UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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SECTION 26 11 16

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02/10, CHG 2: 11/19

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SECTION 26 11 16

SECONDARY UNIT SUBSTATIONS
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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 FLUID 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).
****

****
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 GRAPHICS

Go to http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/for

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)

TABLE NUMBER	TITLE
EC-1	Energy costs at NAVFAC LANT Activities (2 pages)

****

****

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

****

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 in 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 C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments
ANSI C57.12.13	(1982) Conformance Requirements for Liquid-Filled Transformers

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A653/A653M	(2020) 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 D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
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 D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System
ASTM D3487	(2016; E2017) Standard Specification for Mineral Insulating Oil 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	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
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	(2015) 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	(2015; Corr 2017) 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) 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	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

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) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA

20-1; TIA 20-2; TIA 20-3; TIA 20-4) 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 (2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

****

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

****

Section 26 08 00 APPARATUS INSPECTION AND TESTING 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, shall 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.

****

****

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 entitled "Coordinated Submittal Reviews" herein.
]

****

NOTE: Do not use the following submittal exception paragraph with dry-type transformers.

****

As an exception to the transformer submittal requirements specified herein, liquid-filled transformers manufactured by ABB in South Boston, VA; by Cooper Power Systems in Waukesha, WI; or by Howard Industries in Laurel, MS need not meet the submittal requirements of this contract. Instead, the following shall be submitted:

a. A certification, from the manufacturer, that the technical requirements of this specification shall be met.

b. An outline drawing of the transformer with devices identified (paragraph entitled "Transformer Drawings," item a).

c. ANSI nameplate data of the transformer (paragraph entitled "Transformer Drawings", item b).

****

NOTE: Use "will" on all NAVFAC SE projects. Coordinate with paragraph entitled "Source Quality Control."

****

d. Routine and other tests (paragraph entitled "Routine and Other Tests"), shall be conducted by the manufacturer and [may][will] be witnessed by the government (paragraph entitled "Source Quality Control"). Provide transformer test schedule required by submittal item "SD-11 Closeout Submittals". Provide certified copies of the tests.

e. Provide acceptance test reports required by submittal item "SD-06 Test Reports".

f. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data".

1.4.1 Coordinated Submittal Reviews

****
NOTE: Include bracketed items "a" and "b" for NAVFAC LANT and NAVFAC SE projects. Choose the bracketed option "CI44" 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 CI44, 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 CI44 and dry-type transformers to CI46.
****

[a. Submit transformer submittals to Code [[CI44][CI46], Atlantic][074, Southern] Division, Naval Facilities Engineering Command for approval. In addition, submit one set of the remaining substation components for surveillance.

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

] SD-02 Shop Drawings

Unit Substation Drawings; G[, [_____]]

[Transformer drawings (to Code [[CI44][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 shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall 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 CI44 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 CI44 and dry-type to CI46.
****

Secondary unit substation[excluding transformer data]; G[, [_____]]

[Unit substation transformer (liquid-filled) (to Code [CI44][074]); G[, [_____]]

][Unit substation transformer (dry-type) (to Code [CI46][074]); G[, [_____]]

] Submittal shall 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 Losses; G[, [_____]]

SD-09 Manufacturer's Field Reports

Load Interrupter Switch production tests; G[, [_____]]

Unit substation transformer design tests (liquid-filled)[(to code [CI44][074])]; G[, [_____]]

Unit substation transformer routine and other tests (liquid-filled) [(to code [CI44][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 entitled "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 [[CI44 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 shall include, but are not limited to the following:

a. An outline drawing, with front, top, 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[[fused] load interrupter switch,][current transformers, meters,] and ampere rating of bus bars.

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

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

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

]1.5.1.2 Transformer Drawings

Drawings shall 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 shall provide certification.

1.5.3 Transformer Losses

****

NOTE: Use this paragraph, without the bracketed sentence, for oil-filled transformers. Also use this paragraph for dry-type transformers on NAVFAC LANT projects and include the bracketed sentence.
****

Submit certification from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Losses".[If tests on transformers of "basically the same design" are not available, provide written certification by manufacturer that transformers will meet the specified losses, and state what the losses will be. Submit report with transformer shop drawings and product data.]

1.5.4 Substation Product Data

Submittal shall 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 entitled "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, "shall" 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 shall 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 shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall 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 shall 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

shall not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Assembled Operation and Maintenance Manuals

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

a. Manufacturer's O&M information required by the paragraph entitled, "SD-10 Operation and Maintenance Data."

b. Catalog data required by the paragraph entitled, "SD-03 Product Data."

c. Drawing required by the paragraph entitled, "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 shall 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 shall comply with IEEE C37.121 regardless of the kVA rating specified. Substation shall consist of [one][_____] incoming section[s], [one][_____] transformer section[s], and [one][_____] outgoing section[s].[Substation shall be designed for outdoor service with ventilation openings and gasketing provided to ensure a weatherproof assembly under rain, snow, sleet, and hurricane conditions.] Substations shall be subassembled and coordinated by one manufacturer and shall be shipped in complete sections ready for connection at the site. Where practicable, substation shall be shipped as one unit. External doors shall have provisions for padlocking.

2.2.1 Incoming Section[s]

The incoming section shall consist of [a metal-enclosed interrupter switchgear section][an air-filled terminal chamber] for connecting the

incoming circuit [directly][through a [fused][nonfused] load interrupter switch] to the transformer. 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 shall be NEMA ICS 6 Type [3R][1][_____][as indicated][, fabricated entirely of ASTM A167 type 304 or 304L stainless steel].[Bases, frames and channels of enclosure shall be corrosion resistant and shall be fabricated of [ASTM A167 type 304 or 304L stainless steel][or][galvanized steel]. Base shall include any part of enclosure that is within 75 mm 3 inches of concrete pad.][Galvanized steel shall 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 shall 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 shall 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 shall 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 shall 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 shall be [intermediate] [distribution] class. Arresters for use at elevations in excess of 6000 feet above mean sea level shall be specifically rated for that purpose. Arresters shall 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[, UL listed and labeled load interrupter switchgear]. Provide a three-pole, single-throw, deadfront, metal-enclosed, load interrupter switch with manual stored energy operator. Switch shall be [fused, with fuses mounted on a single frame][non-fused] and designed for easy inspection[and fuse replacement]. The switch shall be operated by a manually charged spring stored energy mechanism which shall simultaneously disconnect or connect ungrounded conductors. The moveable blade of the switch shall be deenergized when in the open position. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus shall extend the width of the switch enclosure and shall be bolted directly thereto. Connect frame of unit to ground bus. The door shall have an inspection window to allow

full view of the position of the three switch blades through the closed door. Switch shall have provision for padlocking in the open and closed positions. [Switch][Switch/fuse integrated] ratings shall be as follow:

Rated Maximum Voltage, kV	Rated Withstand Impulse Voltage, kV BIL	Continuous and Load Interrupting Current, A	Short-Circuit Current kA rms Sym	Short-Time / Fault-Close Current kA
[4.76]	[60]	[600][1200]	[25][38]	[40][61]
[15]	[95]	[600][1200]	[25][38]	[40][61]
[25.8]	[125]	[600][1200]	[25][38]	[40][61]
[38]	[150]	[600][1200]	[25]	[40]

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

][2.2.1.5 Primary Protective Device Connection

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

]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. For liquid-filled transformers, select impedance value in accordance with technical note under paragraph entitled "Specified Transformer Losses."

7. 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.

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

9. 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).
****

ANSI C57.12.13. [Mineral oil liquid-filled][Less-flammable liquid-filled]. Transformer [base][,including the tank, radiators, flanges, base, lifting provisions, and hardware,] shall be fabricated of ASTM A167 type 304, 304L, or 316 stainless steel.[Transformer base shall include any part of the transformer that is within 75 mm 3 inches of concrete pad.] Paint coating system shall 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 shall 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 shall comply with the following:

kVA Range	DECIBELS (MAX)
225-300	55
301-500	56
501-700	57
701-1000	58

kVA Range	DECIBELS (MAX)
1001-1500	60
1501-2000	61
2001-2500	62
2501-3000	63
3001-4000	64

2.2.2.2 Transformer Accessories

The transformer shall 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, Qualitrol series 208.

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

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

]]2.2.2.3 Specified Transformer Losses

****

NOTE: Steps to specifying transformer losses for oil-filled transformers:

1. Print Tables US-1, US-2, US-3, and EC-1 or EC-2 as applicable (directions included at the front of this specification).

2. Obtain energy cost for the specific activity from the cognizant EFD or PWC. Energy costs should be based on the cost of energy without the demand charge factors scaled in. Use Table EC - 1 for energy costs at the indicated NAVFAC LANT activities. Use Table US-2 for energy costs at all NAVFAC SE activities. (Additional tables will be added for other EFD's as the information becomes available.)

3. Use Tables US-1, US-2, and US-3 to specify losses and impedances for transformers based on energy cost range, and transformer primary and secondary voltages.

4. Perform fault current calculations to verify that distribution equipment is coordinated with impedance specified.

****

No-load losses (NLL) shall be [_____] watts at 20 degrees C and load losses (LL) shall be [_____] watts at 85 degrees C.

The values for the specified losses shall be used for comparison with the losses determined during the routine tests. If the routine test values for no-load losses exceed the specified no-load losses by more than 10 percent, or the total losses exceed the specified total losses (sum of no-load and load losses) by more than 6 percent, the transformer is unacceptable.

2.2.2.4 Insulating Liquid

****

NOTE: Choose one of the following options. For NAVFAC LANT, choose less-flammable transformer

liquids for all projects unless there is a specific requirement to do otherwise.
****

[a. 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.

][b. Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV tested per ASTM D877/D877M. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

The fluid shall be a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM as "less flammable" fluids. The fluid shall meet the following fluid properties:

1. Pour point: ASTM D97, less than -15 degree C

2. Aquatic biodegradation: EPA 712-C-98-075, 100 percent

3. Trout toxicity: OECD Test 203, zero mortality of EPA 821-R-02-012, pass

][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,] shall be fabricated of ASTM A167 type 304 or 304L stainless steel.[Transformer base shall include any part of the transformer that is within 75 mm 3 inches of concrete pad.] Paint coating system shall comply with IEEE C57.12.29.

****
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] shall 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.
****

a. Transformer shall 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 shall be accessible by removing the front panel and shall be made when the transformer is de-energized.

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

h. Dry type transformer shall have the following accessories.

1. Winding temperature indicator

[2. Auxiliary cooling equipment and controls

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

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

]][2.2.3.2 Specified Transformer Losses

****
NOTE: On NAVFAC LANT and NAVFAC SE projects only, include the paragraphs entitled "Specified Transformer Losses." The appropriate NLL and LL values for each transformer will be provided by Code CI46 or Code 074 at the 100 percent review. Until that time, leave the following bracketed values blank.
****

No-load losses (NLL) shall be [_____] watts at 80 degrees C, and load losses (LL) shall be [_____] watts at 100 degrees C. The values for the specified losses shall be used for comparison with the losses determined during the routine tests. If the routine test values for no-load losses exceed the specified no-load losses by more than 10 percent, or the total losses exceed the specified total losses (sum of no-load and load losses) by more than 6 percent, the transformer is unacceptable.

]]2.2.4 Outgoing Section

[The outgoing section shall 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 shall consist of a full height air terminal compartment. This compartment shall contain the indicated metering,[instruments,][and][control power transformers] and shall 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 shall 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 shall 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 shall consist of a secondary transition section for connecting to a low-voltage [switchboard][switchgear section]. The [switchboard][switchgear] shall 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 shall be flexible braid bus. The secondary transition section shall have a hinged front panel.

]2.2.4.1 Outgoing Section Enclosure

Provide outgoing section enclosure in accordance with the requirements in paragraph entitled, "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 shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter shall be coordinated to system requirements.

****
NOTE: 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: shall 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 shall 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 shall have a five-dial pointer type register.[The kilowatt-hour meter shall 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 shall have 16 mm 0.56 inch, minimum, LED's.[Watthour meter shall have a single line display with 16 mm 0.56 inch, minimum, LED's.] The meters shall accept[input from standard 5A secondary instrument transformers][and][direct voltage monitoring range to [300][600] volts, phase to phase to phase]. Programming shall be via a front panel display and a communication interface with a computer. Password secured programming shall be stored in non-volatile EEPROM memory. Digital communications shall be Modbus [ASCII][RTU] protocol via an [RS232C][RS485] serial port[and an independently addressable [RS232C][RS485] serial port]. The meter shall calculate and store average max/min demand values for all readings based on a user selectable sliding window averaging period. The meter shall have programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.[Meter shall provide THD measurement to the thirty-first order.][Historical trend logging capability shall include ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. The unit shall also store and time stamp up to 100 programmable triggered conditions.][Event waveform recording shall be triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Waveforms shall 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 shall 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 shall have a Form C KYZ pulse output relay.

][b. Power Meter: Meter shall 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 shall 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 shall simultaneously display phase A, B, and C current. Detected alarm conditions include over/under current, and over percent THD.

][e. Digital Watthour Meter: Meter shall have a single selectable display for watts, total kilowatt hours (kWh) and watt demand (Wd). The meter shall 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.

****

ANSI C39.1 for electrical indicating switchboard style instruments, with 2 percent accuracy. The ac ammeters and voltmeters shall 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 shall 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 shall 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 shall 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 shall be of sufficient capacity to control moisture condensation in the compartments, shall be 250 watts minimum, and shall be controlled by a thermostat[and humidistat] located in each section. Thermostat shall 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 shall 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 shall have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and shall 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 shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units. External wiring shall be color coded consistently for similar terminal boards.

2.2.13 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to securely grip the wire, and shall 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 shall 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 Section33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

[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 shall be provided for secondary unit substation equipment[and for each fence gate]. Padlocks shall be keyed[alike][as directed by the Contracting Officer]. Padlocks shall 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. Use the section appropriate for the specific agency.
****

[Concrete associated with electrical work for other than encasement of underground ducts shall be 30 MPa 4000 psi minimum 28-day compressive strength unless specified otherwise. All concrete shall 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.
****

[Shall be composed of fine aggregate, coarse aggregate, portland cement, and water so proportioned and mixed as to produce a plastic, workable mixture. Fine aggregate shall be of hard, dense, durable, clean, and uncoated sand. The coarse aggregate shall be reasonably well graded from 4.75 mm to 25 mm 3/16 inch to one inch. The fine and coarse aggregates shall be free from injurious amounts of dirt, vegetable matter, soft fragments or other deleterious substances. Water shall 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 shall be 30 MPa 4000 psi minimum 28-day compressive strength unless specified otherwise. Slump shall not exceed 100 mm 4 inches. Retempering of concrete will not be permitted. Exposed, unformed concrete surfaces shall be given a smooth, wood float finish. Concrete shall be cured for a period of not less than 7 days, and concrete made with high early strength portland cement shall 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 shall be between 4 and 6 percent.

]2.3 MANUFACTURER'S NAMEPLATES

Each item of equipment shall 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 shall be made of noncorrosive metal.[Equipment containing liquid dielectric shall include the type of dielectric on the nameplate.][Sectionalizer switch nameplates shall 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 shall identify the function and, when applicable, the position. Nameplates shall 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 shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm one by 2.5 inches. Lettering shall 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 shall be a decal and shall have nominal dimensions of 178 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" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall 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 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 shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

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

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

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

5. Calibrating standard shall be of higher accuracy than that of the instrument tested.

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

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

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

2.6.2 Load Interrupter Switch Production Tests

IEEE C37.20.3. Furnish reports of production tests performed on the actual equipment for this project. Required tests shall 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 shall have been performed prior to the award of this contract.

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

b. Temperature rise: "Basically the same design" for the temperature

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

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

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

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

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

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

f. Load losses (LL) and impedance voltage

g. Dielectric

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

      (a) State test voltage levels

      (b) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports.[As an

alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand-delivered at the factory witness test.]

2. Applied voltage

3. Induced voltage

h. Leak

i. Sample insulating liquid. Sample shall 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 shall 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 shall be certified and signed by a registered professional engineer. Engineers stamp and signature shall 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 shall be performed by the manufacturer on[each of] the actual transformer[s] prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence shall be as follows:

a. 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

]PART 3 EXECUTION

3.1 INSTALLATION

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

3.2 GROUNDING

****
NOTE: Where rock or other soil conditions prevent obtaining a specified ground value, specify other methods of grounding. Where it is impractical to obtain 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 shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 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 shall be bonded directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Lead lengths shall be kept as short as practicable with no kinks or sharp bends. Substation transformer neutral connections shall not be smaller than No. 1/0 AWG. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply.[Fence and equipment connections shall not be smaller than No. 4

AWG. Ground fence at each gate post and cornerpost and at intervals not exceeding 3050 mm 10 feet. Bond each gate section to the fence post through a 3 by 25 mm 1/8 by one inch flexible braided copper strap and clamps.]

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified in Section 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 shall 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 shall be placed on a 150 mm 6 inch thick, well-compacted gravel base. Top of concrete slab shall be approximately 100 mm 4 inches above the finished grade. Edges above grade shall have 15 mm 1/2 inch chamfer. The slab shall 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 shall 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 shall be at least 100 mm 4 inches thick. The top of the concrete slab shall be approximately 100 mm 4 inches above finished floor. Edges above floor shall have 15 mm 1/2 inch chamfer. The slab shall 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 shall 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 shall 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 Interrupter Switchgear (Air Switches)

a. Visual and Mechanical Inspection

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

2. Inspect physical and mechanical condition.

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

4. Verify appropriate anchorage and required area clearances.

5. Verify appropriate equipment grounding.

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

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

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

] 9. 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.

10. Test interlocking systems for correct operation and sequencing.

11. Verify correct phase barrier materials and installation.

12. Compare switch blade clearances with industry standards.

13. Inspect all indicating devices for correct operation

b. Electrical Tests

1. Perform insulation-resistance tests.

2. Perform over-potential tests.

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

4. Measure closed contact-resistance across each switch blade[and fuse holder].

[5. Measure fuse resistance.

] 6. Verify heater operation.

3.6.1.2 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.

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.

[3.6.1.3 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 overpotential test on all high- and low-voltage windings-to-ground.

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

]3.6.1.4 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.

3.6.1.5 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.

3.6.1.6 Grounding System

a. Visual and Mechanical Inspection

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

b. Electrical Tests

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

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

****
NOTE: Do not use this paragraph for NAVY projects.
****

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented as directed by the Contracting Officer. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

][3.6.3 Pre-Energization Services

****
NOTE: Do not use this paragraph for NAVY projects or projects where Section 26 08 00 APPARATUS INSPECTION AND TESTING is included.
****

Calibration, testing, adjustment, and placing into service of the installation shall 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 shall be performed subsequent to testing but prior to the initial energization. The equipment shall 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 shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall 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 shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall 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 shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Test shall 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 shall be given 5 working days' advance notice of the dates and times for checks, settings, and tests.

-- End of Section --