Preparing Activity: NASA Superseding
UFGS-26 12 19.00 40 (November 2014)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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

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DIVISION 26 - ELECTRICAL

SECTION 26 12 19.00 40

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

05/23

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SECTION 26 12 19.00 40

PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS
05/23

****

NOTE: This guide specification covers the requirements for dead-front three-phase pad-mounted transformers 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 NAVFAC SE 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).

****

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NOTE: TO DOWNLOAD UFGS GRAPHICS

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

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

For NAVFAC SE facilities use Table 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 NAVFAC LANT 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

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2023) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D117	(2018) Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Liquids
ASTM D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D923	(2007) Standard Practice for Sampling Electrical Insulating Liquids
ASTM D971	(2020) Standard Test Method for Interfacial Tension of Insulating Liquids Against Water by the Ring Method
ASTM D974	(2014; E 2016) Standard Test Method for Acid and Base Number by Color-Indicator Titration
ASTM D1500	(2012; R 2017) Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)

ASTM D1524	(2015; R 2022) Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field
ASTM D1533	(2012) Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System
ASTM D1816	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes
ASTM D3487	(2016; E2017) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D3612	(2002; R 2017) Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography

FM GLOBAL (FM)

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.42	(2016) Specifications for High-Voltage (> 1000 V) Fuses and Accessories
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.34	(2022) Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below
IEEE C57.12.38	(2014) IEEE Standard for Pad-Mounted-Type, Self-Cooled, Single-Phase Distribution Transformers 250 kVA and Smaller: High Voltage, 34,500 GrdY/19 920 V and Below;

	Low Voltage, 480/240 V and Below
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C57.104	(2019) IEEE Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

UNDERWRITERS LABORATORIES (UL)

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

1.2 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, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

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

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

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

****

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

****

NOTE: Include the bracketed option on "CIEE and 074 review" for NAVFAC Atlantic and NAVFAC SE projects respectively. For other projects, submittal review is performed by the designer of record. If submittal review by NAVFAC Atlantic or NAVFAC SE 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 Systems 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 of the transformer high side fuses (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item e).]

****
NOTE: Use "will" on all NAVFAC SE 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)[; 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:

1.4.1.1 Outline Drawing

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

1.4.1.2 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 METERING.
****

1.4.1.3 Elementary Diagrams and Wiring Diagrams

Include terminals identified of watthour meter and current transformers.

1.4.1.4 One-line Diagram

Including switch(es), current transformers, meters, and fuses.

1.4.1.5 Time-current Curves

Manufacturer's published time-current curves 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 two years prior to bid opening. The two-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 two-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 two-year field service record are acceptable if a certified record of satisfactory field operation for not less than 6,000 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 three years prior to date of delivery to site, unless specified otherwise.

1.5 MAINTENANCE MATERIAL SUBMITTALS

1.5.1 Additions to Operation and Maintenance Data

Include the following on the actual transformer(s) provided:

1.5.1.1 Instruction Manual

Include pertinent items and information highlighted.

1.5.1.2 Outline Drawing

Include front, top, and side views.

1.5.1.3 Spare Part Data

Provide a list of the replaceable spare parts.

1.5.1.4 Routine and Field Acceptance Test Reports

1.5.1.5 Fuse Curves for Primary Fuses

1.5.1.6 Watthour Demand Meter, CT's, and Fuse Block Information

1.5.1.7 Actual Nameplate Diagram

1.5.1.8 Maintenance Procedure

Provide removal and installation instructions for the replaceable components.

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 is Type 1 as defined by IEEE C57.12.38 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 C37.42; 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 C37.42. 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.

][f. 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 Low Voltage

****
NOTE: Installation of circuit breakers in the secondary compartment is not recognized by ANSI standards, and limits accessibility by covering lugs, gauges, 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 insulated boots, low voltage bushing support, and fill plug.

2.1.1.4 Metering

Provide metering equipment in accordance with Section 26 27 14.00 20 ELECTRICITY METERING.

2.1.1.5 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.

[2.1.1.6 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 NAVFAC SE 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 68 degrees F and load losses (LL) are [_____] watts at 85 degrees C 185 degrees F. 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.

]2.1.1.7 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 572 degrees F 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 5 degrees F

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

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

]2.1.1.8 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.

2.1.1.9 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 within 75 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.]

2.1.1.10 Arc Flash Exposure Reduction Means

Provide additional features as indicated below to reduce exposure to arc flash.

a. Additional transformer rating nameplate: Include an additional nameplate, located outside of the cable compartment on the high voltage side of the tank, in accordance with IEEE C57.12.00. Mount the nameplate with an industrial grade double-sided adhesive.

b. External drain valve with sampler: Provide a 25.4 mm 1-inch drain valve with sampling device located outside of the cable compartment on the high voltage side of the tank. Protect the valve with a hinged cover and padlock provisions.

c. External instrumentation package: Locate all gauges and instrumentation devices inside a separate NEMA 250 Type 4 enclosure, mounted outside the high voltage side of the tank, such that access to them does not require exposure to any live circuits. Devices must include the following: liquid level gauge, dial-type thermometer with maximum temperature indicator, pressure/vacuum gauge, pressure relief valve and 12.7 mm 1/2-inch fluid sampling valve.

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. 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.

[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 is 30 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 seven 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 four and six percent.

]2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

****

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

****

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.

2.3.1.1 Test Instrument Calibration

a. The manufacturer has a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. The accuracy is directly traceable to the National Institute of Standards and Technology.

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

d. Dated calibration labels are visible on all test equipment.

e. Calibrating standard is of higher accuracy than that of the instrument tested.

f. 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:

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

   (2) 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.

Submit test reports certified and signed by a registered professional engineer.

2.3.2.1 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.

2.3.2.2 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.

a. IEEE C57.12.90, paragraph 10.3 LIGHTNING IMPULSE TEST PROCEDURES and IEEE C57.98.

b. State test voltage levels.

c. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

2.3.2.3 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.

2.3.2.4 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.

2.3.2.5 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:

2.3.3.1 Cold Resistance Measurements

Provide reference temperature.

2.3.3.2 Phase Relation

2.3.3.3 Ratio

2.3.3.4 No-load Losses (NLL) and Excitation Current

2.3.3.5 Load Losses (LL) and Impedance Voltage

2.3.3.6 Dielectric

a. Impulse

b. Applied voltage

c. Induced voltage

2.3.3.7 Leak

2.3.3.8 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 NAVFAC SE 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 NAVFAC SE 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.

3.2.4 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 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.

3.3.1.1 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.

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

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

(6) Remove a sample of insulating liquid in accordance with ASTM D923. Test sample for the following:

(a) Dielectric breakdown voltage: ASTM D1816.

(b) Acid neutralization number: ASTM D974.

(c) Interfacial tension: ASTM D971.

(d) Color: ASTM D1500.

(e) Visual Condition: ASTM D1524.

(f) Water in insulating liquids: ASTM D1533.

(7) Remove a sample of insulating liquid in accordance with ASTM D923 and perform Dissolved-Gas-Analysis (DGA) in accordance with IEEE C57.104 or ASTM D3612.

3.3.1.2 Grounding System

a. Visual and mechanical inspection

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

****
NOTE: For NAVFAC SE 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.

3.3.2 Follow-Up Verification

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

-- End of Section --