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USACE / NAVFAC / AFCESA / NASA **UFGS-26 12 19.10 (November 2009)**

Preparing Activity: NAVFAC **Superseding**
UFGS-26 12 19.10 (April 2006)
UFGS-16272 (January 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2009
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DIVISION 26 - ELECTRICAL

SECTION 26 12 19.10

THREE-PHASE PAD-MOUNTED TRANSFORMERS

11/09

-- End of Section Table of Contents --

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SECTION 26 12 19.10

THREE-PHASE PAD-MOUNTED TRANSFORMERS
11/09

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NOTE: This guide specification covers three-phase pad-mounted transformers of the dead-front and live-front types for exterior applications.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

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

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

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

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: 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 Atlantic, has significant experience and technical expertise in these areas. If Reach-back support is desired, the technical representative (electrical engineer) editing this document for a specific project must contact the NAVFAC Atlantic Capital Improvements Electrical Engineering (Code CIEE) Office for consultation during the design stage of the project. A listing of the technical proponents, including their organization designation and telephone number, is on the Internet.
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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 SUBSTATIONS
--Section 26 12 19.20 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS
--Section 26 13 00.00 20 SF6 INSULATED PAD-MOUNTED SWITCHGEAR
--Section 26 23 00 SWITCHBOARDS AND SWITCHGEAR
--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: This section utilizes the following AutoCAD files (details) which are available in metric (SI) and U.S. Customary (IP) system dimensions. Use the files to develop project specific drawings.

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

TO DOWNLOAD TRANSFORMER DETAILS

Go to http://www.wbdg.org/ccb/browse_cat.php?o=78&c=232. Select the appropriate CADD 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, do not modify details, but indicate these changes as notes below the detail.

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NOTE: The following information shall be shown 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 12, "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.

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PART 1 GENERAL

1.1 REFERENCES

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.

ACI INTERNATIONAL (ACI)

ACI 318M	(2008; Errata 2008; Errata 2009) Metric Building Code Requirements for Structural Concrete and Commentary

ASTM INTERNATIONAL (ASTM)

ASTM A 167	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM C 260	(2006) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM D 117	(2002) Standard Guide for Sampling, Test Methods, Specifications and Guide for Electrical Insulating Oils of Petroleum Origin
ASTM D 1535	(2008) Specifying Color by the Munsell System
ASTM D 3487	(2008) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D 877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D 92	(2005a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D 97	(2009) Pour Point of Petroleum Products

FM GLOBAL (FM)

FM P7825	(2005) Approval Guide

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2006; Errata 2007; INT 44-56 2007; INT 47, 49, 50, 52-56 2008; INT 57, 58, 51, 48 2009) National Electrical Safety Code
IEEE C37.47	(2000) High Voltage Current-Limiting Type Distribution Class Fuses and Fuse Disconnecting Switches
IEEE C37.90	(2005) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.109	(1993; R 2008) Guide for Liquid-Immersed Transformer Through-Fault-Current Duration
IEEE C57.12.00	(2006) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2005) Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.12.34	(2004; Errata 2005) Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 2500 kVA and Smaller—High-Voltage: 34 500 GrdY/19 920 Volts and Below; Low Voltage: 480 Volts and Below
IEEE C57.12.90	(2006; INT 2009) Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2008) Standard Requirements for Instrument Transformers
IEEE C57.98	(1993; R 1999) Guide for Transformer Impulse Tests
IEEE C62.11	(2005; Amendment A 2008) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms
IEEE Std 386	(2006) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.1	(2008) Electric Meters; Code for Electricity Metering
NEMA C12.10	(2004) Physical Aspects of Watthour Meters
NEMA C12.7	(2005) Requirements for Watthour Meter Sockets
NEMA LI 1	(1998) Industrial Laminated Thermosetting Products

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code - 2008 Edition

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	(1996) 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	(2007) Standard for 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 Std 100.

1.4 SUBMITTALS

****

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

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

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

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" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pad-mounted transformer drawings[; G][; G, [_____]]

SD-03 Product Data

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

Submittal shall include manufacturer's information for each

component, device, insulating fluid, and accessory provided with the transformer.

SD-06 Test Reports

Acceptance checks and tests[; G][; G, [_____]]

Submittal shall include acceptance criteria and limits for each test in accordance with NETA ATS "Test Values".

SD-07 Certificates

Transformer Efficiencies[; G][; G, [_____]]

Submit certification, including supporting calculations, from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Efficiencies."

[Transformer Losses[; G][; G, [_____]]

In addition, submit certification from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Losses."

] SD-09 Manufacturer's Field Reports

Pad-mounted transformer design tests[; G][; G, [_____]]

Pad-mounted transformerroutine and other tests[; G][; G, [_____]]

SD-10 Operation and Maintenance Data

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

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

SD-11 Closeout Submittals

Transformer test schedule[; G][; G, [_____]]

Submit report of test results as specified by paragraph entitled "Field Quality Control."

****
NOTE: Include the bracketed option when reach-back support has been coordinated with NAVFAC Atlantic 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 CIEE, NAVFAC Atlantic, Naval Facilities Engineering 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 Cooper Power Systems 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, the following items shall be submitted:

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

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

c. ANSI nameplate data of the transformer (paragraph entitled "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 (properly overlaid on one full size logarithmic paper) of the transformer high side fuses (paragraph entitled "Pad-Mounted Transformer Drawings", item e) with transformer damage curve, inrush curve, and thru fault current indicated.

] e. Routine and other tests (in PART 2, see paragraph entitled "Source Quality Control", subparagraph entitled "Routine and Other Tests"), shall be conducted by the manufacturer and may be witnessed by the government. Provide transformer test schedule required by submittal item "SD-11 Closeout Submittals". Provide certified copies of the tests.

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

Drawings shall indicate, but not be limited to the following:

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

b. ANSI 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.

e. Manufacturer's published time-current curves (on full size logarithmic paper) 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, 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.

1.5.3 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. 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.

1.5.3.1 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 shall not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

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

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

****
NOTE: Select the appropriate sections. For Navy projects with underground electrical work, use 33 71 02.00 20, UNDERGROUND ELECTRICAL DISTRIBUTION. For Army projects with underground electrical work, use 33 70 02.00 10, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.
****

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 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION,][Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM,][and][Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND].

2.2 THREE-PHASE PAD-MOUNTED TRANSFORMERS

****
NOTE: Use dead-front transformers unless available system fault current exceeds equipment ratings. If live-front transformers are required, their use shall be approved by the Authority Having Jurisdiction.
****

IEEE C57.12.34, IEEE C57.12.28 and as specified herein.

2.2.1 Compartments

The high- and low-voltage compartments shall be 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.

****
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.

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.

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.

****

2.2.1.1 High Voltage, Dead-Front

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

[a. Insulated high-voltage load-break connectors: IEEE Std 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 shall have a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

][b. Insulated high-voltage dead-break connectors: IEEE Std 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: 40,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector shall 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 Std 386, 200 amperes, [15][25][35][_____] kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise.[Provide feed-thru inserts as indicated.]

] d. Load-break switch

****

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

If specifying an internally protected, 35 kV delta-connected primary transformer, then the fault

interrupting switch must be used.
****

[Radial-feed 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 shall 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 10,000 rms amperes symmetrical. Locate the switch handles in the high-voltage compartment. Operation of switches shall be as follows:

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

][Fault Interrupting Switch: IEEE C37.90. Radial-feed oil-immersed vacuum bottle type rated at 35 kV, 150 kV BIL, with a continuous current rating and load-break rating of 600 amperes, and a short-circuit interrupting current rating of 12,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment. Each fault interrupting switched way shall utilize internally mounted current transformers and an electronic overcurrent control to provide three-pole ganged tripping for single-phase and three-phase faults. The electronic overcurrent control shall provide Category II transformer primary protection in accordance with IEEE C57.109.

****
NOTE: Do not provide expulsion or current-limiting fuses for delta-connected primary 35 kV applications.
****

][e. Provide bayonet type, oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. Bayonet fuse links shall 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. In order to eliminate or minimize oil spills, the bayonet fuse assembly shall include an oil retention valve inside the housing which closes when the fuse holder is removed and an external drip shield. Warning shall be conspicuously displayed within the high-voltage compartment cautioning against removing or inserting fuses unless the load-break switch is in the open position 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.
****

][f. 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, suitable for plugging into inserts.[Provide three arresters for radial feed circuits.][Provide [three][six] arresters for loop feed circuits.]

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

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

][2.2.1.2 High Voltage, Live-Front

****
NOTE: When live-front is selected, delete the above

paragraphs on dead-front.

****

High-voltage compartment shall contain the incoming line, transformer high-voltage bushings, [load-break switch handle(s),][fault interrupting switch,] access to [oil-immersed fuses][dry-well fuse canisters],[surge arresters,] tap changer handle, insulated phase barriers, and ground pad.

****

NOTE: For Navy projects use 33 71 02.00 20, UNDERGROUND ELECTRICAL DISTRIBUTION. For Army projects use 33 70 02.00 10, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

****

a. Cable terminators: Provide as specified in Section[33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION][33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND].

b. Load-break switch

****

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

If specifying an internally protected, 35 kV delta-connected primary transformer, then select the fault interrupting switch.

****

[Radial-feed 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 shall 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 10,000 rms amperes symmetrical. Locate the switch handles in the high-voltage compartment. Operation of switches shall be as follows:

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

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION LINE A SW. OPEN	LINE A SW. CLOSE	LINE B SW OPEN	LINE B SW CLOSE	XFMR. SW OPEN	XFMR. SW CLOSE
	connected to Line A only						
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	

][Fault Interrupting Switch: IEEE C37.90. Radial-feed oil-immersed vacuum bottle type rated at 35 kV, 150 kV BIL, with a continuous current rating and load-break rating of 600 amperes, and a short-circuit interrupting current rating of 12,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment. Each fault interrupting switched way shall utilize internally mounted current transformers and an electronic overcurrent control to provide three-pole ganged tripping for single-phase and three-phase faults. The electronic overcurrent control shall provide Category II transformer primary protection in accordance with IEEE C57.109.

****

NOTE: Do not provide expulsion or current-limiting fuses for delta-connected primary 35 kV applications.

****

][c. Provide bayonet type, oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. Bayonet fuse links shall 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. In order to eliminate or minimize oil spills, the bayonet fuse assembly shall include an oil retention valve inside the housing which closes when the fuse holder is removed and an external drip shield. Warning shall be conspicuously displayed within the high-voltage compartment cautioning against removing or inserting fuses unless the load-break switch is in the open position 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 mm0.25 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 ANSI standards, and limits accessibility by covering lugs, gages, and accessories. Do not use.
****

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

****
NOTE: Include the bracketed option for NASA projects only.
****

a. Accessories shall include drain valve with sampler device, fill plug, pressure relief device, liquid level gage, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator. [Provide a removable 600V Volt rated secondary NEMA spade terminal insulating system to completely insulate and cover these exposed live parts within the secondary compartment.]

****
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. Some Airforce projects may require use of section 26 27 13.10 30 ELECTRIC METERS and some Navy projects may require use of section 26 27 14.10 20 ELECTRICITY METERING (Draft).

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 section appropriately.

****

b. Metering: NEMA C12.10. Provide a socket-mounted electronic programmable outdoor watthour meter, surface mounted flush against the side of the low-voltage compartment as indicated. Meter shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter shall be coordinated to system requirements.

****

NOTE: When Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS is used, coordinate meter requirements. Form 9S, in text below, is for three-phase, four-wire wye systems, for other system configurations, designer shall 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 23 DIRECT DIGITAL CONTROL HVAC AND OTHER LOCAL BUILDING SYSTEMS].

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

3. Class: 20; Form: [9S][___]; Accuracy: +/- 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: shall be programmed for [15][30][60] minutes with rolling demand up to six subintervals per interval.

****
NOTE: Select the second bracketed option for NASA projects only.
****

7. Meter fusing: Provide a [fuse block][fully enclosed pullout, deadfront type 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: NEMA 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 to match the pad-mounted transformer to which the box-mounted socket is attached. The Munsell color notation is specified in ASTM D 1535.

****
NOTE: Select the second bracketed option for NASA projects only.
****

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][Provide shorting type terminal blocks and route current transformer leads from the shorting type terminal blocks] 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

	(VOLTS)				
	208			240	
kVA	CT Ratio	RF	Meter Class	CT Ratio	RF	Meter Class
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
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 5 feet (1.5 meters) when the construction is fire-resistant or non-combustible. An equally sized mineral oil-filled transformer requires 15 feet (4.6 meters) and 25 feet (7.6 meters) of separation for fire-resistant and non-combustible construction, respectively. Silicone-filled transformers shall not be used.

2. Use IEEE C57.12.00, Table 12 - Designation of voltage ratings of three-phase windings, such as "4160 V - 480Y / 277 V". Connections shall be Delta-GrdY configuration for three phase systems. Other system connections require waiver from UFC 3-550-01 criteria.

3. Select impedance value in accordance with Table PMT-1 when specifying losses in paragraph entitled "Specified Transformer Losses." When "Specified Transformer Efficiencies" paragraph is used, utilize impedance value indicated in product standards for that particular type of transformer.

4. Delete inapplicable sound levels.

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

6. Delete last sentence of item g regarding removable ground strap if transformer secondary winding is delta type.

****

a. Less-flammable 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 shall be rated [_____] kVA, [95][60][_____] kV BIL.

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 shall be 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. Tap changers shall clearly indicate which tap setting is in use.

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

f. Audible sound levels shall comply with the following:

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. Transformer shall include lifting lugs and provisions for jacking under base. The transformer base construction shall be suitable for using rollers or skidding in any direction. Provide transformer top with an access handhole.[Transformer shall have its kVA rating conspicuously displayed [using 75-mm 3-inch high yellow letters] on its enclosure.] The transformer shall have an insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

****

NOTE: Use the following guidelines for specifying transformer losses and efficiencies.

1. On Navy projects and on projects where using the specific no-load and load loss values, include the optional paragraph and use Table PMT-1 (located at the end of this specification section). This table contains the losses and impedances for transformers based on primary and secondary voltages.

2. The losses indicated in Table PMT-1 are a compilation of loss data from leading transformer manufacturers. The transformer designs are all optimized around the median range for energy costs - $0.04 to $0.08 per kilowatt-hour, and the calculations consider total owning costs.

3. "10 CFR 431, Subpart K" is a result of the Energy Policy and Conservation Act (EPACT) of 2005. Subpart K is the new "minimum" industry standard for distribution transformers manufactured on or after January 1, 2010.

4. Using the losses represented in Table PMT-1, in conjunction with the requirements for efficiencies in "10 CFR 431, Subpart K", will continue to ensure the higher level of efficiency for transformers that has been set by the Navy over the last decade.

****

2.2.2.1 Specified Transformer Efficiencies

Provide transformer efficiency calculations utilizing the no-load and load losses. No-load losses (NLL) shall be referenced at 20 degrees C. Load losses (LL) shall be referenced at 85 degrees C and at 50 percent of the nameplate load. If the tested transformer efficiency is less than the

efficiency indicated in 10 CFR 431, Subpart K, paragraph 431.196(b), the transformer is not acceptable.

[2.2.2.2 Specified Transformer Losses

In addition to complying with the efficiencies required by 10 CFR 431, Subpart K, 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.

]2.2.3 Insulating Liquid

a. Less-flammable transformer liquids: NFPA 70 and FM P7825 for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D 92 and a dielectric strength not less than 33 kV tested per ASTM D 877. 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 D 97, less than -15 degree C

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

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

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

]2.2.3.1 Liquid-Filled Transformer Nameplates

Distribution transformers shall be provided with 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 hostile environments, the additional cost of totally stainless steel tanks and stainless steel or aluminum metering enclosures, may be justified. Manufacturer's standard construction material is acceptable only in noncoastal and noncorrosive environments. Choose the second bracketed option for hostile environments.

****

[Bases and cabinets of transformers shall be corrosion resistant and shall be fabricated of stainless steel conforming to ASTM A 167, Type 304 or 304L. Base shall include any part of pad-mounted transformer that is within

75 mm 3 inches of concrete pad.

][Entire transformer assembly, including tank and radiator, base, enclosure, and metering enclosure shall be fabricated of stainless steel conforming to ASTM A 167, 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. Paint coating system shall comply 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 D 1535.

2.3 WARNING SIGNS

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28, such as for pad-mounted transformers, 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. Decal shall be Panduit No. PPSO710D72 or approved equal.

[[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.]

]2.4 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 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. The label format shall be as indicated.

2.5 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section[33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION][33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND].

[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 projects.
****

Padlocks shall be provided for pad-mounted 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.

]2.7 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 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE or Section 03 30 00 CAST-IN-PLACE CONCRETE. Use Section 03 30 00 for Navy projects and Section 03 31 00.00 10 for other projects.
****

[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][03 31 00.00 10 CAST-IN-PLACE STRUCTURAL 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 or Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL 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 1 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 C 260. Air content shall be 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. 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.

2.8.2 Design Tests

IEEE C57.12.00 states that "design tests are made only on representative apparatus to substantiate the ratings assigned to all other apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for[each of] the specified transformer(s). Design tests shall have been performed in accordance with IEEE C57.12.90prior 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 pad-mounted 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 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 shall include 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 shall be 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 shall be 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

Electrical installations shall 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 that 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 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION][33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND]. 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.

****

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" shall apply.

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 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION][33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND].

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

NEMA 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.

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

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.

]3.6 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. Unless otherwise indicated, the slab shall be at least 200 mm 8 inches thick, reinforced with a 152 mm by 152 mm - 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 finished grade with gradual slope for drainage. Edges above grade shall have 15 mm 1/2 inch chamfer. Slab shall be of adequate size to project at least 200 mm 8 inches beyond 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.
****

Cast-in-place concrete work shall conform to the requirements of[Section[03 30 00 CAST-IN-PLACE CONCRETE][03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE]][ACI 318M].

[3.6.2 Sealing

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

****

When the installation is complete, the Contractor shall seal all entries into the equipment enclosure with an approved sealing method. Seals shall be 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.

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.

****

[3. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground. Calculate polarization index.

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

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 of each current transformer and its secondary wiring.

3. Perform a polarity test of each current transformer.

4. Perform a ratio-verification test.

3.7.1.3 Watthour Meter

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 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 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, the Contractor shall 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, the Contracting Officer shall be given 5 working days advance notice of the dates and times of checking and testing.

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NOTE: Steps to specifying transformer losses.

1. Use Table PMT-1 to specify losses and impedances for transformers based on transformer primary and secondary voltages.

2. For any loss data application not covered in Table PMT-1 or for any technical guidance concerning losses acceptable to the Government, contact NAVFAC Atlantic Code CIEE at (757) 322-4277.

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

TABLE PMT-1

	(PRIMARY VOLTS = 4160V)					
	(SECONDARY VOLTS)					
	480Y/277V			208Y/120V		
kVA	NLL	LL	Min %Z	NLL	LL	Min %Z
75	158	719	2.15	152	756	2.70
112.5	223	880	2.69	223	945	2.81
150	255	1082	3.44	285	1171	2.70
225	373	1469	2.65	372	1595	3.16
300	454	1698	3.81	457	2029	3.83
500	719	2579	3.73	723	3073	4.37
750	841	4358	5.32	922	5328	5.32
1000	1003	5930	5.32			
1500	1367	9363	5.32			

	(PRIMARY VOLTS = 12470V)					
	(SECONDARY VOLTS)					
	480Y/277V			208Y/120V		
kVA	NLL	LL	Min %Z	NLL	LL	Min %Z
75	158	745	2.70	167	742	2.45
112.5	210	894	2.69	224	917	3.22
150	291	1075	2.96	291	1103	3.11
225	373	1494	2.67	412	1728	2.52
300	438	1718	3.88	475	1872	3.86
500	721	2500	3.91	741	3017	4.24
750	856	4445	5.32	922	5272	5.32
1000	1047	5590	5.32	1309	7713	5.32
1500	1363	8539	5.32			
2000	Obtain values					
2500	from manufacturer					

TABLE PMT-1 (CONTINUED)

	(PRIMARY VOLTS = 24940V)					
	(SECONDARY VOLTS)					
	480Y/277V			208Y/120V		
kVA	NLL	LL	Min %Z	NLL	LL	Min %Z
75	175	706	2.69	173	686	2.64
112.5	235	847	2.90	220	888	3.24
150	289	1042	2.94	299	1101	2.79
225	400	1419	3.39	389	1451	3.31
300	462	1789	3.94	557	1869	3.88
500	728	2535	3.84	745	3093	4.83
750	878	4310	5.32	1081	4844	5.32
1000	1128	5423	5.32			
1500	1601	7631	5.32			
2000	Obtain values					
2500	from manufacturer					

	(PRIMARY VOLTS = 34500V)					
	(SECONDARY VOLTS)					
	480Y/277V			208Y/120V		
kVA	NLL	LL	Min %Z	NLL	LL	Min %Z
75	197	657	3.04	178	726	2.68
112.5	215	852	2.91	259	808	2.98
150	280	1053	3.89	304	1183	3.17
225	415	1516	3.30	378	1670	3.50
300	502	1658	3.55	533	2208	3.68
500	395	2745	4.08	719	3110	4.07
750	998	4187	5.32	928	5100	5.32
1000	1105	5382	5.32	1398	7196	5.32
1500	1601	8027	5.32			
2000	2456	10722	5.32			
2500	2861	12773	5.32			

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