer must have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and must conform to NEMA ST 20.[Energize electric heaters 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.]

2.2.11 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.

2.2.12 Terminal Boards

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

2.2.13 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve must be elliptically shaped to securely grip the wire, and must be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker must indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.2.14 Grounding and Bonding

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. A continuous ground bus bar shall run the length of the switchgear, the ground bus bar shall be accessible from the back of the switchgear. The ground bus bar must be hard-drawn copper of 98 percent minimum conductivity, minimum size 6 mm by 50 mm 1/4 by 2 inches.

[2.2.15 Padlocks

****

NOTE: Designer must assure that Section 08 71 00 DOOR HARDWARE is included and is edited to include padlocks. Delete this paragraph if padlocks are not to be provided by the contractor.

Do not use this paragraph for NAVFAC LANT projects unless there is a specific requirement.

****

Padlocks must be provided for secondary unit substation equipment[and for each fence gate]. Padlocks must be keyed[alike][as directed by the Contracting Officer]. Padlocks must comply with Section 08 71 00 DOOR HARDWARE.

]2.2.16 Cast-in-Place Concrete

****

NOTE: Use the first bracketed paragraph when project includes a concrete section in Division 3; otherwise, the second bracketed paragraph may be used. Coordinate requirements with Section 03 30 00 CAST-IN-PLACE CONCRETE.

****

[Concrete associated with electrical work for other than encasement of underground ducts must be 30 MPa 4000 psi minimum 28-day compressive strength unless specified otherwise. All concrete must conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

] **********

NOTE: If concrete requirements are detailed and no cast-in-place concrete section is to be included in the project specification, refer to Section 03 30 00 CAST-IN-PLACE CONCRETE, and select such portions as needed to provide complete requirements in addition to the requirements below.

****

[Must be composed of fine aggregate, coarse aggregate, portland cement, and water so proportioned and mixed as to produce a plastic, workable mixture. Fine aggregate must be of hard, dense, durable, clean, and uncoated sand. The coarse aggregate must be reasonably well graded from 4.75 mm to 25 mm 3/16 inch to one inch. The fine and coarse aggregates must be free from injurious amounts of dirt, vegetable matter, soft fragments or other deleterious substances. Water must be fresh, clean, and free from salts, alkali, organic matter, and other impurities. Concrete associated with electrical work for other than encasement of underground ducts must be 30 MPa 4000 psi minimum 28-day compressive strength unless specified otherwise. Slump must not exceed 100 mm 4 inches. Retempering of concrete will not be permitted. Exposed, unformed concrete surfaces must be given a smooth, wood float finish. Concrete must be cured for a period of not less than 7 days, and concrete made with high early strength portland cement must be repaired by patching honeycombed or otherwise defective areas with cement mortar as directed by the Contracting Officer. Air entrain concrete exposed to weather using an air-entraining admixture conforming to ASTM C260/C260M. Air content must be between 4 and 6 percent.

]2.3 MANUFACTURER'S NAMEPLATES

Each item of equipment must have a nameplate bearing, as a minimum, the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. Include additional information as applicable to fully identify the equipment. Nameplates must be made of noncorrosive metal.[Equipment containing liquid dielectric must include the type of dielectric on the nameplate.][Sectionalizer switch nameplates must have a schematic with all switch positions shown and labeled.] As a minimum, provide nameplates for transformers, circuit breakers, meters, switches, and switchgear.

2.4 FIELD FABRICATED NAMEPLATES

****

NOTE: Use the bracketed sentence to specify labels for secondary unit substations where emergency breakers are located within the secondary unit substations. Provide note on the drawings to indicate where red labels are required.

****

ASTM D709. Provide laminated plastic nameplates for each secondary unit substation, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription must identify the function and, when applicable, the position. Nameplates must be melamine plastic, 3 mm 0.125 inch thick, white with [black][_____] center core.[Provide red laminated plastic label with white center core where indicated.] Surface must be matte finish. Corners must be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 25 mm by 65 mm one by 2.5 inches. Lettering must be a minimum of 6.35 mm 0.25 inch high normal block style.

2.5 WARNING SIGNS

Provide warning signs for the enclosures of secondary unit substations having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.29, such as for secondary unit substations, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign must be a decal and must have nominal dimensions of 178 mm by 255 mm 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 50 mm 2 inch high letters. The word "DANGER" must be in white letters on a red background and the words "HIGH VOLTAGE" must be in black letters on a white background.

[b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 355 mm by 255 mm 14 by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 75 mm 3 inch high white letters on a red and black field.

]2.6 SOURCE QUALITY CONTROL

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

2.6.1 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.

Test Instrument Calibration

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

(2) The accuracy must be directly traceable to the National Institute of Standards and Technology. Test equipment must qualify for the UL standard of Scope of Accreditation ISO ISO/IEC 17025and ANSI Z540.1.

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

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

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

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

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

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

2.6.2 Load Interrupter Switch Production Tests

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

Production Tests

(1) Dielectric

(2) Mechanical operation

[(3) Grounding of instrument transformer case

][(4) Electrical operation and control wiring

]2.6.3 Transformer Design Tests (Liquid-Filled)

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 product data and shop drawings for[each of] the specified transformer[s]. Design tests must have been performed prior to the award of this contract.

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

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

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

lightning impulse tests must include both the primary and secondary windings of that transformer.

(1) IEEE C57.12.90 paragraph 10.3 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.

2.6.4 Transformer Routine and Other Tests (Liquid-Filled)

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

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

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

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

f. Load losses (LL) and impedance voltage

g. Dielectric

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

(a) State test voltage levels

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

(2) Applied voltage

(3) Induced voltage

h. Leak

i. Sample insulating liquid. Sample must be tested for:

(1) Dielectric breakdown voltage

(2) Acid neutralization number

(3) Specific gravity

(4) Interfacial tension

(5) Color

(6) Visual condition

(7) Water in insulating liquid

(8) Measure dissipation factor or power factor

j. Perform dissolved gas analysis (DGA)

[2.6.5 Transformer Design Tests (Dry-Type)

****
NOTE: Delete the paragraphs on Dry-Type Transformers when Liquid-Filled Transformers are used.
****

In accordance with IEEE C57.12.01 and IEEE C57.12.91. 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 in the same submittal package as the product data, shop drawings, and certificates of transformer losses for[each of] the specified transformer[s]. Design tests must have been performed prior to the award of this contract.

a. Provide required submittals in a hard-covered binder with index and tabs.

b. Tests must be certified and signed by a registered professional engineer. Engineers stamp and signature must appear on at least the first page of the factory test reports.

c. Temperature rise:

(1) "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 (AA), the same temperature rise rating, the same insulating class and the same insulating medium as the transformer specified.

(2) Provide temperature rise readings, formulas, calculations of average temperature rise, and description of test method.

d. Lightning impulse:

(1) "Basically the same design" for the lightning impulse dielectric

test means a unit-substation transformer with the same BIL and the same coil construction (such as wire wound primary and sheet wound secondary).

(2) IEEE C57.12.91 and IEEE C57.98. Provide design lightning impulse tests consisting of a reduced full-wave, two-chopped waves, and one full wave test for each phase of the primary and secondary windings of the same transformer.

(3) State test voltage levels.

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

(5) Partial Discharge Test per IEEE C57.124. Provide transformer ratings, description and diagram of test method used, test readings and final results.

][2.6.6 Transformer Routine and Other Tests (Dry-Type)

In accordance with IEEE C57.12.01 and IEEE C57.12.91. Routine and other tests must be performed by the manufacturer on[each of] the actual transformer[s] prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence must be as follows:

a. Resistance measurements

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. Lightning impulse: Perform the complete design type impulse tests on the transformer primary winding only.

(1) IEEE C57.12.91 and IEEE C57.98

(2) State test voltage levels

(3) 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.]

h. Low frequency dielectric

(1) Applied voltage

(2) Induced voltage

]2.7 STATION BATTERIES AND CHARGER

****
NOTE: For NAVFAC SE projects, specify maintenance-free sealed batteries only. Provide only when an external control power source is required for circuit breaker or switch operation.
****

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

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

b. Sealed batteries: Provide batteries with leak proof, spill proof electrolyte utilizing highly absorbent material to separate the positive and negative plates. Battery jars must be hermetically sealed with welded seams. Batteries must be maintenance-free and shall must not require water to be added. Capacity must be calculated by switchgear manufacturer and approved by Contracting Officer before acceptance.

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

(1) AC power failure

(2) DC ground detection

(3) High DC voltage

(4) Low DC voltage

(5) Charger failure

(6) Battery discharging

(7) End of discharge

(8) DC current limit

(9) Common summary alarm

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

PART 3 EXECUTION

3.1 INSTALLATION

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

3.2 GROUNDING

****

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

****

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

3.2.1 Grounding Electrodes

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

3.2.2 Substation Grounding

****

NOTE: Where the rated secondary current exceeds 400 amperes, increase the size of the substation transformer neutral ground connection to not less than 12.5 percent of the cross-sectional area of the

secondary phase conductors. Provide a "detail" for surge arrester grounding. For ungrounded and single-grounded systems, modify paragraph in accordance with IEEE C2.
****

Provide bare copper cable not smaller than No. 4/0 AWG not less than 610 mm 24 inches below grade interconnecting the indicated ground rods. Surge arrester and neutrals must be bonded directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Lead lengths must be kept as short as practicable with no kinks or sharp bends. Substation transformer neutral connections must not be smaller than No. 1/0 AWG. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" must apply.[Fence and equipment connections must not be smaller than No. 4 AWG. Ground fence at each gate post and cornerpost and at intervals not exceeding 3050 mm 10 feet. Bond each gate section to the fence post through a 3 mm by 25 mm 1/8 by one inch flexible braided copper strap and clamps.]

3.2.3 Connections

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

3.2.4 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 Interrupter Switchgear

IEEE C37.20.3.

[3.3.2 Meters and Instrument Transformers

ANSI C12.1.

]3.3.3 Field Applied Painting

Where field applied painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Field Fabricated Nameplate Mounting

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

3.3.5 Warning Sign Mounting

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 9 meters 30 feet apart.

[3.3.6 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. 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 transformer.

****

3.4.1 Exterior Location

Mount unit substation on concrete slab. Unless otherwise indicated, the slab must be at least 200 mm 8 inches thick, reinforced with a 152 by 152 - MW19 by MW19 6 by 6 - W2.9 by W2.9 mesh placed uniformly 100 mm 4 inches from the top of the slab. Slab must be placed on a 150 mm 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 100 mm 4 inches above the finished grade. Edges above grade must have 15 mm 1/2 inch chamfer. The slab must be of adequate size to project at least 200 mm 8 inches beyond the equipment. 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. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter. Cut off and bush conduits 75 mm 3 inches above slab surface.

3.4.2 Interior Location

Mount unit substation on concrete slab. Unless otherwise indicated, the slab must be at least 100 mm 4 inches thick. The top of the concrete slab must be approximately 100 mm 4 inches above finished floor. Edges above floor must have 15 mm 1/2 inch chamfer. The slab must be of adequate size to project at least 100 mm 4 inches beyond the equipment. 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. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter. Cut off and bush conduits 75 mm 3 inches above slab surface.

3.4.3 Cast-in-Place Concrete

****

NOTE: Use the first bracketed option when project

includes a concrete section in Division 3; otherwise the second bracketed option may be used.
****

Cast-in-place concrete work must conform to the requirements of[Section 03 30 00 CAST-IN-PLACE CONCRETE][ACI 318M].

[3.5 PADLOCKS

****
NOTE: Delete this paragraph if padlocks are not to be provided by the contractor.
****

Provide padlocks for secondary unit substation equipment[and for each fence gate].

]3.6 FIELD QUALITY CONTROL

3.6.1 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.

3.6.1.1 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 net][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.

3.6.1.2 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 öf 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.

3.6.1.3 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 and pumps operate correctly and that fan and pump 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) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify correct liquid level in transformer tank.

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

(8) Verify correct equipment grounding.

(9) Verify the presence of transformer surge arresters.

(10) Verify that positive pressure is maintained on gas blanketed transformers.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform dissolved gas analysis (DGA).

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

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

[3.6.1.4 Transformers - (Dry-Type)

a. Visual and Mechanical Inspection

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

(2) Inspect physical and mechanical condition.

(3) Verify that control and alarm settings on temperature indicators are as specified.

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

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

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

(7) Verify that resilient mounts are free and shipping brackets have been removed.

(8) Verify that winding core, frame, and enclosure groundings are correct.

(9) Verify the presence of transformer surge arresters.

(10) Verify that as-left tap connections are as specified.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform power-factor tests or dissipation-factor tests in accordance with the test equipment manufacturer's instructions.

(3) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(4) Perform turns-ratio tests.

(5) Perform an applied-voltage test on high and low voltage windings-to-ground. See IEEE C57.12.91. The ac dielectric-withstand-voltage test result must not exceed 75 percent of factory test voltage for one-minute duration. The dc dielectric-withstand-voltage test result must not exceed 100 percent of the ac rms test voltage specified in IEEE C57.12.91 for a one-minute duration. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

(6) Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

]3.6.1.5 Current 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) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

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

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.6.1.6 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) Verify 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) Verify that current transformer[and voltage transformer] secondary circuits are intact.

3.6.1.7 Grounding System

a. Visual and Mechanical Inspection

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

b. Electrical Tests

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

(2) Submit the measured ground resistance of each ground rod or grounding system, indicating the location of the rod or 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.

[3.6.2 Protective Relays

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NOTE: Do not use this paragraph for NAVY projects.
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Protective relays must be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests must include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings must be implemented as directed by the Contracting Officer. Relay contacts must be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers must be field tested in accordance with IEEE C57.13.

][3.6.3 Pre-Energization Services

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NOTE: Do not use this paragraph for NAVY projects or projects where Section 26 08 00 APPARATUS INSPECTION AND TESTING is included.
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Calibration, testing, adjustment, and placing into service of the installation must be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of 2 years of current product experience. The following services must be performed subsequent to testing but prior to the initial energization. The equipment must be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment must be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations must be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests must be performed after the installation of completed assemblies. Components must be inspected for damage caused during installation or shipment to ensure packaging materials have been removed. Components capable of being both manually and electrically operated must be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested must be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer.

]3.6.4 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor must show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Test must require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days' advance notice of the dates and times for checks, settings, and tests.

-- End of Section --