**********

**USACE / NAVFAC / AFCEC / NASA** | **UFGS-26 12 19.00 40 (November 2014) Change 1 - 08/17**

**Preparing Activity: NASA** | **Superseding UFGS-26 12 19.00 40 (February 2011)**

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2020**

**********

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 12 19.00 40

PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

**11/14**

-- End of Section Table of Contents --

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| | |
|---|---|
| **USACE / NAVFAC / AFCEC / NASA** | **UFGS-26 12 19.00 40 (November 2014) Change 1 - 08/17** |
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**********

SECTION 26 12 19.00 40

PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS
**11/14**

**********

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

**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 750 kVA on 5 kV systems and for kVA ratings up to and including 1500 kVA on 15 and 25 kV systems.**

**For voltages above 25 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 2000 amperes is discouraged due to the size and quantity of secondary conductors. Therefore, transformers above 750 kVA serving 208Y/120 volt loads and transformers above 1500 kVA serving 480Y/277 volt loads should be in a secondary unit substation configuration.**

**Contact the cognizant EFD or PWC for direction.**

**For SOUTHNAVFACENGCOM projects, determine the use of secondary unit substations on a case by case basis.**

**Use the following related guide specifications for power distribution equipment:**

**Section 26 08 00 APPARATUS INSPECTION AND TESTING**

**Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS**

**Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION**

**Section 26 11 14.00 10 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION**

**Section 26 11 13.00 20 PRIMARY UNIT SUBSTATION**

**Section 26 11 16 SECONDARY UNIT SUBSTATIONS**

**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**

**Section 26 23 00 SWITCHBOARDS AND SWITCHGEAR**

**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: TO DOWNLOAD UFGS GRAPHICS**

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

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

**For SOUTHNAVFACENGCOM facilities use Table PM-2.**

| TABLE NUMBER | TITLE |
|---|---|
| PM-1 | Transformer Loss & Impedance Data - for Energy Cost (EC) Less Than or Equal to $0.04 (2 pages) |
| PM-2 | Transformer Loss & Impedance Data - for Energy Cost (EC) Greater Than $0.04 and Less Than or Equal to $0.08 (2 pages) |

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

**********

**********

**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 11(b), "Designation of voltage ratings of three-phase windings".) 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

**********

**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.

1.1 REFERENCES

**********

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

**Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of**

**the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.**

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

**********

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

AMERICAN CONCRETE INSTITUTE (ACI)

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

| | |
|---|---|
| ANSI C12.1 | ((2014; Errata 2016) Electric Meters - Code for Electricity Metering |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A240/A240M | (2019) 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 | (2017; Errata 1-2 2017; INT 1 2017) 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 | (2015) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers |
| IEEE C57.12.25 | (1990) Standard for Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers With Separable Insulated High-Voltage Connectors; High Voltage, 34,500 Grdy/ 19,920 Volts and Below; Low Voltage, 240/120 Volts; 167 kVa and Smaller Requirements |
| IEEE C57.12.28 | (2014) Standard for Pad-Mounted Equipment - Enclosure Integrity |
| IEEE C57.12.34 | (2015) 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 | (2015; Corr 2017) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers |
| IEEE C57.13 | (2016) Requirements for Instrument Transformers |
| IEEE C57.98 | (2011) Guide for Transformer Impulse Tests |
| IEEE C62.11 | (2012) 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 | (2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

| | |
|---|---|
| RCBEA GUIDE | (2004) NASA Reliability Centered Building and Equipment Acceptance Guide |

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

| | |
|---|---|
| ANSI C12.7 | (2014) Requirements for Watthour Meter Sockets |
| NEMA LI 1 | (1998; R 2011) Industrial Laminating Thermosetting Products |
| NEMA/ANSI C12.10 | (2011) Physical Aspects of Watthour Meters - Safety Standards |

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

| | |
|---|---|
| NFPA 70 | (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code |

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

| | |
|---|---|
| OECD Test 203 | (1992) Fish Acute Toxicity Test |

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

| | |
|---|---|
| EPA 600/4-90/027F | (1993) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms |
| EPA 712-C-98-075 | (1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation" |

UNDERWRITERS LABORATORIES (UL)

| | |
|---|---|
| UL 467 | (2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment |

## 1.2 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.

## 1.3 SUBMITTALS

**********

**NOTE: Review Submittal Description (SD) definitions**

**in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.**

**The Guide Specification technical editors have designated 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 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.**

**An "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING. Locate the "S" submittal under the SD number that best describes the submittal item.**

**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 information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

**********

**NOTE: Include the bracketed option on "CIEE and 074 review" for NAVFAC Atlantic and SOUTHNAVFACENGCOM projects respectively. For other projects, submittal review is performed by the designer of record. If submittal review by NAVFAC Atlantic or SOUTHNAVFACENGCOM is specifically desired, coordinate the responsible Government agency with the respective Code CIEE or 074 during the design process. Add appropriate information in Section 01 33 00 SUBMITTAL PROCEDURES to coordinate with the**

**special requirements.**
**********

[[Code CIEE, NAVFAC Atlantic][Code 074, Southern Division, Naval Facilities Engineering Command] will review and approve all submittals in this section requiring Government approval.] As an exception to this paragraph, transformers 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, submit the following items:

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

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 any 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 (on full size logarithmic paper) of the transformer high side fuses (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item e).]

**********

**NOTE: Use "will" on all SOUTHNAVFACENGCOM projects. Coordinate with paragraph TESTS, INSPECTIONS AND VERIFICATIONS.**

**********

e. Conduct by the manufacturer, routine and other tests (in PART 2, see paragraph ROUTINE AND OTHER TESTS and [may][will] be witnessed by the government (in Part 2, see paragraph TESTS, INSPECTIONS AND VERIFICATIONS). 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".

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 Losses[; G[, [_____]]]

SD-09 Manufacturer's Field Reports

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[, [_____]]]

SD-11 Closeout Submittals

Transformer Test Schedule[; G[, [_____]]]

Warranty[; G[, [_____]]]

## 1.4 QUALITY CONTROL

### 1.4.1 Pad-Mounted Transformer Drawings

Submit pad-mounted transformer drawings. Indicate on drawings, but not limit to the following:

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

b. ANSI nameplate data.

**********
**NOTE: Navy policy requires that all facilities be metered. If exception is taken, coordinate with paragraphs ADDITIONS TO OPERATION AND MAINTENANCE DATA and THREE PHASE METERING.**
**********

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.

### 1.4.2 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. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

### 1.4.3 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. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Provide products that 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, use items 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.

#### 1.4.3.1 Alternative Qualifications

Products having less than a 2-year field service record are 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.

#### 1.4.3.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than 3 years prior to date of delivery to site, unless specified otherwise.

### 1.4.4 Predictive Testing And Inspection Technology Requirements

**********

**NOTE: The Predictive Testing and Inspection (PT&I) tests prescribed in section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS are MANDATORY for all [NASA] [_____] assets and systems identified as Critical, Configured, or Mission Essential. If the system is non-critical, non-configured, and not mission essential, use sound engineering discretion to assess the value of adding these additional test and acceptance requirements. See Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS for additional information regarding cost feasibility of PT&I.**

**********

This section contains systems and/or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems are installed properly and contain no identifiable defects that shorten the design life of a system and/or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

## 1.5 MAINTENANCE MATERIAL SUBMITTALS

### 1.5.1 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

## 1.6 WARRANTY

Provide [_____] copies of the warranty to the Contracting Officer. Ensure the equipment items are 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 MANUFACTURED UNITS

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 UNDERGROUND ELECTRICAL DISTRIBUTION,][ and][ Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM].

### 2.1.1 Three-Phase Pad-Mounted Transformers

**********

**NOTE: Use dead-front transformers unless available system fault current exceeds equipment ratings. If live-front transformers are required, approve their use by the cognizant EFD.**

**********

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

#### 2.1.1.1 Compartment Construction

[ Single compartment are Type 1 as defined by IEEE C57.12.25 with combination high- and low-voltage compartment. Compartment is of the clam shell type with lockable (having pad-locking provisions) hinged cover and

single-point latching.

][Separate the high- and low-voltage compartments with steel isolating barriers extending the full height and depth of the compartments. Compartment doors are 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. Use dry-well canister fuses only when specifically required by the activity.**

**Do not provide standoff bushings unless this transformer is the only dead-front transformer on the base. Public works 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.**

**********

2.1.1.2 High Voltage, Dead-Front

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

**********

**NOTE: The following paragraph is based on 200-ampere connectors. If transformer primary load current is greater than 200 amperes or if primary cable size is greater than No. 4/0 AWG, determine the appropriate connector system.**

**Portions of the 4.16 kV system at Dam Neck, VA and all of the 11.5 kV system at Norfolk Naval Shipyard, VA have a fault capability in excess of 10,000 amps. Locating the current-limiting fuses ahead of the load-break switch as specified in this paragraph will limit the available fault current to less than 10,000 amps. Therefore, 600 amp separable insulated connectors with a short time rating of 25,000 rms symmetrical amperes and load-break switches can be used on pad-mounted transformers in these locations.**

**********

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

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

c. Load-break switch

**********
**NOTE: Choose one of the following options.**
**********

[ (1) Radial-feed oil-immersed type rated at [15][_____] kV, [95][_____] kV BIL, with a continuous current rating and load-break rating of [200][_____] amperes, and a make-and-latch rating of 10,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment.

][ (2) Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Ensure each switch is rated at [15][_____] kV, [95][_____] kV BIL, with a continuous current rating and load-break rating of [200][_____] 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 is as follows:

| Arrangemen No. | Description of Switch Arrangement | SWITCH POSITION | | | | | |
|---|---|---|---|---|---|---|---|
| | | Line A Switch | | Line B Switch | | Transformer Switch | |
| | | 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 B only | X | | | X | | X |
| 4 | Transformer open and loop closed | | X | | X | X | |
| 5 | Transformer open and loop open | X | | X | | X | |

] d. Provide bayonet type, oil-immersed, expulsion fuses in series with

oil-immersed, partial-range, current-limiting fuses. Ensure 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. In order to eliminate or minimize oil spills, include with the bayonet fuse assembly an oil retention valve inside the housing which closes when the fuse holder is removed and an external drip shield. Conspicuously display warning 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.

(1) Bayonet fuse assembly: 150 kV BIL.

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

(2) 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: When dry-well canisters are selected, delete the above paragraphs on oil-immersed fuses.**
**********

[e. Current-limiting fuses, dry-well mount: IEEE C37.47. Provide fuses in air-insulated, oil-sealed, dead-front, non-load-break dry-well fuse canisters, on the load side of the load-break switch serving the transformer. Interlock fuse canisters with the load-break switch so that the fuses may be removed and inserted only when the switch is in the "Off" position. Ensure fuses remove the transformer from service in case of an internal fault. Size fuses to approximately 150 percent of the transformer primary full load current rating and in accordance with fuse manufacturer's recommendations for dry-well mounting. Ensure fuses have an interrupting rating of 50,000 rms amperes symmetrical at the system voltage specified. Furnish a spare fuse for each fuse provided.

][. Provide surge arresters conforming to IEEE C62.11, rated at [3][6][9][10][12][15][_____] 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. 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 386, 200 amperes, [15][25][_____] kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushing well inserts[ and insulated standoff bushings].

][2.1.1.3 High Voltage, Live-Front

**********
**NOTE: When live-front is selected, delete the above paragraphs on dead-front.**
**********

Provide a high-voltage compartment containing the incoming line, transformer high-voltage bushings, load-break switch handle(s), access to [oil-immersed fuses][dry-well fuse canisters],[ 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 one of the following options.**
**********

[ (1) Radial-feed oil-immersed type rated at [15][_____] kV, [95][_____] kV BIL, with a continuous current rating and load-break rating of [200][_____] amperes, and a make-and-latch rating of 10,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment.

][ (2) Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Rate each switch at [15][_____] kV, [95][_____] kV BIL, with a continuous current rating and load-break rating of [200][_____] 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 is as follows:

| Arrangement No. | Description of Switch Arrangement | SWITCH POSITION | | | | | |
|---|---|---|---|---|---|---|---|
| | | Line A Switch | | Line B Switch | | Transformer Switch | |
| | | 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 |

| Arrangemen No. | Description of Switch Arrangement | SWITCH POSITION | | | | | |
|---|---|---|---|---|---|---|---|
| | | Line A Switch | | Line B Switch | Transformer Switch | | |
| 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 | |

] c. Provide bayonet type, oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. Ensure 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. In order to eliminate or minimize oil spills, include with the bayonet fuse assembly an oil retention valve inside the housing which closes when the fuse holder is removed and an external drip shield. Conspicuously display warning 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.

(1) Bayonet fuse assembly: 150 kV BIL.

**********

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

**********

(2) 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: When dry-well canisters are selected, delete the above paragraphs on oil-immersed fuses.**

**********

[ d. Current-limiting fuses, dry-well mount: IEEE C37.47. Provide fuses in air-insulated, oil-sealed, dead-front, non-load-break dry-well fuse canisters, on the load side of the load-break switch serving the transformer. Interlock fuse canisters with the load-break switch so that the fuses may be removed and inserted only when the switch is in the "Off" position. Ensure fuses remove the transformer from service in case of an internal fault. Size fuses to approximately 150 percent of the transformer primary full load current rating and in accordance with fuse manufacturer's recommendations for dry-well mounting.

Ensure fuses have an interrupting rating of 50,000 rms amperes symmetrical at the system voltage specified. Furnish a spare fuse for each fuse provided.

][e. Surge arresters: IEEE C62.11, rated [3][6][9][10][12][15][_____] kV.[ Provide three arresters for radial feed circuits.][ Provide [three][six] arresters for loop feed circuits.]

] f. 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.

]2.1.1.4 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.**
**********

Provide low-voltage compartment containing low-voltage bushings with NEMA spade terminals, accessories,[ metering,] stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. Accessories 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.

2.1.1.5 Three-Phase Metering

**********
**NOTE: When Section 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, the designer determines the appropriate form designation.**
**********

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

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

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

d. Cover: Polycarbonate and lockable to prevent tampering and unauthorized removal.

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

f. Demand Register:

(1) Provide solid state

(2) Meter reading multiplier:

(a) Indicate multiplier on the meter face.

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

g. 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.

h. 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 to match the pad-mounted transformer to which the box-mounted socket is attached. The Munsell color notation is specified in ASTM D1535.

i. 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.

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

**********
**NOTE: Form 4S, in text below, is for single-phase, three-wire systems, for other system configurations, determine the appropriate form designation.**
**********

(a) Design: Provide meter designed for use on a single-phase, three-wire, [240/120][480/240] volt system with two current transformers. Include necessary KYZ pulse initiation hardware for energy monitoring and control system (EMCS)[ as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC].

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

(c) Class: 20

Form: 4S, accuracy: plus or minus 1.0 percent

Finish: Class II

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

(e) Kilowatt-hour register: Five digit electronic programmable type

(f) Demand register

1. Provide solid state

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

3. Demand interval length: Program for [15][30][60] minutes with rolling demand up to six subintervals per interval.

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

(h) 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 to match the pad-mounted transformer to which the box-mounted socket is attached. The Munsell color notation is specified in ASTM D1535.

]

**********

**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 |
| 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.**

**********

2.1.1.6 Transformer

**********

**NOTE: Use the following guidelines for specifying transformers.**

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

**2. Use IEEE C57.12.00, Table 11(b), voltage designations, such as "4160 V - 480Y / 277 V".**

**3. Select impedance value in accordance with technical note under paragraph SPECIFIED TRANSFORMER LOSSES.**

**4. Delete inapplicable sound levels.**

**5. Delete last sentence if transformer secondary winding is delta type.**

**********

a. [Oil-insulated][Less-flammable liquid-insulated], two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient,

self-cooled type.

b. Transformer is rated [_____] kVA, [95][60][_____] kV BIL.

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

d. Ensure tap changer is an 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. Ensure tap changers clearly indicate which tap setting is in use.

e. Minimum tested impedance cannot be less than [_____] percent at 85 degrees C on Three-Phase transformers [and [_____] at 85 degrees C on Single-Phase transformers].

f. Ensure audible sound levels 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 |

g. Include lifting lugs for the transformer and provisions for jacking under base. Ensure the transformer base construction is suitable for using rollers or skidding in any direction. Provide transformer top with an access handhole.[ Conspicuously display its kVA rating on its enclosure.] Ensure the transformer has an insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

[2.1.1.7 Specified Transformer Losses

**********

**NOTE: Steps to specifying transformer losses.**

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

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

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

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

**********

No-load losses (NLL) are [_____] watts at 20 degrees C and load losses (LL) are [_____] watts at 85 degrees C. Use the values for the specified losses 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.

Submit certification from the manufacturer indicating conformance with requirements.

]2.1.1.8 Insulating Liquid

**********

**NOTE: Choose one of the following options. For NAVFAC Atlantic , choose less-flammable transformer liquids for all projects unless there is a specific requirement to do otherwise.**

**********

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

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

(1) Provide a fluid that is a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM as "less flammable" fluids. Ensure the fluid meets the following fluid properties:

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

(b) Aquatic biodegradation: EPA 712-C-98-075, 100 percent

(c) Trout toxicity: OECD Test 203, zero mortality of EPA 600/4-90/027F, pass

]2.1.1.9 Liquid-Filled Transformer Nameplates

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

2.1.1.10 Corrosion Protection

**********
**NOTE: Use stainless steel bases and cabinets for most applications. In hostile environments, the additional cost of totally stainless steel tanks and metering may be justified. Manufacturer's standard construction material is acceptable only in noncoastal and non-corrosive environments. Choose the second bracketed option for hostile environments.**
**********

[Provide corrosion resistant transformer cabinets and bases fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Base includes any part of pad-mounted transformer that is within75 mm 3-inches of concrete pad. Paint bases, cabinets, and tanks Munsell 7GY3.29/1.5 green. Ensure paint coating system complies with IEEE C57.12.28. The Munsell color notation is specified in ASTM D1535.][Fabricate entire transformer assembly, including tank and radiator, base, enclosure, and metering enclosure of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Form enclosure of stainless steel sheets. Paint entire transformer assembly Munsell 7GY3.29/1.5 green. Ensure paint coating system complies with IEEE C57.12.28. The Munsell color notation is specified in ASTM D1535.]

2.2 ACCESSORIES

2.2.1 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). Provide a decal type sign and 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" is printed in white letters on a red background and the words "HIGH VOLTAGE" is printed in black letters on a white background. Decal is 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.

]2.2.2 Grounding and Bonding

Ensure equipment conforms to UL 467. Provide grounding and bonding as specified in Section[ 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION].

[2.2.3 Padlocks

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

**Do not use this paragraph for NAVFAC Atlantic projects.**

**********

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

]2.2.4 Cast-In-Place Concrete

**********

**NOTE: Use the first bracketed paragraph when project includes a concrete section in Division 3; otherwise, the second bracketed paragraph may be used. Coordinate requirements with Section03 30 00 CAST-IN-PLACE CONCRETE, for other projects.**

**********

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

**********

**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.**

**********

[ Concrete composed of fine aggregate, coarse aggregate, portland cement, and water so proportioned and mixed as to produce a plastic, workable mixture. Fine aggregate is of hard, dense, durable, clean, and uncoated sand. The coarse aggregate is well graded from 4.75 mm to 25 mm 3/16 inch to 1-inch. Ensure the fine and coarse aggregates are free from injurious amounts of dirt, vegetable matter, soft fragments or other deleterious substances. Use fresh, clean water, free from salts, alkali, organic matter, and other impurities. Concrete associated with electrical work for other than encasement of underground ducts is30 MPa 4000 psi minimum 28-day compressive strength unless specified otherwise. Slump cannot exceed 100 mm 4-inches. Retempering of concrete will not be permitted. Give exposed, unformed concrete surfaces a smooth, wood float finish. Cure concrete for a period of not less than 7 days. Repair concrete made with high early strength portland cement by patching honeycombed or otherwise defective areas with cement mortar as directed by the Contracting Officer. Air entrain concrete exposed to weather using an air-entraining admixture conforming to ASTM C260/C260M. Ensure air content is between 4 and 6 percent.

]2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

**********

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

**********

### 2.3.1 Transformer Test Schedule

The Government [reserves the right to][will] 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 has a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) The accuracy is directly traceable to the National Institute of Standards and Technology.

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

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

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

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

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

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

### 2.3.2 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). Perform design tests prior to the award of this contract.

a. Submit test reports 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 includes the primary windings only of that transformer.

(1) IEEE C57.12.90, paragraph 10.3 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.

### 2.3.3 Routine and Other Tests

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

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

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

e. Load losses (LL) and impedance voltage

f. Dielectric

(1) Impulse

(2) Applied voltage

(3) Induced voltage

g. Leak

h. Dissolved gas analysis (DGA)

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 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 in drawings. At some activities, curbs or raised edges may also be required around liquid filled transformer.**
**********

Mount transformer on concrete slab. Unless otherwise indicated, the slab is at least 200 mm 8-inches thick, reinforced with a 152 mm x 152 mm - MW19 by MW19 (6 by 6 - W2.9 by W2.9) 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 100 mm 4-inches from the top of the slab. Place the slab on a 150 mm 6-inch thick, well-compacted gravel base. Top of concrete slab is approximately 100 mm 4-inches above finished grade with gradual slope for drainage. Edges above grade are 15 mm 1/2-inch chamfer. Ensure slab is 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.

3.1.1.1 Cast-In-Place Concrete

**********
**NOTE: Use the first bracketed option when project includes a concrete section in Division 3; otherwise, the second bracketed option may be used.**
**********

Ensure cast-in-place concrete work conforms to the requirements of Section[ 03 30 00 CAST-IN-PLACE CONCRETE][ ACI 318M].

[3.1.1.2 Sealing

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

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

]3.2 INSTALLATION

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

3.2.1 Grounding

**********
**NOTE: For SOUTHNAVFACENGCOM projects, delete this paragraph and its subparagraphs, and use optional paragraph TRANSFORMER GROUNDING instead.**
**********

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

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

3.2.1.1 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.

3.2.1.2 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" applies.

3.2.1.3 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.

3.2.1.4 Grounding and Bonding Equipment

Conform equipment to UL 467, except as indicated or specified otherwise.

[3.2.2 Transformer Grounding

**********
**NOTE: For SOUTHNAVFACENGCOM projects, use this paragraph in lieu of the previous paragraph GROUNDING.**

**********

Provide a 1/0 bare copper-ground girdle around transformer. Bury girdle 305 mm one-foot deep and placed 915 mm 3-feet laterally from the transformer enclosure. Connect girdle to enclosure at two opposite places using 1/0 copper. Exothermically weld joints.

]3.2.3 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.

3.2.3.1 Meters and Current Transformers

ANSI C12.1.

3.2.4 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.

[3.2.5 Warning Sign Mounting

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

]3.3 FIELD QUALITY CONTROL

3.3.1 Predictive & Acceptance Testing

**********

**NOTE: If the specified system is identified as critical, configured, or mission essential, use Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS to establish predictive and acceptance testing criteria, above and beyond that listed below.**

**********

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

3.3.2 Performance of Acceptance Checks and Tests

Perform acceptance checks and tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.3.2.1 Pad-Mounted Transformers

a. Visual and mechanical inspection

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

(2) Inspect physical and mechanical condition. Check for damaged or

cracked insulators and leaks.

(3) 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.

(4) Verify correct liquid level in tanks.

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

(6) Verify correct equipment grounding.

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

] b. Electrical tests

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

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

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

3.3.2.2 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.

(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 required grounding and shorting connections provide good contact.

b. Electrical tests

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

(2) Perform insulation-resistance test.

(3) Perform a polarity test.

(4) Perform a ratio-verification test.

3.3.2.3 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.

3.3.2.4 Grounding System

a. Visual and mechanical inspection

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

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**NOTE: For SOUTHNAVFACENGCOM projects, delete "Electrical tests" below.**
**********

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. Equip the instrument 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.

3.3.3 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, give the Contracting

Officer 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --