UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION 26 12 19.10

THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS

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SECTION 26 12 19.10

THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS
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****
NOTE: This guide specification covers the requirements for three-phase pad-mounted, liquid-filled transformers of the dead-front and live-front types for exterior applications.

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: Use pad-mounted transformers (properly protected with bayonet type, oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses) for kVA ratings up to and including 1500 kVA on 5 kV systems and for kVA ratings up to and including 2500 kVA on 15, 25, and 35 kV systems.

For voltages above 35 kV and in ratings above those previously indicated, this specification requires significant modifications and additional specification sections may need to be added on the project.

This specification is for standard step-down

applications in utility distribution systems. For step-up applications (i.e. solar/wind generation, etc.), this specification requires significant modifications to address proper voltage designations, overcurrent and fault protection, etc.

The use of pad-mounted transformers with secondary currents exceeding 3000 amperes is discouraged due to the size and quantity of secondary conductors. Therefore, transformers above 1000 kVA serving 208Y/120 volt loads and transformers above 2500 kVA serving 480Y/277 volt loads should be in a secondary unit substation configuration.

Available fault current level and arc-flash energy become extremely hazardous at the larger kVA size transformers. Designer should consider these parameters and evaluate multiple service points.
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NOTE: For Navy and Air Force projects, this specification incorporates a "reduced shop drawing submittal process" for listed manufacturers who previously satisfied reduced shop drawing submittal process requirements. This specification also includes unique routine and other test requirements, transformer loss certificate, transformer test schedule, and field quality control acceptance tests and reports. The preparing activity, NAVFAC LANT, has significant experience and technical expertise in these areas. If Reach-back support is desired, for a specific NAVFAC or Air Force project, the technical representative (electrical engineer) editing this document for that project must contact the NAVFAC LANT Capital Improvements Electrical Engineering (Code CI44) Office for consultation during the design stage of the project, prior to including the requirement in the specification.
****

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NOTE: Use the following related guide specifications for power distribution equipment:
--Section 26 08 00 APPARATUS INSPECTION AND TESTING
--Section 26 11 13.00 20 PRIMARY UNIT SUBSTATIONS
--Section 26 11 16 SECONDARY UNIT SUBSTATION
--Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS
--Section 26 13 00 SF6/HIGH-FIREPOINT FLUID INSULATED PAD-MOUNTED SWITCHGEAR
--Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM
--Section 26 23 00 LOW VOLTAGE SWITCHGEAR
--Section 26 24 13 SWITCHBOARDS
--Section 26 27 13.10 30 ELECTRIC METERS
--Section 26 27 14.00 20 ELECTRICITY METERING
--Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION

Do not use the following related guide specifications except for Army Civil Works projects. They have not been unified.
--Section 26 11 14.00 10 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION
--Section 26 28 00.00 10 MOTOR CONTROL CENTERS, SWITCHBOARDS AND PANELBOARDS
--Section 26 22 00.00 10 480-VOLT STATION SERVICE SWITCHGEAR AND TRANSFORMERS
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****
NOTE: Coordination is required between this section and metering equipment specification sections. See Section 26 27 14.00 20 ELECTRICITY METERING or 26 27 13.10 30 ELECTRIC METERS for transformer and metering details, which are available in metric (SI) and U.S. Customary (IP) system dimension. Use these files to develop project specific drawings, including:

File Name	Description
PADMDE1	Three Phase, Ungrounded or Single Grounded Primary System - with Surge Arresters
PADMDE2	Three Phase, Ungrounded or Single Grounded Primary System - without Surge Arresters
PADMDE3	Three Phase, Multi-Grounded Primary System (Delta-Wye) - with Surge Arresters
PADMDE4	Three Phase, Multi-Grounded Primary System (Delta-Wye) - without Surge Arresters
PADMDE5	Three Phase, Multi-Grounded Primary System (Wye-Wye) - with Surge Arresters
PADMDE6	Three Phase, Multi-Grounded Primary System (Wye-Wye) - without Surge Arresters
ARCFLASH	Arc Flash Warning Label

NOTE: To download UFGS Forms, Graphics, and Tables, go to: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables
Pad-mounted transformer graphics are located with Metering Specification UFGS 26 27 14.00.

Select the appropriate Electrical .ZIP file(s) and extract the desired details.

Do not include list of details, or details themselves, in project specifications. Insert the appropriate details on drawings and modify optional and blank items. If special features are required, modify transformer details as required to indicate the actual requirements for each particular installation.

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****

NOTE: Show the following information on the project drawings:

1. Single-line diagram showing pad-mounted transformer connectors, inserts, surge arresters, switches, fuses, current transformers with ratings, and meters as applicable.

2. Grounding plan.

3. Type and number of cables, and size of conductors for each power circuit.

4. Transformer primary and secondary voltages. (Use IEEE C57.12.00, Table 8, "Designation of voltage ratings of three-phase windings (schematic representation)".) State the primary voltage (nominal) actually in service and not the voltage class.

5. 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 within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 318	(2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016; Errata 7-9 2017) Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14)
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

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2023) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
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 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 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 C37.47	(2011) Standard for High Voltage Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.12.34	(2022) Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7	(2022) Requirements for Watthour Meter

	Sockets
NEMA 260	(1996; R 2004) Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels
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

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) 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, are as defined in IEEE Stds Dictionary.

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.

****

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:

SD-02 Shop Drawings

Pad-mounted Transformer Drawings; G[, [_____]]

SD-03 Product Data

Pad-mounted Transformers; G[, [_____]]

SD-06 Test Reports

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

SD-07 Certificates

Transformer Efficiencies; G[, [_____]]

SD-09 Manufacturer's Field Reports

Transformer Test Schedule; G[, [_____]]

Pad-mounted Transformer Design Tests; G[, [_____]]

Pad-mounted Transformer Routine and Other Tests; G[, [_____]]

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5; G[, [_____]]

****
NOTE: Include the bracketed option below on Navy and Air Force projects where "reach-back support" has already been coordinated with NAVFAC LANT per the 3rd introductory Technical Note. Add appropriate information in Section 01 33 00 SUBMITTAL PROCEDURES to coordinate with the special requirements.
****

[1.4.1 Government Submittal Review

[Code CI44, NAVFAC LANT, Naval Facilities Engineering Systems Command][_____] will review and approve all submittals in this section requiring Government approval.

]1.4.2 Reduced Submittal Requirements

Transformers designed and manufactured by ABB in Jefferson City, MO; by Eaton's Cooper Power Series Transformers in Waukesha, WI; by ERMCO in Dyersburg, TN; or by Howard Industries in Laurel, MS need not submit the entire submittal package requirements of this contract. Instead, submit the following items:

a. A certification, signed by the manufacturer, stating that the manufacturer will meet the technical requirements of this specification.

b. An outline drawing of the transformer with devices identified (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item a).

c. ANSI nameplate data of the transformer (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item b).

****
NOTE: The designer is responsible for providing proper settings for secondary over-current device(s) to ensure proper protection of equipment and coordination with transformer high side fuses. Include the following option for transformers serving secondary over-current devices containing adjustable trips.
****

[d. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the [EasyPower] [SKM PowerTools for Windows] [_____] computer program of the transformer high side fuses (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item e).

] e. Provide transformer test schedule and routine and other tests required by submittal item "SD-09 Manufacturer's Field Reports".

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

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

1.5 QUALITY ASSURANCE

1.5.1 Pad-Mounted Transformer Drawings

****
Note: Delete bracketed metering information for Navy and Air Force projects when separate metering specification is used. May still need for Army and NASA projects until metering specification is unified.
****

Include the following as a minimum:

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

b. IEEE nameplate data.

c. Elementary diagrams and wiring diagrams[with terminals identified of watthour meter and current transformers].

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

****
NOTE: Include the following option for transformers serving secondary over-current devices containing adjustable trips.
****

[e. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the [EasyPower] [SKM PowerTools for Windows] [_____] computer program of the transformer high side fuses.

]1.5.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, except of NFPA 70 when more stringent requirements are specified or indicated, 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. Provide equipment,

materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated.

1.5.3 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, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide 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.

1.5.3.1 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.

1.5.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

****
NOTE: Delete bracketed information for Navy and Air Force projects when separate metering specification is used. May still need for Army and NASA projects until metering specification is unified.
****

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. In addition to requirements of Data Package 5, include the following on the actual transformer(s) provided:

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, front, top, and side views

c. Prices for spare parts and supply list

d. Routine and field acceptance test reports

e. Fuse curves for primary fuses

[f. Information on watthour demand meter, CT's, and fuse block

] g. Actual nameplate diagram

h. Date of purchase

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be pad-mounted transformers and related accessories are specified in[Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION,][Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM,][and] Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2 THREE-PHASE PAD-MOUNTED TRANSFORMERS

****

NOTE: According to IEEE 386, 200 ampere separable insulated connectors normally used on dead-front pad-mounted transformers have both a fault closure and a short-time current rating of 10,000 amperes. Therefore, from a safety standpoint, dead-front configurations which utilize these connectors should only be used at system locations which have available fault currents of less than 10,000 rms symmetrical amperes.

This specification does not address the materials used for the winding (copper versus aluminum) and it is assumed that the manufacturer will provide their standard product with respect to the winding construction, based on the cost of materials at the time of order acceptance. No failure data has been obtained indicating that copper windings have a longer life than aluminum windings. If copper windings are specified, the cost increase for three-phase distribution transformers has recently been about 15 percent. Do NOT specify winding materials.

****

IEEE C57.12.34, IEEE C57.12.28 and as specified herein. Submit manufacturer's information for each component, device, insulating fluid, and accessory provided with the transformer.

2.2.1 Compartments

Provide high- and low-voltage compartments separated by steel isolating barriers extending the full height and depth of the compartments. Compartment doors: hinged lift-off type with stop in open position and three-point latching.

2.2.1.1 High Voltage, Dead-Front

****

NOTE: Current policy is to use oil-immersed fuses in series with current limiting fuses to achieve better protection and obtain life cycle cost

benefits.

For 15 kV and 25 kV, 200 A bushings, select bushing wells and bushing well inserts. For 15 kV and 25 kV, 600 A bushings and for 35 kV bushings, select one-piece bushings.

Do not provide standoff bushings unless this transformer is the only dead-front transformer on the base. The Public Works Department normally carries standoff bushings in their vehicles. Provide protective caps when providing standoff bushings and to cover unused bushing well inserts when not providing surge arresters.

Coordinate lead-in paragraph with bracketed options below.

Choose minimum high-voltage compartment dimensions for transformers used in loop feed applications to accommodate installation of loop feed, feed-through inserts, and surge arresters.

NOTE: For systems with a fault capability greater than 10,000 amps, for applications utilizing loop feed load-break switches, or when the primary cable size is greater than No. 4/0 AWG, use 600A separable insulated dead-break connectors.

****

High-voltage compartment contains: the incoming line, insulated high-voltage [load-break][dead-break]connectors, [bushing well inserts,][feed-thru inserts,] six high-voltage [bushing wells][one-piece bushings] configured for loop feed application, load-break switch handle(s), [access to oil-immersed bayonet fuses,][dead-front surge arresters,] tap changer handle, connector parking stands[with insulated standoff bushings],[protective caps,] and ground pad.

[Minimum high-voltage compartment dimensions: IEEE C57.12.34, Figures 16 and 17.

][a. Insulated high-voltage load-break connectors: IEEE 386, rated [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL]. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector must have a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

][b. Insulated high-voltage dead-break connectors: IEEE 386, rated [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL]. Current rating: 600 amperes rms continuous. Short time rating: 25,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector must have a [200 ampere bushing interface for surge arresters,] steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

****

NOTE: Provide bushing well inserts and feed-through inserts only on load-break applications, not on

dead-break.
****

][c. Bushing well inserts[and feed-thru inserts]: IEEE 386, 200 amperes, [15][25] kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise.[Provide feed-thru inserts as indicated.]

][d. One-piece bushings: IEEE 386, [200][600] amperes, [15][25][35][_____] kV Class.

] e. Load-break switch

****
NOTE: Choose between load-break radial-feed switch and load-break loop feed switches.

There are three types of load-break switches: two-, three-, and four-position. UFC 3-550-01 recognizes only two-position load-break switch. Two-position switch is hot stick operable and requires minimum input torque to operate.
****

[Radial-feed two-position oil-immersed type rated at [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL], with a continuous current rating and load-break rating of [200][300][_____] amperes, and a make-and-latch rating of 12,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment.

][Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Each switch must be rated at [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL], with a continuous current rating and load-break rating of [200][300][_____] amperes, and a make-and-latch rating of 12,000 rms amperes symmetrical. Locate the switch handles in the high-voltage compartment. Operation of switches must be as follows:

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION					
		LINE A SW.		LINE B SW		XFMR. SW	
		OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE
1	Line A connected to Line B and both lines connected to transformer		X		X		X
2	Transformer connected to Line A only		X	X			X
3	Transformer connected to Line Bonly	X			X		X

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION					
		LINE A SW.		LINE B SW		XFMR. SW	
		OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE
4	Transformer open and loop closed		X		X	X	
5	Transformer open and loop open	X		X		X	

****
NOTE: Provide bayonet type fuses for all transformer applications 38 kV and below.
****

][f. Provide bayonet oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. The bayonet fuse links sense both high currents and high oil temperature in order to provide thermal protection to the transformer. Coordinate transformer protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults beyond the interrupting rating of the expulsion fuse. Include an oil retention valve inside the bayonet assembly housing, which closes when the fuse holder is removed, and an external drip shield to minimize oil spills. Display a warning label adjacent to the bayonet fuse(s) cautioning against removing or inserting fuses unless the transformer has been de-energized and the tank pressure has been released.

Bayonet fuse assembly: 150 kV BIL.

****
NOTE: For transformers with loop-feed sectionalizer switching, delete the bracketed option regarding placement of current-limiting fuses.
****

Oil-immersed current-limiting fuses: IEEE C37.47; 50,000 rms amperes symmetrical interrupting rating at the system voltage specified.[Connect current-limiting fuses ahead of the radial-feed load-break switch.]

****
NOTE: Provide bushing-mounted elbow type arresters at the ends of all radials and in normally open locations in loops. Provide arresters for all voltage levels above 5 kV.
****

][g. Surge arresters: IEEE C62.11, rated [3][6][9][10][12][15][18][21][24][27][30][36][_____] kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap.[Provide three arresters for radial feed circuits.][Provide [three][six] arresters for loop feed circuits.]

] h. Parking stands: Provide a parking stand near each bushing.[Provide

insulated standoff bushings for parking of energized high-voltage connectors on parking stands.]

[i. Protective caps: IEEE 386, [200][600] amperes, [15][25][35][_____] kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushings.

][2.2.1.2 High Voltage, Live-Front

****

NOTE: Obtain approval from the Authority Having Jurisdiction (AHJ) when live-front is selected and delete the above paragraphs on dead-front.

****

High-voltage compartment contains: the incoming line, transformer high-voltage bushings, load-break switch handle(s),[access to oil-immersed bayonet fuses,][surge arresters,] tap changer handle, insulated phase barriers, and ground pad.

a. Cable terminators: Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

b. Load-break switch

****

NOTE: Choose between load-break radial-feed switch and load-break loop feed switches.

****

[Radial-feed two-position oil-immersed type rated at [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL], with a continuous current rating and load-break rating of [200][300][_____] amperes, and a make-and-latch rating of 12,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment.

][Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Each switch must be rated at [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL], with a continuous current rating and load-break rating of [200][300][_____] amperes, and a make-and-latch rating of 12,000 rms amperes symmetrical. Locate the switch handles in the high-voltage compartment. Operation of switches must be as follows:

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION					
		LINE A SW.		LINE B SW		XFMR. SW	
		OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE
1	Line A connected to Line B and both lines connected to transformer		X		X		X

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION					
		LINE A SW.		LINE B SW		XFMR. SW	
		OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE
2	Transformer connected to Line A only		X	X			X
3	Transformer connected to Line B only	X			X		X
4	Transformer open and loop closed		X		X	X	
5	Transformer open and loop open	X		X		X	

****

NOTE: Provide bayonet type fuses for all transformer applications 38 kV and below.

****

][c. Provide bayonet oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. The bayonet fuse links sense both high currents and high oil temperature in order to provide thermal protection to the transformer. Coordinate transformer protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults beyond the interrupting rating of the expulsion fuse. Include an oil retention valve inside the bayonet assembly housing, which closes when the fuse holder is removed, and an external drip shield to minimize oil spills. Display a warning label adjacent to the bayonet fuse(s) cautioning against removing or inserting fuses unless the transformer has been de-energized and the tank pressure has been released.

Bayonet fuse assembly: 150 kV BIL.

****

NOTE: For transformers with loop-feed sectionalizer switching, delete the bracketed option regarding placement of current-limiting fuses.

****

Oil-immersed current-limiting fuses: IEEE C37.47; 50,000 rms amperes symmetrical interrupting rating at the system voltage specified.[Connect current-limiting fuses ahead of the radial-feed load-break switch.]

****

NOTE: Provide arresters at the ends of all radials and in normally open locations in loops. Provide arresters for all voltage levels above 5 kV.

****

][d. Surge arresters: IEEE C62.11, rated [3][6][9][10][12][15][18][21][24][27][30][36][_____] kV.[Provide three arresters for radial feed circuits.][Provide [three][six] arresters for loop feed circuits.]

] e. Insulated phase barriers: NEMA LI 1, Type GPO-3, 6.35 mm 0.25 inch minimum thickness. Provide vertical barriers between the high-voltage bushings and a single horizontal barrier above the high-voltage bushings.

]2.2.1.3 Low Voltage

****

NOTE: Installation of circuit breakers in the secondary compartment is not recognized by IEEE standards, and limits accessibility by covering lugs, gages, and accessories. Do not use.

****

Low-voltage compartment contains: low-voltage bushings with NEMA spade terminals, accessories, metering, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. Include the following accessories: drain valve with sampler device, fill plug, pressure relief device, liquid level gage, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator.

****

NOTE: Many Activities have, or are in the process of, converting to basewide metering systems. A unified metering specification is under development to replace the metering requirements in this section.

Use the first bracketed metering paragraph below for Navy projects and possibly for Air Force projects. Navy projects require use of section 26 27 14.00 20 ELECTRICITY METERING. Air Force projects may require use of section 26 27 13.10 30 ELECTRIC METERS.

Delete all other paragraphs for the Air Force and Navy projects.

Coordinate with the Activity and provide specific requirements "to match existing systems" when necessary. If specifying proprietary products, insure that appropriate "Justification and Authorization (J & A)" documentation has been obtained by project manager and "proprietary language requirements" have been added to Division 1 as well as to this section of the specifications.

If there are any components (such as meters, housing, or current transformers) that will be Government Furnished Contractor Installed (GFCI), or Government Furnished Government Installed (GFGI), edit Division 1 and this specification.

****

[b. Metering: Provide as specified in Section [26 27 14.00 20 ELECTRICITY METERING][26 27 13.10 30 ELECTRIC METERS].

][c. Metering: NEMA/ANSI C12.10. Provide a socket-mounted electronic programmable outdoor watthour meter, surface mounted flush against the side of the low-voltage compartment as indicated. Program the meter at the factory or in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Coordinate the meter to system requirements.

****

NOTE: When Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC is used, coordinate meter requirements. Form 9S, in text below, is for three-phase, four-wire wye systems, for other system configurations, designer must determine the appropriate form designation.

****

(1) 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].

(2) Coordination: Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

(3) Class: 20; Form: [9S][_____]; Accuracy: plus or minus 1.0 percent; Finish: Class II

(4) Cover: Polycarbonate and lockable to prevent tampering and unauthorized removal.

(5) Kilowatt-hour Register: five digit electronic programmable type

(6) Demand Register:

(a) Provide solid state

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

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

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

(8) Socket: ANSI C12.7. Provide NEMA Type 3R, box-mounted socket having automatic circuit-closing bypass and having jaws compatible with requirements of the meter. Cover unused hub openings with blank hub plates. Paint box [Munsell 7GY3.29/1.5 green][Munsell 5BG7.0/0.4 sky gray (ANSI 70)] [_____] to match the pad-mounted transformer to which the box-mounted socket is attached. The Munsell color notation is specified in ASTM D1535.

(9) Current transformers: IEEE C57.13. Provide butyl-molded window type current transformers with 600-volt insulation, 10 kV BIL and mount on the low-voltage bushings. Route current transformer leads in a location as remote as possible from the power transformer secondary cables to permit current measurements to be taken with hook-on-ammeters. Provide three current transformers per power transformer with characteristics listed in the following table.

****

NOTE: The following guidelines for specifying current transformers are based on the standard current transformer primary rating which is just below the full load current of the power transformer.

1. 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 transformer kVA size and secondary voltage. Example: for a 500 kVA transformer at 208 volts - select 1200/5, 1.5, 0.3 - B-0.5.

	VOLTS					
	208			240		
kVA	CT Ratio	RF	Meter Class	CT Ratio	RF	Meter Class
75	200/5	4.0	0.3 thru B-0.1	200/5	4.0	0.3 thru B-0.1
112.5	300/5	3.0	0.3 thru B-0.2	200/5	4.0	0.3 thru B-0.1
150	400/5	4.0	0.3 thru B-0.2	300/5	3.0	0.3 thru B-0.2
225	600/5	3.0	0.3 thru B-0.5	400/5	4.0	0.3 thru B-0.2
300	800/5	2.0	0.3 thru B-0.5	600/5	3.0	0.3 thru B-0.5
500	1200/5	1.5	0.3 thru B-0.5	1200/5	1.5	0.3 thru B-0.5
750	2000/5	1.5	0.3 thru B-1.8	1500/5	1.5	0.3 thru B-0.9

	VOLTS					
	480			600		
kVA	CT Ratio	RF	Meter Class	CT Ratio	RF	Meter Class
75	200/5,	4.0	0.3 thru B-0.1	200/5	4.0	0.3 thru B-0.1
112.5	200/5,	4.0	0.3 thru B-0.1	200/5	4.0	0.3 thru B-0.1
150	200/5,	4.0	0.3 thru B-0.1	200/5	4.0	0.3 thru B-0.1

	VOLTS					
	480			600		
kVA	CT Ratio	RF	Meter Class	CT Ratio	RF	Meter Class
225	200/5,	4.0	0.3 thru B-0.1	200/5	4.0	0.3 thru B-0.1
300	300/5,	3.0	0.3 thru B-0.2	200/5	4.0	0.3 thru B-0.1
500	600/5,	3.0	0.3 thru B-0.5	400/5	4.0	0.3 thru B-0.2
750	800/5,	2.0	0.3 thru B-0.5	600/5	3.0	0.3 thru B-0.5
1000	1200/5	1.5	0.3 thru B-0.5	800/5	2.0	0.3 thru B-0.5
1500	1500/5	1.5	0.3 thru B-0.9	1200/5	1.5	0.3 thru B-0.5
2000	2000/5	1.5	0.3 thru B-1.8	1500/5	1.5	0.3 thru B-0.9
2500	3000/5	1.33	0.3 thru B-1.8	2000/5	1.5	0.3 thru B-1.8

2. Incorporate the appropriate values in table below.

****

kVA	Sec. Volt	CT Ratio	RF	Meter Acc. Class
[500]	[208Y/120]	[1200/5]	[1.5]	[0.3 thru B-0.5]
[750]	[480Y/277]	[800/5]	[2.0]	[0.3 thru B-0.5]

]2.2.2 Transformer

****

NOTE: Use the following guidelines for specifying transformers and insulating liquids.

1. On Navy projects use of biodegradable less-flammable liquid is required.

For other projects, biodegradable less-flammable liquid and mineral oil are permitted. Previously the use of mineral oil-filled transformers was recommended wherever possible. Currently, biodegradable less-flammable transformer liquids that improve transformer operating characteristics are available with little, if any premium cost. This requirement is supported by UFC 3-600-01, "Fire Protection Engineering for Facilities", identifies building and equipment separation distances based on insulating liquid type. Mineral oil is more restrictive than less-flammable liquid. For example, a 1500 kVA transformer containing 600 gallons of less-flammable liquid requires a building

separation distance of 1.5 meters 5 feet when the construction is fire-resistant or non-combustible. An equally sized mineral oil-filled transformer requires 4.6 meters 15 feet and 7.6 meters 25 feet of separation for fire-resistant and non-combustible construction, respectively. Do not specify silicone-filled transformers.

2. Use IEEE C57.12.00, Table 8 - Designation of voltage ratings of three-phase windings, such as "4160 V - 480Y / 277 V". Connections must be Delta-GrdY configuration for three phase systems. Other system connections require waiver from UFC 3-550-01 criteria.

3. Include bracketed option to display transformer rating on enclosure when directed by Activity. For NASA projects only, include 3 inch yellow lettering bracketed options.

4. Delete (2) of item g regarding removable ground strap if transformer secondary winding is delta type.

****

a. Less-flammable [bio-based] liquid-insulated[or oil-insulated], two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Transformer rated [_____] kVA.

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

d. Tap changer: externally operated, manual type for changing tap setting when the transformer is de-energized. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Indicate which tap setting is in use, clearly visible when the compartment is opened.

e. Minimum tested percent impedance at 85 degrees C:

2.50 for units rated 75kVA and below
2.87 for units rated 112.5kVA to 300kVA
4.03 for 500kVA rated units
5.32 for units rated 750kVA and above

f. Comply with the following audible sound level limits:

kVA	DECIBELS (MAX
75	51
112.5	55

150	55
225	55
300	55
500	56
750	57
1000	58
1500	60
2000	61
2500	62

g. Include:

(1) Lifting lugs and provisions for jacking under base, with base construction suitable for using rollers or skidding in any direction.

[(2) An insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

] (3) Provide transformer top with an access handhole.

[(4) kVA rating conspicuously displayed [using 75 mm 3 inch high yellow letters]on its enclosure.

]2.2.2.1 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

2.2.3 Insulating Liquid

a. 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.

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

(2) Aquatic biodegradation: EPA 712-C-98-075, ultimately biodegradable as designated by EPA.

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

[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.

]2.2.3.1 Liquid-Filled Transformer Nameplates

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

2.2.4 Corrosion Protection

****

NOTE: Use stainless steel bases and cabinets for most applications. In highly corrosive environments, the additional cost of totally stainless steel tanks and metering enclosures may be justified. Manufacturer's standard construction material is acceptable only in noncoastal and noncorrosive environments. Choose the second bracketed option for project locations with Environmental Severity Classifications (ESC) of C4 and C5. See UFC 1-200-01 for determination of ESC for project locations.

****

[Provide corrosion resistant bases and cabinets of transformers, fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Base includes any part of pad-mounted transformer that is within 75 mm 3 inches of concrete pad.

][Provide entire transformer assembly, including tank and radiator, base, enclosure, and metering enclosure fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Form enclosure of stainless steel sheets. The optional use of aluminum is permitted for the metering enclosure.

] Paint entire transformer assembly [Munsell 7GY3.29/1.5 green][Munsell 5BG7.0/0.4 sky gray (ANSI 70)][_____], with paint coating system complying with IEEE C57.12.28 [and IEEE C57.12.29]regardless of base, cabinet, and tank material. The Munsell color notation is specified in ASTM D1535.

2.3 WARNING SIGNS AND LABELS

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts in accordance with NEMA Z535.4 and NEMA 260.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28, such as for pad-mounted transformers, provide self-adhesive warning labels on the outside of the high voltage compartment door(s)with nominal dimensions of 178 by 255 mm 7 by 10 inches with the legend "WARNING HIGH VOLTAGE" printed in two lines of nominal 50 mm 2 inch high letters. Include the work "WARNING" in white letters on an orange background and the words "HIGH VOLTAGE" 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 "WARNING HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 75 mm 3 inch high white letters on an orange and black field.

]2.4 ARC FLASH WARNING LABEL

****
NOTE: Include the Arc Flash Warning Label detail on the drawings. See the technical notes at the beginning of section to obtain the AutoCAD drawing file of the label.
****

Provide arc flash warning label for the enclosure of pad-mounted transformers. Locate this self-adhesive warning label on the outside of the high voltage compartment door warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.5 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

[2.6 PADLOCKS

****
NOTE: Designer must assure that Section 08 71 00 DOOR HARDWARE is included and is edited to include padlocks.

Do not use this paragraph for Navy and Air Force projects.
****

Provide padlocks for pad-mounted equipment[and for each fence gate], keyed [alike][as directed by the Contracting Officer]. Comply with Section 08 71 00 DOOR HARDWARE.

]2.7 CAST-IN-PLACE CONCRETE

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

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

****
NOTE: If concrete requirements are detailed and no cast-in-place 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.
****

[Provide concrete associated with electrical work as follows:

a. Composed of fine aggregate, coarse aggregate, portland cement, and water so proportioned and mixed as to produce a plastic, workable mixture.

b. Fine aggregate: hard, dense, durable, clean, and uncoated sand.

c. Coarse aggregate: reasonably well graded from 4.75 mm to 25 mm 3/16 inch to 1 inch.

d. Fine and coarse aggregates: free from injurious amounts of dirt, vegetable matter, soft fragments or other deleterious substances.

e. Water: fresh, clean, and free from salts, alkali, organic matter, and other impurities.

f. Concrete associated with electrical work for other than encasement of underground ducts: 30 MPa 4000 psi minimum 28-day compressive strength unless specified otherwise.

g. Slump: Less than 100 mm 4 inches. Retempering of concrete will not be permitted.

h. Exposed, unformed concrete surfaces: smooth, wood float finish.

i. 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.

j. Air entrain concrete exposed to weather using an air-entraining admixture conforming to ASTM C260/C260M.

k. Air content: between 4 and 6 percent.

]2.8 SOURCE QUALITY CONTROL

2.8.1 Transformer Test Schedule

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

a. Test Instrument Calibration

(1) Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) Accuracy: Traceable to the National Institute of Standards and Technology.

(3) Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.

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

(5) Calibrating standard: 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.

2.8.2 Design Tests

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

a. Tests: certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (KNAN), 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 pad-mounted 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 includes the primary windings only 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" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.34.

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

f. Short circuit: "Basically the same design" for the short circuit test means a pad-mounted transformer with the same kVA as the transformer

specified.

2.8.3 Routine and Other Tests

IEEE C57.12.00. Routine and other tests: performed in accordance with IEEE C57.12.90 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 as follows:

a. Phase relation

b. Ratio

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

d. Load losses (LL) and impedance voltage

e. Dielectric

(1) Impulse

(2) Applied voltage

(3) Induced voltage

f. Leak

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding [25][_____] 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 ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Pad-Mounted Transformer Grounding

****

NOTE: Ensure plans show the secondary neutral grounding conductor sized in accordance with NFPA 70 and the primary neutral grounding conductor when required. Ensure the CADD detail used matches how this paragraph is edited. Transformer is to have a ground ring and the normal number of ground rods is either four or two. The one ground rod option

should only be chosen if required by local installation requirements.
****

Provide a ground ring around the transformer with [1/0][4/0] AWG bare copper.[Provide four ground rods in the ground ring, one per corner.][Provide two ground rods in the ground ring at opposite corners.][Provide one ground rod in the ground ring with the ground rod located in the transformer cabinet.] Install the ground rods at least 3000 mm 10 feet apart from each other. Provide separate copper grounding conductors and connect them to the ground loop as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

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 pad-mounted transformers furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

[3.3.1 Meters and Current Transformers

****
Note: Delete this paragraph for Navy and Air Force projects, this information is covered in their associated metering specifications.
****

ANSI C12.1.

]3.4 FIELD APPLIED PAINTING

Where field 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.

[3.5 WARNING SIGN MOUNTING

****
NOTE: Include the following option when pad-mounted transformer is guarded by a fence.
****

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.

]3.6 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 requirement is located. Include construction requirements for concrete slab only if slab is not detailed on drawings. Do not provide curbs or raised edges around liquid filled transformers unless specifically approved by Technical Proponent (link provided in the technical note at the beginning of this section).
****

Mount transformer on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 200 mm 8 inches thick, reinforced with a 152 by 152 mm MW19 by MW19 6 by 6 inches - W2.9 by W2.9 mesh placed uniformly 100 mm 4 inches from the top of the slab.

b. Place slab on a 150 mm 6 inch thick, well-compacted gravel base.

c. Install slab such that top of concrete slab is approximately 100 mm 4 inches above the finished grade with gradual slope for drainage.

d. Provide edges above grade with 15 mm 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 200 mm 8 inches beyond the equipment.

Stub up conduits, with bushings, 50 mm 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.6.1 Cast-In-Place Concrete

****
NOTE: Use the first bracketed option when project includes a concrete section in Division 03; otherwise, the second bracketed option may be used.
****

Provide cast-in-place concrete work in accordance with the requirements of[Section 03 30 00 CAST-IN-PLACE CONCRETE][ACI 318][ACI 318M].

[3.6.2 Sealing

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NOTE: Require sealing of cable wells (windows) in the concrete pad if rodent intrusion is a problem.
****

When the installation is complete, seal all entries into the equipment enclosure with an approved sealing method. Provide seals of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

]3.7 FIELD QUALITY CONTROL

3.7.1 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. Submit reports, including acceptance criteria and limits for each test in accordance with NETA ATS "Test Values".

3.7.1.1 Pad-Mounted Transformers

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) Inspect anchorage, alignment, and grounding.

(4) Verify the presence of PCB content labeling.

(5) Verify the bushings and transformer interiors are clean.

(6) 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.

(7) Verify correct liquid level in tanks and bushings.

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

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

(10) Verify de-energized tap changer position is left as specified.

[(11) Verify the presence of transformer surge arresters.

] b. Electrical tests

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

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

****

NOTE: Include the bracketed option for additional field electrical tests for NASA projects only.

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[(3) Perform insulation-resistance tests, winding-to-winding and each winding-to-ground. Calculate polarization index. Verify that the tap changer is set at the specified ratio.

(4) Perform turns-ratio tests at all tap positions.

(5) Perform insulation power-factor or dissipation-factor tests on all windings in accordance with test equipment manufacturer's published data.

(6) Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests.

(7) Measure the resistance of each high-voltage winding in each de-energized tap-changer position. Measure the resistance of each low-voltage winding in each de-energized tap-changer position, if applicable.

(8) Remove and test a sample of insulating liquid for the following: Dielectric breakdown voltage, Acid neutralization number, Specific gravity, Interfacial tension, Color, Visual Condition, Water in insulating liquids (Required on 25 kV or higher voltages and on all silicone-filled units.), and Power factor or dissipation factor.

(9) Perform dissolved-gas analysis (DGA) on a sample of insulating liquid.

][3.7.1.2 Current Transformers

****
Note: Delete bracketed optional paragraphs for Navy and Air Force projects. This information is covered in their associated metering specifications.
****

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 wiring.

(5) Verify the unit is clean.

(6) 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.

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

(8) Verify correct operation of transformer withdrawal mechanism and grounding operation.

(9) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical tests

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

(2) Perform insulation-resistance test.

(3) Perform a polarity test.

(4) Perform a ratio-verification test.

][3.7.1.3 Watthour Meter

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Note: Delete bracketed optional paragraphs for Navy and Air Force projects. This information is covered in their associated metering specifications.

****

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

(2) Verify that correct multiplier has been placed on face of meter, where applicable.

(3) Verify that current transformer secondary circuits are intact.

]3.7.1.4 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 resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument

equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

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

[3.7.1.5 Surge Arresters, Medium- and High-Voltage

a. Visual and mechanical inspection

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

(2) Inspect physical and mechanical condition.

(3) Inspect anchorage, alignment, grounding, and clearances.

(4) Verify the arresters are clean.

(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 the ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical tests

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

(2) Perform an insulation-resistance test on each arrester, phase terminal-to-ground.

(3) Test grounding connection.

]3.7.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer 5 working days in advance of the dates and times of checking and testing.

-- End of Section --