C57.12.20™

IEEE Standard for Overhead-Type Distribution Transformers, 500 kVA and Smaller: High Voltage, 34 500 V and Below; Low Voltage, 7970/13 800Y V and Below

IEEE Power Engineering Society

Sponsored by the
Transformers Committee

IEEE
3 Park Avenue
New York, NY 10016-5997, USA

9 December 2005

IEEE Std C57.12.20™-2005
(Revision of
IEEE Std C57.12.20-1997)

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Sponsor

Transformer Committee
of the
IEEE Power Engineering Society

Approved 9 June 2005

IEEE-SA Standards Board

Abstract: This standard covers certain electrical, dimensional, and mechanical characteristics and safety features of single- and three-phase, 60 Hz, mineral-oil-immersed, self-cooled, overhead-type distribution transformers 500 kVA and smaller, high voltages 34 500 V and below and low voltages 7970/13 800Y V and below.
Keywords: distribution transformer, overhead, mineral oil, transformer

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Introduction

This introduction is not part of IEEE Std C57.12.20™-2005, IEEE Standard for Overhead-Type Distribution Transformers, 500 kVA and Smaller: High Voltage, 34 500 V and Below; Low Voltage, 7970/13 800Y V and Below.

In 1938, the EEI-NEMA (Edison Electric Institute-National Electrical Manufacturers Association) Joint Committee on Standards for Distribution Transformers was organized to develop standards for the various types of distribution transformers. For 23 years, the continuous work of this Joint Committee was evidenced by a series of reports published jointly by the Edison Electric Institute and the National Electrical Manufacturers Association. The last report of overhead-type distribution transformers was the Seventh Report published in April 1961. The Joint Committee's last two reports on overhead-type distribution transformers were approved as American National Standards, the Seventh Report being reissued as American National Standard C57.12.20-1962.

To avoid further duplication of effort and to simplify future revisions, the EEI-NEMA Joint Committee on Standards for Distribution Transformers was dissolved and replaced by new subcommittees of the Accredited Standards Committee on Transformers, Regulators, and Reactors, C57. The work on standards for overhead-type distribution transformers was taken over by the Subcommittee on Distribution Transformers, Overhead and Pad-mounted, C57.12.2.

This standard was prepared by IEEE Subcommittee C57.12.2 on behalf of C57 and is a revision of ANSI C57.12.20-1997, Standard for Overhead Type Distribution Transformers, 500 kVA and Smaller: High Voltage, 34 500 Volts and Below; Low Voltage 7970/13 800Y Volts and Below. The 1981 edition included detailed requirements on relief of excessive pressure. The 1988 revision recognized the step-down and series-multiple designs in distribution transformers, and omitted the platform-type or station-type transformer. In recognition of the dramatic reduction in catastrophic failures of overhead transformers since the formulation of NEMA TR-P7-1975, the 1988 revision included in Section 8 this updated NEMA proposal that was previously designated 2.02 of NEMA Standards Publication for Transformers, Regulators, and Reactors, NEMA TR 1-1980 [B1]. The general industry consensus is that transformers that are built in conformance with this standard and that have adequate overcurrent protection, and recognizing the limitations included therein, will provide for enclosures with reasonable withstand capability.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Transformers, Regulators, and Reactors, C57. Committee approval of the standard does not necessarily imply that all committee members voted for its approval.

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IEEE Standard for Overhead-Type Distribution Transformers, 500 kVA and Smaller: High Voltage, 34 500 V and Below; Low Voltage, 7970/13 800Y V and Below

1. Overview

1.1 Scope

This standard covers certain electrical, dimensional, and mechanical characteristics and safety features of single- and three-phase, 60 Hz, mineral-oil-immersed, self-cooled, overhead-type distribution transformers 500 kVA and smaller, high voltages 34 500 V and below and low voltages 7970/13 800Y V and below.

1.2 Purpose

This standard is intended for use as a basis for determining the performance, interchangeability, and safety of overhead-type distribution transformers and to assist in the proper selection of this equipment.

NOTE—For polychlorinated-biphenyl (PCB) contamination in transformers, refer to the latest federal regulations.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std C37.40™, IEEE Standard Service Conditions and Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.[1]

IEEE Std C37.41™, IEEE Standard Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

IEEE Std C57.12.00™, IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

[1] IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).

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IEEE Std C57.12.31™, IEEE Standard for Pole Mounted Equipment - Enclosure Integrity.

IEEE Std C57.12.70™, IEEE Standard Terminal Markings and Connections for Distribution and Power Transformers.

IEEE Std C57.12.90™, IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.

IEEE Std C57.91™, IEEE Guide for Loading Mineral-Oil-Immersed Transformers.

3. Definitions

For the purposes of this standard, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms,* Seventh Edition [B1][2] should be referenced for terms not defined in this clause.

3.1 back-up protection: Devices external to the transformer enclosure to limit the duration or the potential duration of the flow of current to a fault.

3.2 enclosures: The complete transformer housing, tank, cover, band, etc., that contains the oil, the core and coil, the accessories, etc., of an overhead-type distribution transformer.

3.3 fault: An electrical condition designed to draw a specified value of current.

3.4 internal fusible element: An expulsion fuse that operates in the transformer oil.

3.5 test: Two faults in a given enclosure.

4. Ratings

4.1 Kilovolt-ampere ratings

Kilovolt-ampere ratings are continuous and are based on not exceeding either a 65 °C average winding temperature rise or an 80 °C hot-spot temperature rise. The temperature rise of the insulating oil shall not exceed 65 °C when measured near the top of the tank. Kilovolt-ampere ratings for single-phase and three-phase transformers shall be as shown in Table 1. These ratings are based on the usual temperature and altitude service conditions specified in IEEE Std C57.12.00™.[3]

4.2 Voltage ratings and tap ratings

Voltage ratings for single-phase and three-phase transformers shall be in accordance with Table 2, Table 3, and Table 4. No taps are to be provided unless otherwise specified.

When specified, tap ratings for single- and three-phase transformers shall be in accordance with Table 5. All tap ratings shall be at rated kilovolt-amperes, except as otherwise indicated. Voltages in Table 2, Table 3, and Table 4 are without taps.

[2] The numbers in brackets correspond to those of the bibliography in Annex B.
[3] For information on references, see Clause 2.

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5. Basic lightning impulse insulation levels and dielectric test levels

5.1 Basic lightning impulse

Basic lightning impulse insulation levels (BILs) shall be as shown in Table 2, Table 3, and Table 4.

5.2 Dielectric test

Dielectric test levels shall be in accordance with the distribution levels specified in IEEE Std C57.12.00.

6. Tests

6.1 General

Except as specified in 6.2, tests shall be performed as specified in IEEE Std C57.12.00 and in IEEE Std C57.12.90™.

6.2 Dielectric tests

For single-phase transformers with a BIL of 150 kV or less that have one high-voltage bushing and a high-voltage terminal permanently connected to ground, no applied-voltage test is required. Induced-voltage tests shall be performed by applying between the terminals of one winding a voltage that will be developed from the high-voltage line terminals to ground. This voltage shall be 1000 V plus 3.46 times the rated transformer winding voltage, but in no case shall the line-to-ground voltage developed exceed 40 000 V for 125 kV BIL or 50 000 V for 150 kV BIL. For this test the neutral terminal shall be grounded. An applied voltage test shall be applied on the low-voltage winding.

7. Construction

For the purpose of this standard, two principal reference locations have been established, as shown in Figure 1 and Figure 2. The first of these is a horizontal plane that passes through the top of the bolt slot in the upper support lug. For the second, the transformer cover has been divided into four segments. The segments are numbered in a clockwise direction with the centerline of segment 1 on the centerline of the low-voltage bushings, as shown in Figure 1 and Figure 2.

All dimensions contained in this standard are derived from U.S. customary equivalents. Unless otherwise noted, all dimensions will have a tolerance of ±2 mm (0.063 in).

7.1 Bushings and Terminals

7.1.1 Bushings

Electrical characteristics of transformer bushings shall be as listed in Table 6.

The number, location, and arrangement of bushings for single-phase and three-phase transformers shall be as shown in Figure 4, Figure 7 through Figure 14, and Table 7. The centerline of the high-voltage bushings shall be located within the shaded areas. The positions of high-voltage bushings for three-phase

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transformers need not be symmetrical. Low-voltage bushings shall be of the sidewall or cover type and shall be individually mounted.

Unless otherwise specified, the color of bushings shall match Light Gray Number 70, Munsell Notation 5BG7.0/0.4, as described in IEEE Std C57.12.31™.

7.1.2 Terminals

7.1.2.1 High-voltage terminals

Terminal details shall be as shown in Figure 5a. High-voltage bushings of transformers 200 kV BIL and below shall be equipped with tinned, copper-alloy solderless connectors. High-voltage terminal sizes shall be as shown in Table 8.

7.1.2.2 Low-voltage terminals

Terminal details shall be as shown in Figure 5a and Figure 5b. Low-voltage terminal sizes shall be as shown in Table 9. Terminals of low-voltage windings 600 V and below shall be arranged for vertical take-off.

External spacing between low-voltage bushing terminals shall be such as to provide the maximum clearance between live metal parts in the working area. For low-voltage ratings above 600 V, the electrical characteristics of the bushings determine the spacing. For low-voltage ratings 600 V and below, spacing shall be within the limits of Table 10.

7.1.3 Neutral termination

On single-phase transformers having one high-voltage bushing, the H_2 end of the winding shall be securely connected internally to the grounded clamping structure or the tank. This connection shall be independent of all other electrical connections.

On all three-phase transformers, a fully insulated low-voltage neutral bushing, X_0, shall be provided when the low-voltage windings are wye-connected.

On three-phase transformers, a fully insulated high-voltage neutral bushing, H_0, and a fully insulated low-voltage neutral bushing, X_0, shall be provided where wye-connected high-voltage windings are rated 8.32Y kV and below and low-voltage windings are rated 208Y/120 V or 480Y/277 V.

On three-phase transformers, a common fully insulated low-voltage-type neutral bushing, H_0X_0, shall be provided where wye-connected high-voltage windings are rated above 8.32Y kV and low-voltage windings are rated 208Y/120 V or 480Y/277 V. The high-voltage and low-voltage neutrals shall be connected internally by a link that is accessible and capable of reconnection.

7.1.4 Terminal boards

On single-phase transformers with low-voltage ratings of 120/240 V or 240/480 V, the internal connections to the low-voltage bushings on sizes 100 kVA and smaller shall be arranged to serve in lieu of a low-voltage terminal board. These connections shall be in conformance with and arranged as shown in Figure 6.

7.2 Accessory equipment

Accessory equipment shall be provided and located as shown in Figure 7 through Figure 14.

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7.2.1 Tap changer

(See Item 3 in Figure 7 through Figure 14.) Tap changers for de-energized operation shall be provided on tapped transformers. Each tap-changer position and the tap voltage or percentage associated with it shall be clearly identifiable by reference to nameplate information. All positions of the tap changer shall be operative positions. Transformers may have either an internal tap changer or an externally operated tap changer unless one or the other is specified.

The internal tap changer shall have the operating handle inside the tank above the oil level. The tap changer shall rotate in a clockwise direction from a high tap voltage to a lower tap voltage in the high-voltage winding. The tap changer shall be provided with mechanical stops to identify the highest and lowest tap positions.

The handle of the externally operated tap changer shall be brought out through the side of the tank in or near segment 3, as shown in Figure 7 through Figure 14. It shall be designed to prevent accidental operation by requiring a preliminary step before the tap setting can be changed. Position numbers or letters corresponding to the nameplate shall be clearly identifiable near the handle. There shall be located on or adjacent to the operating mechanism a written caution statement to de-energize the transformer before operating.

7.2.2 Series-multiple connections

(See Item 14 in Figure 7, Figure 8, and Figure 11.) The series-multiple voltage-changing device may be an internally mounted terminal board or externally operated switch, unless one or the other is specified. Either device is for de-energized operation.

Internal terminal boards with movable links shall have all studs identified on the board, and the nameplate shall show the connections to be made for each voltage.

The handle of the externally operated switch shall be brought out through the side of the tank in or near segment 3, as shown in Figure 7, Figure 8, and Figure 11. It shall be designed to indicate voltage position and to prevent accidental operation by requiring a preliminary step before the voltage setting can be changed. Actual voltages or position numbers corresponding to the nameplate shall be clearly identifiable near the handle. There shall be located on or adjacent to the operating mechanism a written caution statement to de-energize the transformer before operating.

7.2.3 Liquid-level marking

(See Item 2 in Figure 7 through Figure 14.) A suitable marking inside the tank shall indicate the correct oil level at 25 °C.

7.2.4 Lifting lugs

(See Item 5 in Figure 7 through Figure 14.) The lifting lugs shall be permanently attached to and arranged on the tank to provide a balanced lift in a vertical direction for the completely assembled transformer and shall be designed to provide a safety factor of five [B5].[4] The safety factor of five is the ratio of the ultimate stress to the working stress of the material used. The working stress is the maximum combined stress developed in the lifting lugs by the static load of the completely assembled transformer [B4].[5]

7.2.5 Relief of excessive pressure

[4] This value is taken from 1.3, Lifting Means, in NEMA MG2-1983, Safety Standard for Construction and Guide of Selection, Installation, and Use of Electric Motors (available from the National Electrical Manufacturers Association).
[5] This value is taken from MIL-STD-209C, Swinging Eyes and Attachments for Lifting and Tying Down Military Equipment (available from the Commanding Officer, Naval Publications and Forms).

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A means as specified in 7.2.5.1 or 7.2.5.2 shall be provided to relieve pressure in excess of pressure that results from normal operation. This excess pressure may build up slowly due to overloads, or high ambient temperatures, or external secondary faults, or internal incipient faults in the low-voltage or high-voltage windings. This excess pressure should result in an emission of only a negligible amount of oil.

7.2.5.1 Pressure-relief valve

(See the note concerning Item 13 in Figure 7 through Figure 14.) A replaceable valve shall be located on the tank above the 140 °C top oil level, by the manufacturer's calculation, and so located as not to interfere with use of support lugs, lifting lugs, operating handles of switches and circuit breakers, or sidewall bushings.

The inlet port shall be 1/4 in or larger National Pipe Thread (NPT) or National Coarse (NC) thread with gasket, sized for specified minimum flow rate. Exposed parts shall be of weather- and corrosion-resistant materials. Gaskets and O-rings shall withstand oil vapor at 105 °C continuously and under operating conditions as described in IEEE Std C57.91™, without seizing or deteriorating, for the life of the transformer.

The valve shall have a pull ring for manually reducing pressure to atmospheric level using a standard hookstick, and shall be capable of withstanding a static pull force of 112 N (25 lbf) for 1 min without permanent deformation. The valve shall withstand for 1 min a static force of 445 N (100 lbf) applied normal to its longitudinal axis at the outermost extremity of the body. When specified, the venting port on the outward side of the valve-head seat shall be protected to prevent entry of dust, moisture, and insects before and after the valve has operated, or a weather-cap-type indicator shall be provided that will remain attached to the valve and provide positive indication to an observer that the valve has operated.

Venting and sealing characteristics shall be as follows:

— Venting pressure = 69 kPa (10 psig) ± 13 kPa (gage) (2 psig)

— Resealing pressure = 42 kPa (gage) (6 psig) minimum

— Zero leakage from reseal pressure to -56 kPa (gage) (8 psig)

— Flow at 103 kPa (gage) (15 psig) = 16.5 L/s (35 Standard Cubic Feet per Minute {SCFM}) minimum, corrected for air pressure of 101 kPa (14.7 psi) (absolute) and air temperature of 21 °C.

7.2.5.2 Cover assembly

A cover assembly designed to relieve excess pressure in the transformer tank shall remain effectively sealed for overloads and external secondary short circuits of the magnitude and duration allowed by industry standards and loading guides. The assembly shall relieve pressure at a minimum of 56 kPa (gage) (8 psig) if designed to reseal, or at a minimum of 138 kPa (gage) (20 psig) if designed for pressure relief without resealing. Such operation shall occur before other components of the tank are ruptured or displaced, and the cover shall remain in position. Manual means of venting the tank before removal of the cover shall be provided. The flow rate shall be at least equal to that of the pressure-relief device specified in 7.2.5.1.

7.2.6 Enclosure integrity

7.2.6.1 Static pressure[6]

[6] Static does not mean constant, but implies the absence of instantaneous, impact-type pressure change forces.

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The completely assembled transformer enclosure shall be of sufficient strength to withstand an internal pressure of 49 kPa (gage) (7 psig) without permanent distortion to the enclosure. The enclosure shall also be of sufficient strength to withstand an internal pressure of 138 kPa (gage) (20 psig) without rupturing or displacing components (excluding the cover gasket and gasket oil leaks) of the transformer.

7.2.6.2 Dynamic pressure

The completely assembled transformer enclosure shall be capable of passing the fault current tests as defined in Clause 9.

7.3 Polarity, terminal markings, and angular displacement

7.3.1 Polarity

Polarity shall be additive for all single-phase transformers in sizes 200 kVA and smaller having high-voltage windings 8660 V and below. Polarity shall be subtractive for all other single-phase transformers.

7.3.2 Angular displacement

The angular displacement between windings of three-phase transformers with delta–delta or wye–wye connections shall be zero degrees. The angular displacement between windings of three-phase transformers with wye–delta or delta–wye connections shall be 30°. Angular displacement between voltages on three-phase transformers shall be in accordance with Table 11.

7.3.3 Terminal markings

External terminal designations shall be as defined by IEEE Std C57.12.70™, although physical terminal markings on tank or cover are not required. The low-voltage terminal designations are shown in Figure 6 for single-phase transformers and in Figure 4 for three-phase transformers.

Internal leads on single-phase transformers shall be individually and permanently identified with the letters A, C, B, and D, as shown in Figure 6, unless a lead support or other means is provided to locate such leads definitively with respect to each other. Where lead supports are used, the leads at the top or terminal side of the lead support shall be in the order A, C, B, D, reading from left to right, facing the low-voltage side. Where lead supports are not used or when the lead support does not fix the leads in the order A, C, B, D or when the leads are not individually identified, the lead terminals shall be such as to ensure that, for multiple connection, lead A is connected only to lead C and lead B only to lead D.

All practical interchangeability, in regard to connections to external terminals, is desirable. Emphasis should be given to interchangeability of the low-voltage connections. For this purpose, the top of the bolt slot in the upper support lug establishes the horizontal reference plane. The departure from complete interchangeability shall not exceed the tolerances specified in Figure 1 and Figure 2.

The identification of low-voltage internal and external connections shall be shown on the nameplate and shall conform to Figure 6 for single-phase transformers and Figure 4 for three-phase transformers.

7.3.4 Instruction nameplate

The instruction nameplate shall be located as shown in Figure 7 through Figure 14.

7.3.4.1 Location

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The instruction nameplate for single-position mounting (see Item 11 in Figure 8 through Figure 14 shall be either attached to the lower support lug or located on the dividing line between segment 2 and segment 3, with a tolerance of ±45° located near the bottom of the tank.

The instruction nameplate for two-position mounting for single-phase transformers only (see Item 11 in Figure 7) shall be either attached to one of the lower support lugs or located on the dividing line between segment 1 and segment 2, with a tolerance of ±45° near the bottom of the tank.

7.3.4.2 Type

Instruction nameplates shall contain the information specified in IEEE Std C57.12.00 (see Item 11 in Figure 7 through Figure 14) except that the BIL rating shall be shown for all single-phase ratings above 16 340 V. The instruction nameplate shall be in accordance with nameplate A as described in IEEE Std C57.12.00.

7.3.4.3 Material

The instruction nameplate shall be made of corrosion-resistant material.

7.3.5 Kilovolt-ampere rating on tank

(See Item 12 in Figure 7 through Figure 14.) The kilovolt-ampere rating, in Arabic numerals 65 mm (2.5 in) high, shall appear on the tank of pole-mounted transformers near the low-voltage bushings. These numerals may be applied by stenciling or by any other suitable means.

7.3.6 Connections for shipment by the manufacturer

High-voltage windings having taps shall be connected for the rated voltage.

High-voltage windings of single-phase transformers designed for series-multiple operation shall be connected for the series voltage.

Low-voltage windings of single-phase transformers designed for both series-multiple and three-wire operation, where the connections are made inside the tank, shall be connected for three-wire operation.

Three-phase transformers with low-voltage windings rated 240 V × 480 V shall be connected for 480 V operation.

7.4 Oil preservation

Distribution transformers shall have a sealed-tank oil-preservation system. Sealed-tank construction is construction in which the interior of the tank is sealed from the atmosphere and the gas volume plus the oil volume remains constant. The transformer shall remain effectively sealed for a top oil temperature range of -5 °C to +105 °C for continuous operation at rated kilovolt-amperes and under the operating conditions as described in IEEE Std C57.91.

7.5 Tanks

7.5.1 Covers and handholes

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The manufacturer's published data shall state if other than bolted-cover construction is used. Single-phase and three-phase transformers with cover bushings and internal tap changers shall have handholes on the cover. (See Item 4 in Figure 7, Figure 8, Figure 9, Figure 11, Figure 12, and Figure 14.) These handholes shall be of adequate size and shall be suitably located to permit operation of the internal tap changer.

7.5.2 Support lugs

(See Item 1 in Figure 7 through Figure 14.) Support lugs shall be designed to provide a safety factor of five when supported in a vertical plane from the top lug only. The safety factor of five shall be as defined for lifting lugs in 7.2.4. Interchangeable mounting to the maximum extent is accomplished by use of Type-A and Type-B support lugs designed in accordance with Figure 3 and located as shown in Figure 1 and Figure 2. An upper and a lower support lug shall be provided for direct-pole mounting.

7.5.3 Tank finish

Unless otherwise specified, the tank finish shall conform to Light Gray Number 70, Munsell Notation 5BG 7.0/0.4, as described in IEEE Std C57.12.31.

7.5.4 Tank grounding

7.5.4.1 Tank grounding provision

(See Item 6 in Figure 7 through Figure 14.) The tank grounding provision shall consist of a steel pad with a 1/2-13 NC tapped hole, 11 mm (0.44 in) deep, and located near the bottom of the tank as shown in Figure 7 through Figure 14. The threads shall be protected by a corrosion-resistant flanged cup pressed into the threaded opening of the ground pad.

7.5.4.2 Tank grounding connector

(See Item 6 in Figure 7, Figure 8, and Figure 9.) The tank grounding connector shall be a solderless connector that will accommodate conductor size Number 8 AWG solid to Number 2 AWG stranded (on single-phase transformers only).

7.5.4.3 Low-voltage grounding connection

(See Item 7 in Figure 7 and Figure 8.) The low-voltage grounding connection shall be an external copper link of adequate size (to handle the short-circuit test in accordance with IEEE Std C57.12.90), securely connecting the low-voltage neutral terminal to the tank.

7.5.4.4 Low-voltage grounding provision

(See Item 8 in Figure 7, Figure 8, Figure 10, Figure 11, Figure 13, and Figure 14.) The low-voltage grounding provision shall consist of a steel pad with a 1/2-in 13-NC tapped hole, 11 mm (0.44 in) deep. The threads shall be protected by a corrosion-resistant flanged cup installed into the threaded opening of the ground pad.

7.5.4.5 Lightning arrester mounting provision

(See Figure 1 and Figure 2.) The lightning arrester mounting provisions shall consist of two steel pads with a 1/2-in 13-NC tapped holes 11 mm (0.44 in) deep and located on the side of the tank in line vertically with

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each high-voltage bushing. The threads shall be protected by a corrosion-resistant flanged cup installed into the threaded opening of the arrester mounting pads.

7.5.4.6 Static cover bond

The transformer cover shall be electrically bonded externally to the tank. The location of the bond shall not interfere with the lifting lugs.

8. Storage and installation

8.1 Storage

The transformer shall be stored in a vertical position and shall remain essentially in that position at all times, including transport to the site and during installation.

8.2 Installation

Equipment manufactured to this specification may be installed in areas where environmental and climatic conditions make operation at varying angles of tilt from the horizontal an important consideration. Under these circumstances, the user may wish to make a particular “angle of tilt” part of their specifications.

9. Design tests for fault current capability of overhead distribution transformer enclosures

9.1 Objective

This test procedure has been designed to determine the ability of an overhead transformer tank or enclosure to withstand a shock- or impulse-type application of internal pressure. The test conditions must ultimately be described in terms of the energy applied, with the pressure wave defined by the rate of rise, peak pressure, duration, and total energy under the curve. However, at this time, sufficient information is not available to so describe an applicable pressure wave. For the interim period until such knowledge is available, this test procedure is based upon defining the electrical conditions associated with generating a particular shock or impulse pressure wave that may be used as a measure of tank or enclosure strength. This test procedure is not intended to include all possible conditions that may occur in service under fault conditions, but rather to establish a meaningful test that is repeatable and capable of duplication in various laboratories and test situations.

The test is intended as a design test to be made on new transformer tanks with a new tank assembly subjected to no more than two faults or pressure shots. It is not intended to provide data for current-limiting fuse application.

Some faults can quickly develop high pressures in the transformer enclosure. The rate of pressure rise and the ultimate tank pressure may vary for different faults. These design tests are to be made on transformer enclosures to demonstrate their capability to withstand pressure changes due to specified faults.

9.2 General requirements

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The transformer to be tested shall be a new unit, complete with its core and coil, bushings, etc. The test shall be conducted at ambient temperature with an initial internal pressure from 42 kPa to 48 kPa (gage) (6 psig to 7 psig). The transformer being tested shall be securely supported by its hanger brackets and mounted clear of the earth. The testing requirements of IEEE Std C37.40™ and IEEE Std C37.41™ shall be followed. The fault current shall be symmetrical. A new enclosure shall be used for each test. A test shall consist of two faults. The second fault shall be accomplished by reusing, "as specified by the manufacturer," all of the original components in the enclosure. Provision shall be made for venting in a safe manner any internal pressure that remains after each fault.

If specified, the manufacturer shall provide a test report. This report shall describe tests on representative production samples of each enclosure diameter with its minimum designed air space.

9.3 Tests

Two tests are covered in this standard. Test Number 1 with a high-current arcing fault, without internal fusible elements, shall be conducted on each enclosure diameter with its minimum designed air space. The minimum designed air space must consider production tolerances. See 9.4.

In addition, Test Number 2, with an internal fusible element, shall be conducted on each enclosure diameter utilizing the internal fusible elements. This test covers the interruption of these fusible elements for both rated interrupting and the lower fault value of current, as identified in 9.5.

It is the intent of this test to utilize the highest energy release fuse element for each enclosure. This is probably the highest interrupting rated fuse element provided for the highest voltage class. The transformer shall not have a secondary breaker, or any other secondary protection.

9.4 Test number 1—an arcing fault in an enclosure

9.4.1 First fault

A simulated internal fault shall be provided. This fault shall consist of a 25 mm (1 in) arc gap mounted horizontally and located 25 mm (1 in) above the core clamps. This gap shall be bridged initially by a 1.500 mm (0.0605 in or 14.5 AWG) diameter or smaller copper wire. The gap shall be connected between the high-voltage terminals or from one high-voltage terminal to ground. The mounting blocks or terminals of the gap shall consist of copper-bearing material and shall have flat surfaces from 6 mm to 20 mm (0.25 in to 0.75 in) in diameter or in width. These gaps shall be designed to maintain this 25 mm (1 in) arc gap for the duration of the fault. The transformer coil shall not be electrically connected in this test circuit. The power source shall be 7.2 kV and adjusted to supply a current of 8000 rms symmetrical amperes.

As this arcing fault will not be self-clearing, back-up protection shall be provided to clear the circuit in approximately one-half to one cycle, which is a typical clearing time for an external distribution fuse cutout. A cutout with up to a 25 K fuse link shall be used to provide back-up protection. A current-limiting device, such as a fuse, cannot be included in the back-up protection.

9.4.2 Second fault

For the second fault, the fault described in 9.4.1 shall be repeated.

9.5 Test number 2—for enclosures with internal fusible elements

For the tests in 9.5.1 and 9.5.2, the sequence of faults shall be either A and then B or B and then A.

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9.5.1 "A" fault

The A fault shall be a bolted line-to-ground on the load side of the fusible element. The power source shall apply the rated voltage of the transformer and shall be capable of delivering the rated interrupting current of the fusible element or 8000 rms symmetrical amperes, whichever is less. The transformer coil shall not be electrically connected in this test circuit.

Back-up protection should be provided to clear the faults in approximately two cycles after the total clearing time of the internal fusible element.

9.5.2 "B" fault

The B fault shall be applied externally to the enclosure at the low-voltage terminals of the transformer, shorting all low-voltage terminals with the required impedance. The transformer coil shall be electrically connected in this test circuit. This fault should draw 25 times rated transformer current. For transformers with 4% impedance or higher, the current will be limited by the transformer impedance. The power source shall be adjusted to the rated voltage of the transformer. The fault current shall operate the fusible element.

Back-up protection should be provided to clear the fault in approximately 2 s after total clearing time of the internal fusible element.

9.6 Test results

No mechanical components from the transformer enclosure shall be propelled or dropped from the tank during the tests. There shall be no rupture of the tank casing or seams. There shall be less than 1 L (1 qt) of oil emitted and no expulsion of flaming oil during the tests. No oil shall continue to leave the inside of the transformer enclosure after the completion of the fault. The transformer shall not be dislodged from its mounting.

Table 1—Kilovolt-ampere ratings

Single-phase	Three-phase
10	30
15	45
25	75
37.5	112.5
50	150
75	225
100	300
167	500
250	—
333	—
500	—

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Table 2—Ratings for single-phase transformers (single-ratio)

Transformer high-voltage rating	BIL (kV)	Minimum kVA rating for low-voltage rating of:			
		120/240[a] 277 or 240/480[a]	2400 or 4800	7200 or 7620 or 7970	Figure reference
12 470GrdY/7200	95	10	50	—	7, 8
13 200GrdY/7620	95	10	50	—	7, 8
13 800GrdY/7970	95	10	50	—	7, 8
24 940GrdY/14 400[b]	125	10	50	50	7, 8, 9
34 500GrdY/19 920[c,d]	150	10	50	50	7, 8, 9
2400/4160Y	60	10	—	—	10
4800/8320Y	75	10	—	—	10
7200/12 470Y	95	10	50	—	11
7620/13 200Y	95	10	50	—	11
13 200/22 860Y[b]	125	10	50	50	11, 12
13 800/23 900Y[b]	125	10	50	50	11, 12
14 400/24 940Y[b]	125	10	50	50	11, 12
12 000	95	10	50	50	11, 12
13 200	95	10	50	50	11, 12
13 800	95	10	50	50	11, 12
16 340	95	10	50	50	11, 12
34 500	200	25	50	50	11, 12

[a] Low-voltage rating of 120/240 V or 240/480 V is suitable for series, multiple, or three-wire service.
[b] Suitable for wye-connection on systems where ground connections permit the use of 18 kV arresters.
[c] Suitable for wye-connection on systems where ground connections permit the use of 27 kV arresters.
[d] When specifying 125 kV BIL, adequate grounding and surge protection studies should be made.

Table 3—Ratings for single-phase transformers (series-multiple)

Transformer high-voltage rating	BIL[a] (kV)	Minimum kVA rating for low-voltage rating of:		
		120/240[b] 277 or 240/480[b]	2400 or 4800	Figure reference
4160GrdY/2400 × 12 470GrdY/7200	60 × 95	10	—	7, 8
4160GrdY/2400 × 13 200GrdY/7620	60 × 95	10	—	7, 8
8320GrdY/4800 × 12 470GrdY/7200	75 × 95	10	—	7, 8
8320GrdY/4800 × 13 200GrdY/7620	75 × 95	10	—	7, 8
12 470GrdY/7200 × 24 940GrdY/14 400	95 × 125	10	—	7, 8
13 200GrdY/7260 × 24 940GrdY/14 400	95 × 125	10	—	7, 8
2400/4160Y × 7200/12 470Y	60 × 95	10	50	11
2400/4160Y × 7620/13 200Y	60 × 95	10	50	11
4800/8320Y × 7200/12 470Y	75 × 95	10	50	11
4800/8320Y × 7620/13 200Y	75 × 95	10	50	11
7200/12 470Y × 14 400/24 940Y	95 × 125	10	50	11
7620/13 200Y × 14 400/24 940Y	95 × 125	10	50	11

[a] Arrester coordination may require higher basic lightning impulse insulation level on the multiple connection than indicated to achieve a minimum protective level of 20%.
[b] Low-voltage rating of 120/240 V or 240/480 V is suitable for series, multiple, or three-wire service.

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Table 4—Ratings for three-phase transformers

Transformer high-voltage rating[a]	Minimum BIL (kV)	Minimum kVA rating for low-voltage rating of:					
		208Y/120	240 or 480	240 × 480	480Y/277	2400 or 4160Y/2400 or 4800 or 8320Y/4800	Figure reference
2400	45	30	30	30	30	—	13
4160	60	30	30	30	30	—	13
4800	60	30	30	30	30	—	13
7200	75	30	30	30	30	150	14
12 000	95	30	30	30	30	150	14
13 200	95	30	—	30	30	150	14
13 800	95	30	30	30	30	150	14
4160Y	60	30	30	30	—	—	13
8320Y	75	—	30	30	—	—	13
12 470Y	95	—	30	30	—	—	14
13 200Y	95	—	30	30	—	—	14
4160Y/2400	60	30	—	—	30	—	13
8320Y/4800	75	30	—	—	30	—	13
12 470Y/7200	95	30	—	—	30	—	14
13 200Y/7620	95	30	—	—	30	—	14
13 800GrdY/7970	95	30	—	—	30	—	14
24 940GrdY/14 400	125	30	—	—	30	—	14
34 500GrdY/19 920	150	30	—	—	30	—	14

[a] All transformers are delta-connected unless otherwise specified.

Table 5—Recommended taps for single-phase and three-phase transformers

Winding voltage		Above rating	Below rating
		The following options are available for all voltages:	
2400/4160Y			
4800/8320Y			
7200/12 470Y			
7620/13 200Y			
13 200/22 860Y	Option 1	(2) 2.5%	(2) 2.5%
12 000			
13 200			
12 470GrdY/7200	Option 2	None	(4) 2.5%
13 200GrdY/7620			
13 800GrdY/7970			
34 500GrdY/19 920			
13 800/23 900Y		14 400 / 14 100	13 500 / 13 200
14 400/24 940Y		None	13 800 / 13 200 / 12 870 / 12 540
13 800		14 400 / 14 100	13 500 / 13 200
16 340[a]		17 200 / 16 770	15 910 / 15 480
24 940GrdY/14 400		None	13 800 / 13 200 / 12 870 / 12 540

NOTE—No taps will be supplied if taps are not specified.
[a] Single-phase only.

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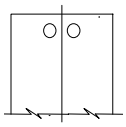
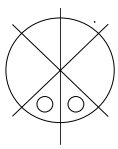
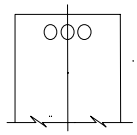
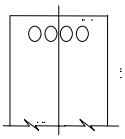
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Table 6—Electrical characteristics of bushings

BIL withstand (kV)	Creepage distance (minimum)	Minimum 60 Hz dry 1 min withstand (kV)	Minimum 60 Hz wet 10 s withstand (kV)
	Millimeters (in)		
30	—	10	6
45	—	15	13
60	—	21	20
75	—	27	24
95	255 (10)	35	30
95[a]	380 (15)	42	36
125	380 (15)	42	36
150	435 (17)	60	50
200	660 (26)	80	75

[a] For 16.34 kV rating only.

Table 7—Number of low-voltage terminals and arrangement for single-phase transformers

kVA range for high-voltage rating of 34 500 and below, 14 400 / 24 940Y and below, 34 500GrdY/19 920 and below				
Low-voltage rating (V)				
120/240	—	—	10–100	167–500
240/480	—	—	10–100	167–500
277	10–500	—	—	—
2400–4800	50–500	—	—	—
7200–7970	—	50–500	—	—

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Table 8—High-voltage terminal sizes

Size of terminal opening millimeters (in)[a]	Terminal detail figure	Size of conductor terminal will accommodate	Single-phase kVA range for high-voltage rating of:		Three-phase kVA range for high-voltage rating of:	
			5000 and below	Above 5000	5000 and below	Above 5000
7.9 (0.31)	5a	Number 8 AWG solid to number 2 AWG stranded	10–167	10–500	30–225	30–500
15.9 (0.63)	5a	Number 6 AWG solid to 4/0-19 stranded	250–500	—	300–500	—

[a] All dimensions have a tolerance of ±0.4 mm (±0.02 in).

Table 9—Low-voltage terminal sizes

Size of terminal opening millimeters (in)[a]	Terminal detail figure	Size of conductor terminal will accommodate	Single-phase kVA range for low-voltage rating of:					Three-phase kVA range for low-voltage rating of:		
			120/240	240/480	277	2400 to 4800	7200 to 7920	208Y/120 240	480Y/277 480	2400 and above
7.9 (0.31)	5a	Number 8 AWG solid to number 2 AWG stranded	—	—	—	50–167	50–500	—	—	30–150
15.9 (0.63)	5a	Number 6 AWG solid to 4/0-19 stranded	10–15	10–25	10–25	250–500	—	30–45	30–75	300–500
20.6 (0.81)	5a	Number 2 AWG solid to 350 kcmil 19 stranded	25–50	37.5–100	37.5–100	—	—	75–150	112.5–300	—
23.8 (0.94)	5a	1/0 solid to 500 kcmil 37 stranded	75	—	—	—	—	225	—	—
31.8 (1.25)	5a	2/0 solid to 1000 kcmil 61 stranded	100	—	—	—	—	300	—	—
Spade H	5b	—	167–250	167–500	167–250	—	—	—	500	—
Spade J	5b	—	333–500	—	333–500	—	—	500	—	—

[a] All dimensions have a tolerance of ± 0.4 mm (± 0.02 in).

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Table 10—Minimum electrical clearances (low-voltage terminals—600 V and below)

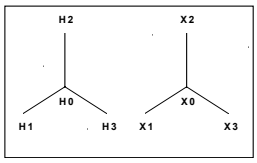
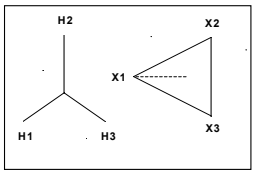
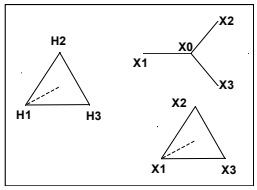
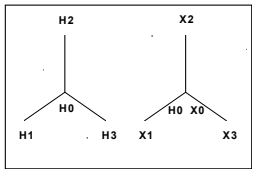
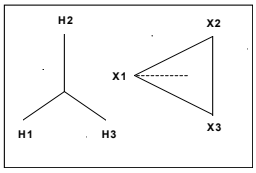
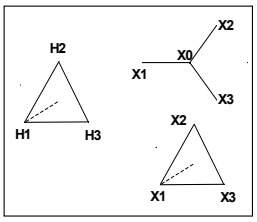
Single-phase rating (kVA)	Three-phase rating (kVA)	Minimum clearance between live metal parts[a]	Maximum spacing between center points of bushing terminals
		Millimeters (in)	Millimeters (in)
10–50	30–150	40 (1.75)[b]	230 (9)
75–500	225–500	75 (3)[b]	230 (9)

[a] When movable parts of bushing terminals are in the same relative position.
[b] When tank dimensions will not permit this spacing, the spacing may be reduced by not more than 20 mm (0.75 in).

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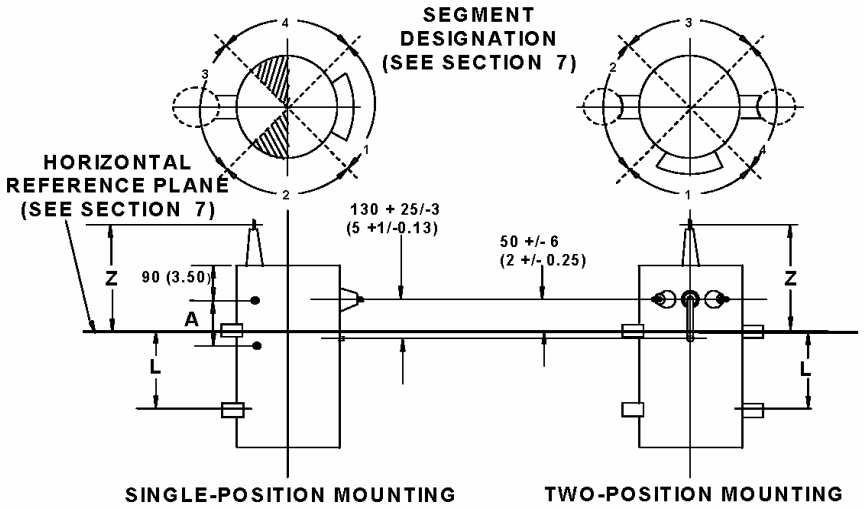
Table 11—Angular displacement

Transformer high-voltage rating	Angular displacement		Minimum kVA range of ratings having low-voltage ratings of:[a]					
	HV	LV	208Y/120	240 or 480	240 × 480	480Y/277	2400 or 4800	4160Y/2400
4160Y/2400 8320Y/4800			30 (a)	—	—	30 (a)	—	—
4160Y 8320Y			—	30 (c)	30 (c)	—	—	—
2400 4160 4800			30 (b)	—	—	30 (b)	—	—
			—	30 (c)	30 (c)	—	—	—
13 800GrdY/7970[b] 12 470Y/7200[b] 13 200Y/7620[b] 24 940GrdY/14 400[b] 34 500GrdY/19 920[b]			30 (d)	—	—	30 (d)	—	—
12 470Y 13 200Y			—	30 (e)	30 (e)	—	—	—
7200 12 000 13 200 13 800			30 (f)	—	—	30 (f)	—	150 (f)
			—	30 (e)	30 (e)	—	150 (e)	—

[a] Letters in parenthesis (a) through (f) designate terminal designation of Figure 4.
[b] High-voltage and low-voltage neutrals internally connected by means of a removable link.

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High-voltage rating	kVA	Support lug type	L	Z[a]
			mm (in)	mm (in)
Up to and including ratings	10–50	A	285 (11.25)	380 ± 75 (15 ± 3)
7620/13 200Y	75–167	B	590 (23.25)	380 ± 75 (15 ± 3)
13 800GrdY/7970	250–333	B	590 (23.25)	380 ± 75 (15 ± 3)
and 12 000	500	B	895 (35.25)	380 ± 75 (15 ± 3)
Ratings	10–50	A	285 (11.25)	420 ± 75 (16.5 ± 3)
13 200/22 860Y	75–167	B	590 (23.25)	420 ± 75 (16.5 ± 3)
24 940GrdY/14 400	250–333	B	590 (23.25)	495 ± 75 (19.5 ± 3)
16 340 and above	500	B	895 (35.25)	495 ± 75 (19.5 ± 3)

Arrester mounting dimensions (based on arrester rating or HV winding insulation BIL)	A[b] mm (in)
Less than or equal to 24 kV (or HV BIL less than 150 kV)	65 (2.50)
Greater than 24 kV (or HV BIL 150 kV or greater)	255 (9.25)

NOTE—Refer to Clause 7 for dimension tolerances. All dimensions are given in millimeters. Dimensions in parentheses are given in inches.

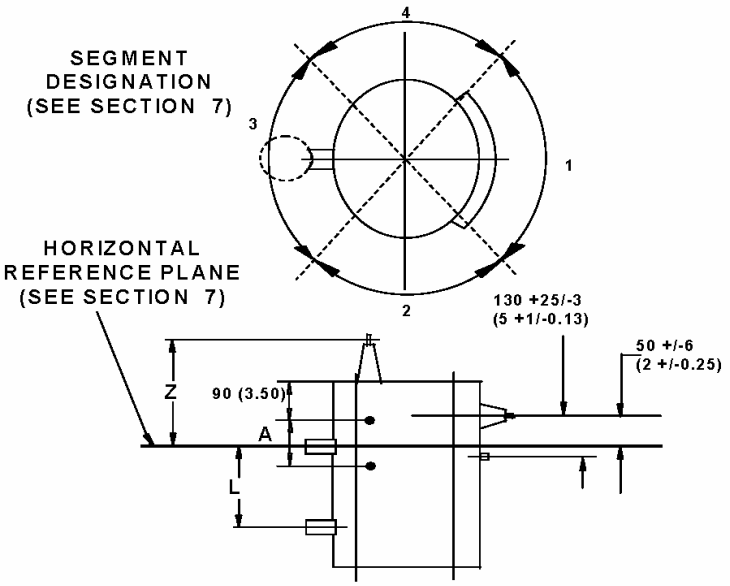
[a] These dimensions apply only to high-voltage cover bushing transformers.

[b] Dimensions apply to arrester mounting provisions described in 7.5.4.5.

Figure 1—Segment designations and interchangeability dimensions for single-phase transformers

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High-voltage rating	kVA	Support lug ytype	L	Z[a]
			mm (in)	mm (in)
Up to and including ratings	15–30	A	590 (23.25)	380 ± 75 (15 ± 3)
13 800GrdY/7970	45–75	B	590 (23.25)	380 ± 75 (15 ± 3)
and 13 800	112.5–300	B	895 (35.25)[b]	380 ± 75 (15 ± 3)
Ratings	15–30	A	590 (23.25)	420 ± 75 (16.5 ± 3)
19 920 and above	45–75	B	590 (23.25)	420 ± 75 (16.5 ± 3)
	112.5–300	B	895 (35.25)[b]	495 ± 75 (19.5 ± 3)

Arrester mounting dimensions (based on arrester rating or HV winding insulation BIL)	A[c] mm (in)
Less than or equal to 24 kV (or HV BIL less than 150 kV)	65 (2.50)
Greater than 24 kV (or HV BIL 150 kV or greater)	255 (9.25)

NOTE—Refer to Clause 7 for dimension tolerances. All dimensions are given in millimeters. Dimensions in parentheses are given in inches.

[a] These dimensions apply only to high-voltage cover bushing transformers.

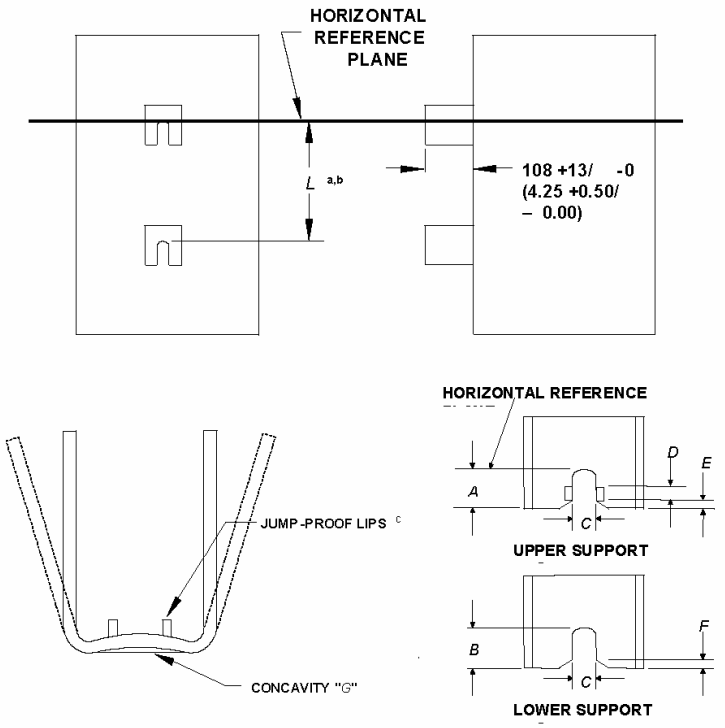
[b] 590 mm (23.25 in) spacing may be used when tank height will not permit the 895 mm (35.25 in) dimension.

[c] Dimensions apply to arrester mounting provisions described in 7.5.4.5.

Figure 2—Segment designations and interchangeability dimensions for three-phase transformers

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Dimensions[d]	Support lug A[e] mm (in)	Support lug B[e] mm (in)
A	44.5 (1.75)	44.5 (1.75)
B	44.5 (1.75)	63.5 (2.50)
C[f]	17.5 (0.69)	20.2 (0.80)
D	15.9 (0.63)	15.9 (0.63)
E	9.5 (0.38)	6.4 (0.25)
F	9.5 (0.38)	12.7 (0.50)
G	3.2 (0.13)	6.4 (0.25)

NOTE—Refer to Clause 7 for dimension tolerances. All dimensions are given in millimeters. Dimensions in parentheses are given in inches.

[a] See Figure 1 and Figure 2 for "L" dimension.

[b] Slots "L" dimension is spaced 20 mm (0.75 in) less than pole bolt spacing.

[c] Jump-proof lips on upper support only.

[d] The dimensions shown must be maintained to obtain a standard mounting and are not intended to show construction details except for slot dimensions.

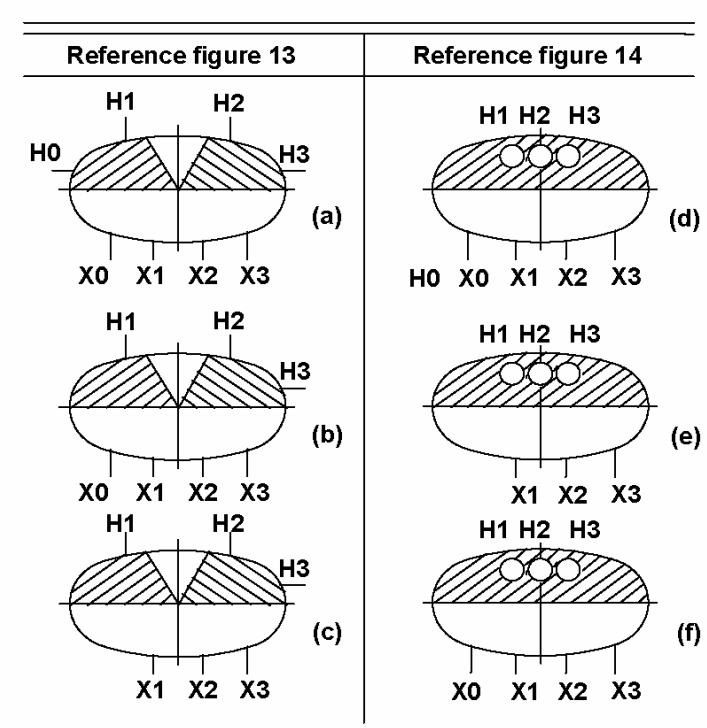
[e] "A" lugs to use 5/8 in bolts. "B" lugs to use 3/4 in bolts. This is in accordance with the specifications in the latest revision of IEEE Std C135.1.

[f] Tolerance for slot dimension "C" shall be ±0.4 mm (±0.016 in).

Figure 3—Support lugs A and B

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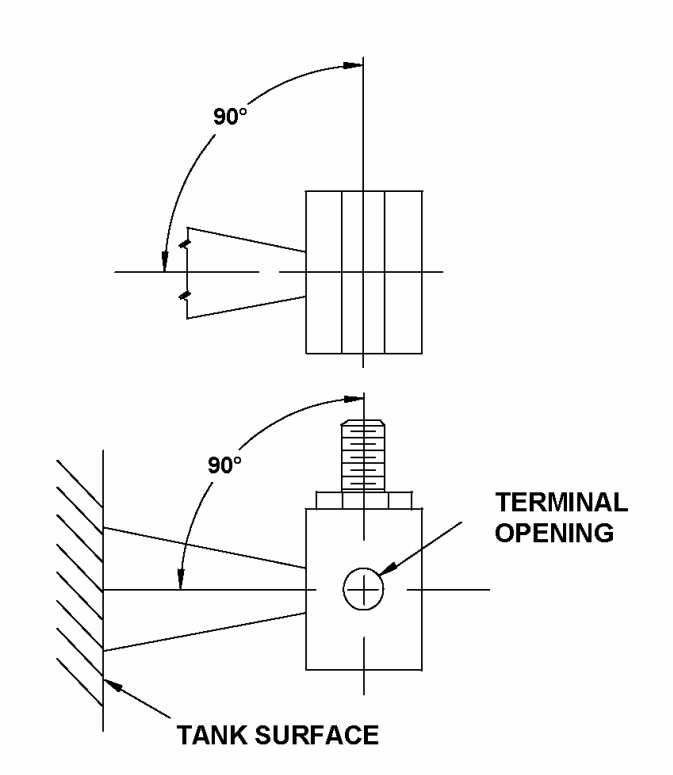
NOTE—See 7.1.1.

Figure 4—Number of terminals, description, and arrangement for three-phase transformers

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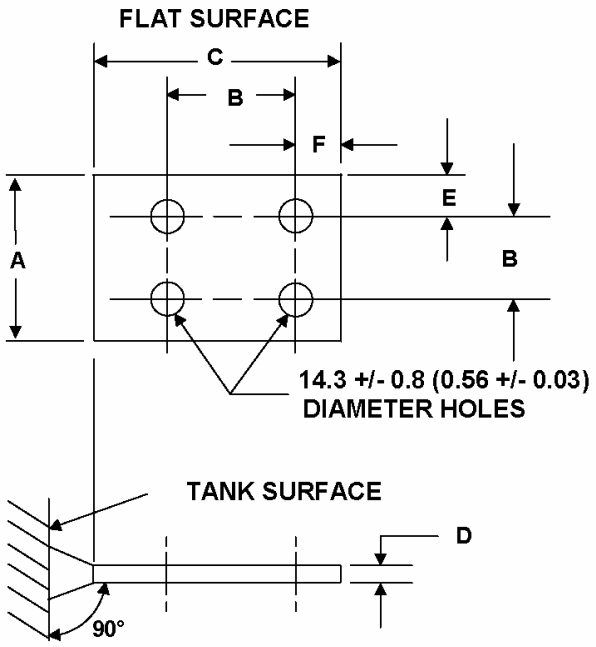


NOTE 1—Threaded parts of connector shall be removable without removing bushings.
NOTE 2—Connector clamping bolts shall be 3/8, 1/2, 5/8, or 3/4 NC threads, class 2 fit.
NOTE 3—One- or two-connector clamping bolts may be used, but U-bolts or J-bolts shall not be used.
NOTE 4—Terminal of low-voltage windings 600 V and below shall be arranged for vertical takeoff.
NOTE 5—Terminals are to be tin-plated and aluminum conductors are to be properly prepared.

Figure 5a—Terminal details—Eyebolt

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SPADE "H" and SPADE "J"

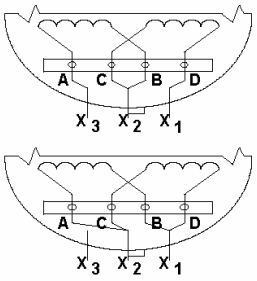
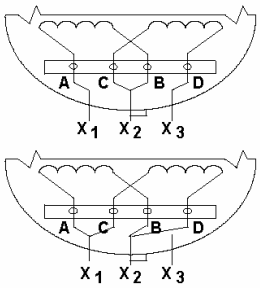
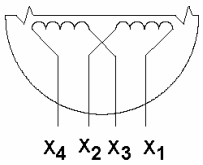
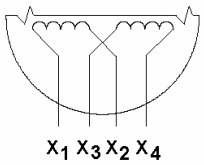
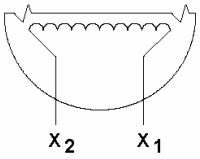
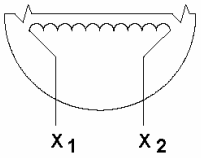
Dimension	Spade "H" mm (in)	Spade "J" mm (in)
A	88.9 (3.50)	101.6 (4.00)
B	44.5 ± 0.8 (1.75 ± 0.03)	44.5 ± 0.8 (1.75 ± 0.03)
C min	85.7 (3.38)	114.3 (4.50)
D min	6.4 (0.25)	9.5 (0.38)
E	22.2 (0.88)	28.6 (1.13)
F	15.9 (0.63)	28.6 (1.13)

NOTE 1—Corners and edges may be rounded.
NOTE 2—Refer to Clause 7 for dimensions tolerances. All dimensions are given in millimeters. Dimensions in parentheses are given in inches.

Figure 5b—Terminal details—Spade H and Spade J

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Description of connection	Additive polarity[a]	Subtractive polarity[b]
Three low-voltage external terminals suitable for series, multiple, or three wire operation 120/240 V 240/480 V		
Four low-voltage external terminals suitable for series, multiple, or three wire operation[c] 120/240 V 240/480 V		
Single low-voltage rating 277 V 2400 V 4800 V 7200 V 7620 V 7960 V		

NOTE—The H_1 terminal for either additive or subtractive polarity is located on the left-hand side when facing the low-voltage terminals.

[a] Polarity is additive for transformers 200 kVA and smaller having high-voltage windings 8660 V and below. See 7.3.1.

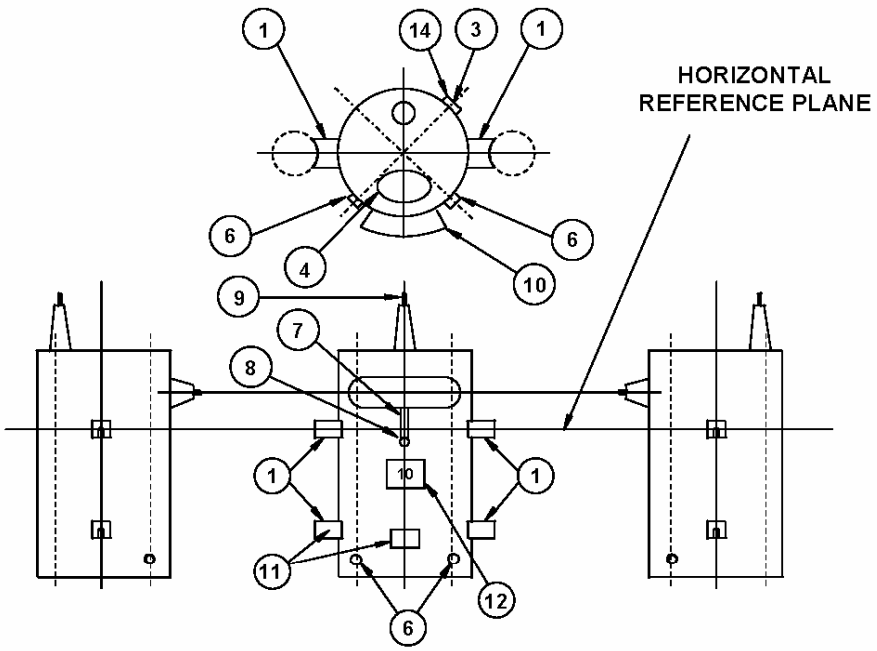
[b] Polarity is subtractive for transformers 200 kVA and smaller having high-voltage windings above 8660 V and for all transformers larger than 200 kVA. See 7.3.1.

[c] Connect X_2 to X_3 externally for series operation. Connect X_2 to X_4 and X_3 to X_1 externally for multiple operation.

Figure 6—Connections and polarity

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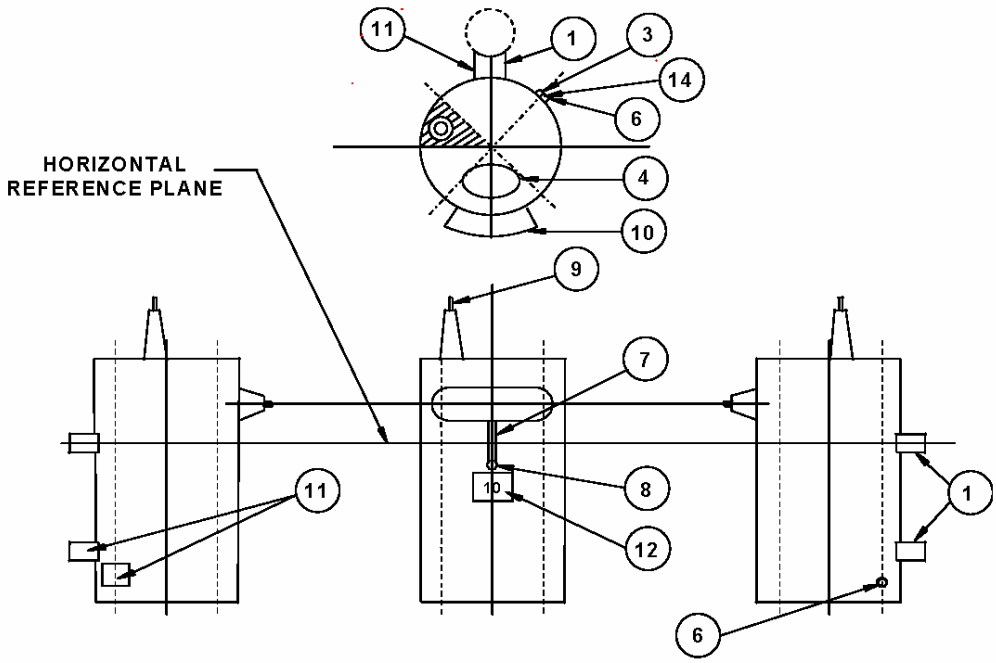
Item number	Section reference	Accessory equipment
1	7.5.2	Support lug—Type A for 10 kVA to 50 kVA
2	7.2.3	Liquid-level marking[a]
3	7.2.1	Tap changer (when specified)
4	7.5.1	Handhole in cover[b]
5	7.2.4	Lifting lugs[c]
6	7.5.4.1 & 7.5.4.2	Tank grounding provision & connector
7	7.5.4.3	Low-voltage grounding connection[d]
8	7.5.4.4	Low-voltage grounding provision[e]
9	7.1.1 & 7.1.2.1	High-voltage bushing terminals
10	7.1.1 & 7.1.2.2	Low-voltage bushing terminals & arrangement
11	7.3.4.1 & 7.3.4.2	Nameplate location—Type A
12	7.3.5	kVA rating on tank
13	7.2.5.1	Pressure-relief valve[f]
14	7.2.2	Series-multiple device (when specified)

NOTE 1—Refer to Table 2 and Table 3 for appropriate high-voltage ratings for this design.
NOTE 2—Low-voltage ratings—600 V and below.
[a] Not shown because it is inside tank.
[b] Supplied only on units with internal tap changers or series-multiple terminal boards.
[c] Not shown because location is not specified.
[d] For 120/240 V only.
[e] For 240/480 V and 277 V.
[f] Segment location not specified. Not required if cover design is in accordance with 7.2.5.2.

Figure 7—Single-phase 10 kVA to 50 kVA for pole mounting (two-position) single high-voltage cover bushings

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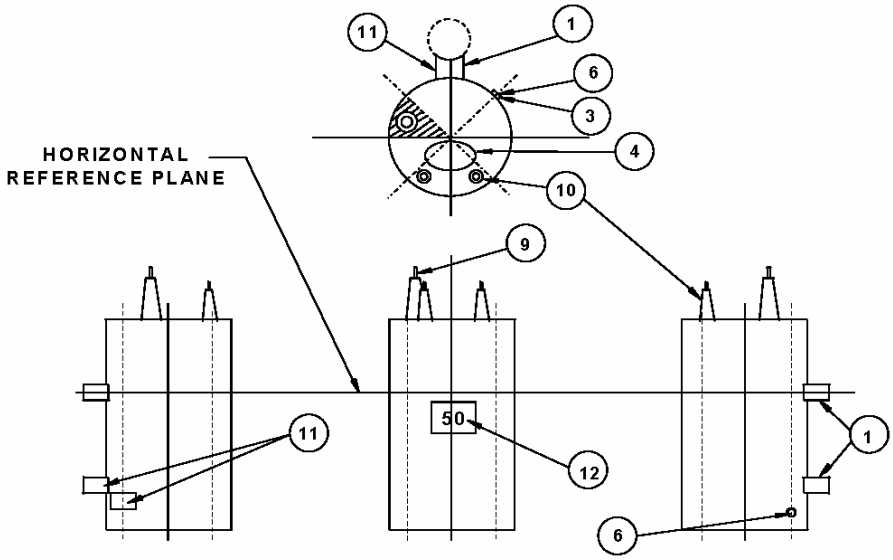
Item number	Section reference	Accessory equipment
1	7.5.2	Support lug—Type A for 10 kVA to 50 kVA
1	7.5.2	Support lug—Type B for 75 kVA to 500 kVA
2	7.2.3	Liquid-level marking[a]
3	7.2.1	Tap changer (when specified)
4	7.5.1	Handhole in cover[b]
5	7.2.4	Lifting lugs[c]
6	7.5.4.1 & 7.5.4.2	Tank grounding provision & connector
7	7.5.4.3	Low-voltage grounding connection[d]
8	7.5.4.4	Low-voltage grounding provision[e]
9	7.1.1 & 7.1.2.1	High-voltage bushing terminals
10	7.1.1 & 7.1.2.2	Low-voltage bushing terminals & arrangement
11	7.3.4.1 & 7.3.4.2	Nameplate location—Type A
12	7.3.5	kVA rating on tank
13	7.2.5.1	Pressure-relief valve[f]
14	7.2.2	Series-multiple device (when specified)

NOTE 1—Refer to Table 2 and Table 3 for appropriate high-voltage ratings for this design.
NOTE 2—Low-voltage ratings—600 V and below (series-multiple) and 5000 V and below (single ratio)
[a] Not shown because it is inside tank.
[b] Supplied only on units with internal tap changers or series-multiple terminal boards.
[c] Not shown because location is not specified.
[d] For 120/240 V only.
[e] For 240/480 V and 277 V.
[f] Segment location not specified. Not required if cover design is in accordance with 7.2.5.2.

Figure 8—Single-phase 10 kVA to 500 kVA for pole mountings (single-position) single high-voltage cover bushings

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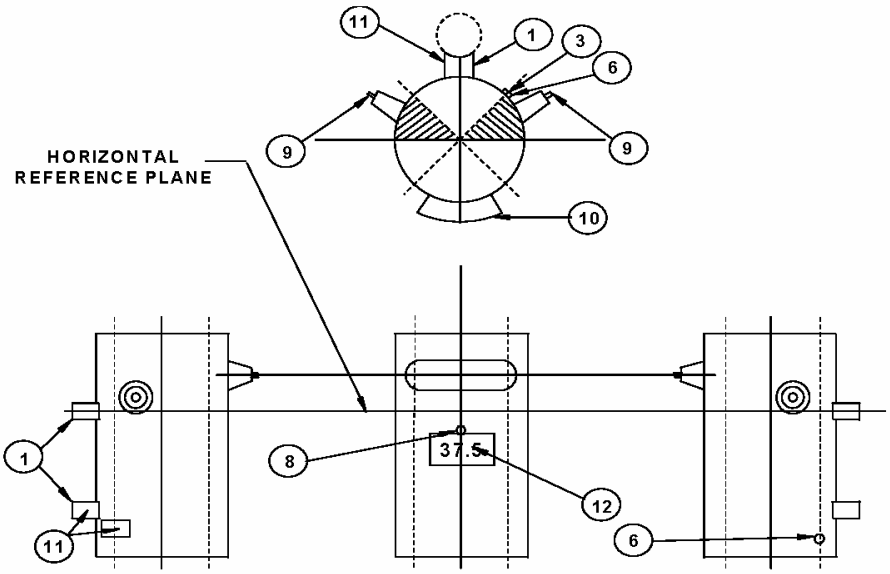
Item number	Section reference	Accessory equipment
1	7.5.2	Support lug—Type A for 50 kVA
1	7.5.2	Support lug—Type B for 75 kVA to 500 kVA
2	7.2.3	Liquid-level marking[a]
3	7.2.1	Tap changer (when specified)
4	7.5.1	Handhole in cover[b]
5	7.2.4	Lifting lugs[c]
6	7.5.4.1 & 7.5.4.2	Tank grounding provision & connector
9	7.1.1 & 7.1.2.1	High-voltage bushing terminals
10	7.1.1 & 7.1.2.2	Low-voltage bushing terminals & arrangement
11	7.3.4.1 & 7.3.4.2	Nameplate location—Type A
12	7.3.5	kVA rating on tank
13	7.2.5.1	Pressure-relief valve[d]

NOTE 1—Refer to Table 2 for appropriate high-voltage ratings for this design.
NOTE 2—Low-voltage ratings—above 5000 V.
[a] Not shown because it is inside tank.
[b] Supplied only on units with internal tap changers.
[c] Not shown because location is not specified.
[f] Segment location not specified. Not required if cover design is in accordance with 7.2.5.2.

Figure 9—Single-phase 50 kVA to 500 kVA for pole mounting (single-position) single high-voltage cover bushing, two low-voltage cover bushings

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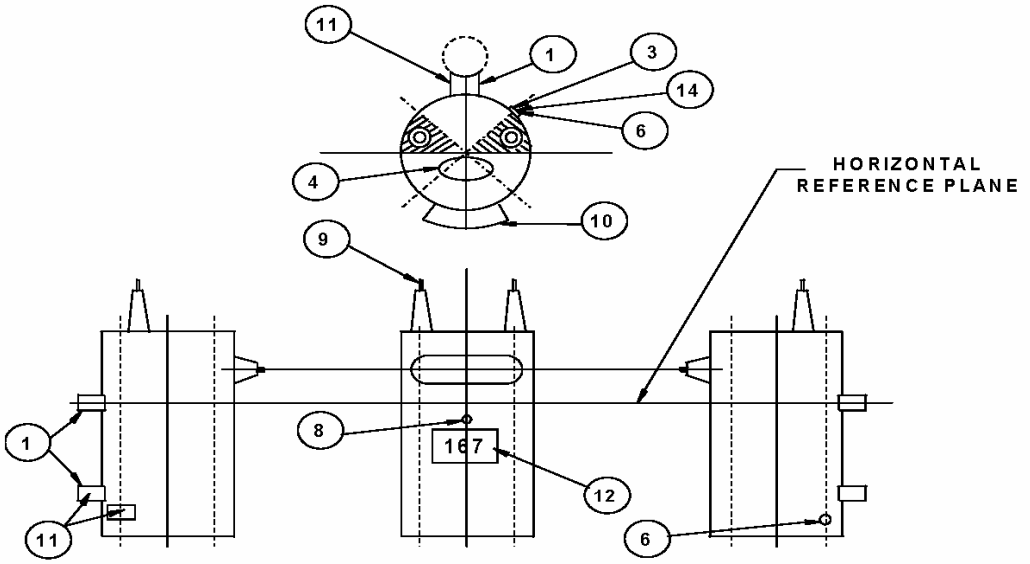
Item number	Section reference	Accessory equipment
1	7.5.2	Support lug—Type A for 10 kVA to 50 kVA
1	7.5.2	Support lug—Type B for 75 kVA to 500 kVA
2	7.2.3	Liquid-level marking[a]
3	7.2.1	Tap changer (when specified)
5	7.2.4	Lifting lugs[b]
6	7.5.4.1	Tank grounding provision
8	7.5.4.4	Low-voltage grounding provisions[c]
9	7.1.1 & 7.1.2.1	High-voltage bushing terminals
10	7.1.1 & 7.1.2.2	Low-voltage bushing terminals & arrangement
11	7.3.4.1 & 7.3.4.2	Nameplate location—Type A
12	7.3.5	kVA rating on tank
13	7.2.5.1	Pressure-relief valve[d]

NOTE 1—Refer to Table 2 for appropriate high-voltage ratings for this design.
NOTE 2—Low-voltage ratings—6000 V and below.
[a] Not shown because it is inside tank.
[b] Supplied only on units with internal tap changers.
[c] Low-voltage grounding provision not required on 250 kVA to 500 kVA.
[f] Segment location not specified. Not required if cover design is in accordance with 7.2.5.2.

Figure 10—Single-phase 10 kVA to 500 kVA for pole mounting (single-position) sidewall high-voltage bushings

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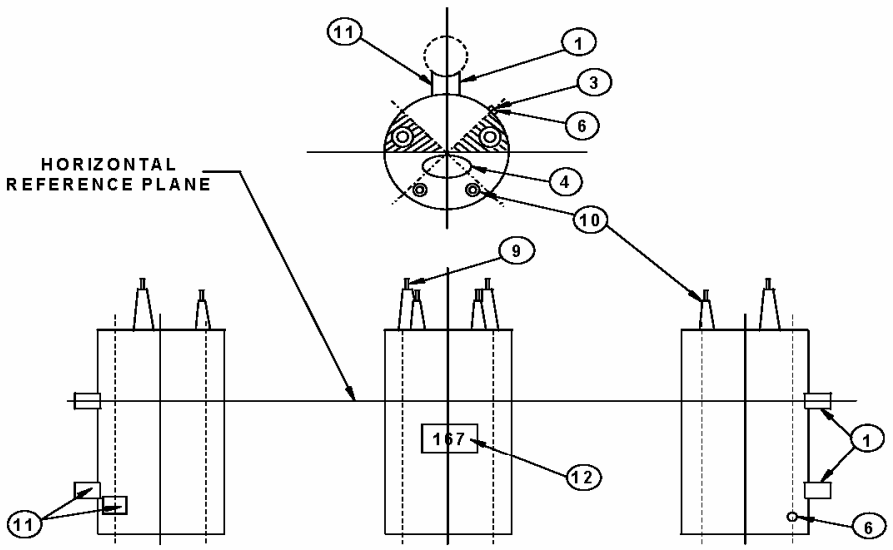
Item number	Section reference	Accessory equipment
1	7.5.2	Support lug—Type A for 10 kVA to 50 kVA
1	7.5.2	Support lug—Type B for 75 kVA to 500 kVA
2	7.2.3	Liquid-level marking[a]
3	7.2.1	Tap changer (when specified)
4	7.5.1	Handhole in cover[b]
5	7.2.4	Lifting lugs[c]
6	7.5.4.1	Tank grounding provision
8	7.5.4.4	Low-voltage grounding provisions[d]
9	7.1.1 & 7.1.2.1	High-voltage bushing terminals
10	7.1.1 & 7.1.2.2	Low-voltage bushing terminals & arrangement
11	7.3.4.1 & 7.3.4.2	Nameplate location—Type A
12	7.3.5	kVA rating on tank
13	7.2.5.1	Pressure-relief valve[e]
14	7.2.2	Series-multiple device (when specified)

NOTE 1—Refer to Table 2 and Table 3 for appropriate high-voltage ratings for this design.
NOTE 2—Low-voltage ratings—5000 V and below.
[a] Not shown because it is inside tank.
[b] Supplied only on units with internal tap changers or series-multiple terminal boards.
[c] Not shown because location is not specified.
[d] Low-voltage grounding provision not required on 250 kVA to 500 kVA.
[e] Segment location not specified. Not required if cover design is in accordance with 7.2.5.2.

Figure 11—Single-phase 10 kVA to 500 kVA for pole mounting (single-position) two high-voltage cover bushings

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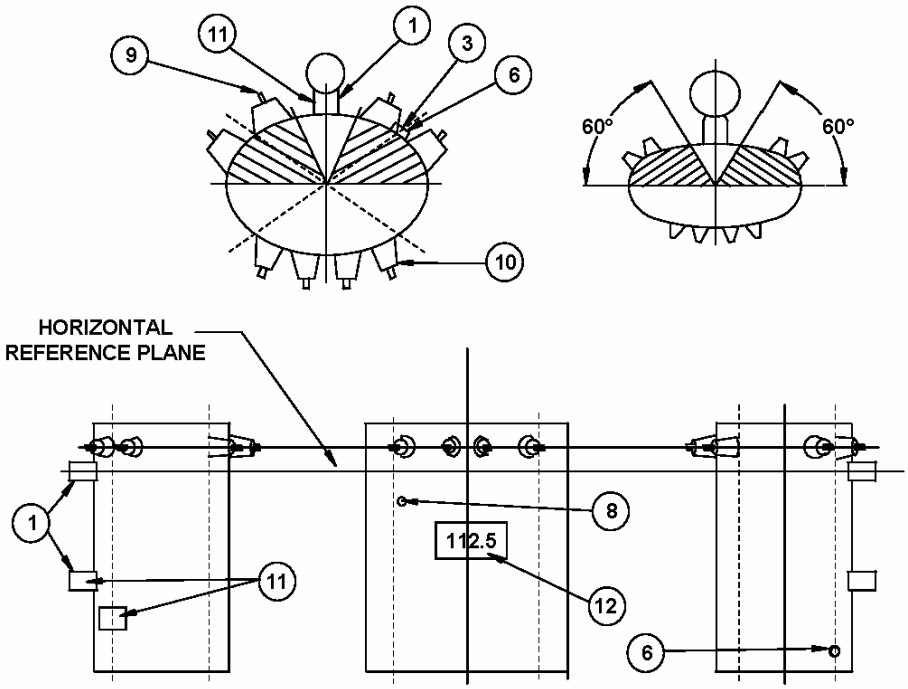


Item number	Section reference	Accessory equipment
1	7.5.2	Support lug—Type A for 50 kVA
1	7.5.2	Support lug—Type B for 75 kVA to 500 kVA
2	7.2.3	Liquid-level marking[a]
3	7.2.1	Tap changer (when specified)
4	7.5.1	Handhole in cover[b]
5	7.2.4	Lifting lugs[c]
6	7.5.4.1	Tank grounding provision
9	7.1.1 & 7.1.2.1	High-voltage bushing terminals
10	7.1.1 & 7.1.2.2	Low-voltage bushing terminals & arrangement
11	7.3.4.1 & 7.3.4.2	Nameplate location—Type A
12	7.3.5	kVA rating on tank
13	7.2.5.1	Pressure-relief valve[d]

NOTE 1—Refer to Table 2 and Table 3 for appropriate high-voltage ratings for this design.
NOTE 2—Low-voltage ratings—above 5000 V.
[a] Not shown because it is inside tank.
[b] Supplied only on units with internal tap changers.
[c] Not shown because location is not specified.
[d] Segment location not specified. Not required if cover design is in accordance with 7.2.5.2.

Figure 12—Single-phase 50 kVA to 500 kVA for pole mounting (single-position) two high-voltage cover bushings, two low-voltage cover bushings

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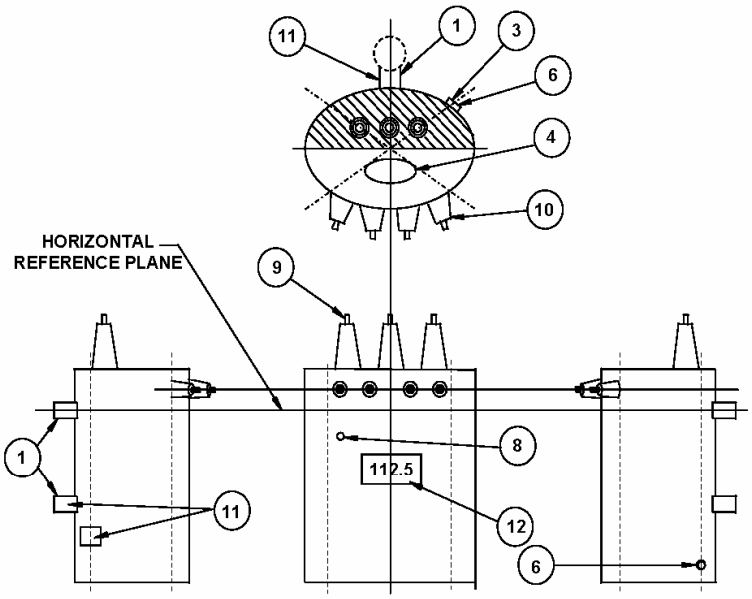


Item number	Section reference	Accessory equipment
1	7.5.2	Support lug—Type A for 30 kVA
1	7.5.2	Support lug—Type B for 45 kVA to 300 kVA[a]
2	7.2.3	Liquid-level marking[b]
3	7.2.1	Tap changer (when specified)
5	7.2.4	Lifting lugs[c]
6	7.5.4.1	Tank grounding provision
8	7.5.4.4	Low–voltage grounding provision
9	7.1.1 & 7.1.2.1	High-voltage bushing terminals
10	7.1.1 & 7.1.2.2	Low-voltage bushing terminals
11	7.3.4.1 & 7.3.4.2	Nameplate location
12	7.3.5	kVA rating on tank
13	7.2.5.1	Pressure-relief valve[d]

NOTE 1—To maintain satisfactory mechanical and electrical clearances on small kilovolt-ampere ratings, it is permissible to encroach on the shaded area.
NOTE 2—Refer to Table 4 for appropriate high-voltage ratings for this design.
NOTE 3—Low-voltage ratings: 600 V and below.
[a] Support lugs are not required on 500 kVA.
[b] Not shown because it is inside tank.
[c] Not shown because location is not specified.
[d] Segment location not specified. Not required if cover design is in accordance with 7.2.5.2.

Figure 13—Three-phase 30 kVA to 300 kVA for pole mounting and 500 kVA for platform mounting sidewall high-voltage bushings

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Item number	Section reference	Accessory equipment
1	7.5.2	Support lug—Type A for 30 kVA
1	7.5.2	Support lug—Type B for 45 kVA to 300 kVA[a]
2	7.2.3	Liquid-level marking[b]
3	7.2.1	Tap changer (when specified)
4	7.5.1	Handhole in cover[c]
5	7.2.4	Lifting lugs[d]
6	7.5.4.1	Tank grounding provision
8	7.5.4.4	Low–voltage grounding provision
9	7.1.1 & 7.1.2.1	High-voltage bushing terminals
10	7.1.1 & 7.1.2.2	Low-voltage bushing terminals & arrangement[e]
11	7.3.4.1 & 7.3.4.2	Nameplate location—Type A
12	7.3.5	kVA rating on tank
13	7.2.5.1	Pressure-relief valve[f]

NOTE 1—To maintain satisfactory mechanical and electrical clearances on small kilovolt-ampere ratings, it is permissible to encroach upon the shaded area.
NOTE 2—Refer to Table 4 for appropriate high-voltage ratings for this design.
NOTE 3—Low-voltage ratings—5000 V and below.
[a] Support lugs are not required on 500 kVA.
[b] Not shown because it is inside tank.
[c] Supplied only on units with internal tap changers.
[d] Not shown because location is not specified.
[e] For above 600 V, 7.1.2.1 is applicable.
[f] Segment location not specified. Not required if cover design is in accordance with 7.2.5.2.

Figure 14—Three-phase 30 kVA to 300 kVA for pole mounting and 500 kVA for platform mounting high-voltage cover bushings

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Annex A

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Auxiliary Mounting Devices

Auxiliary mounting devices for use with transformers covered by this standard are not manufactured, stocked, or furnished by manufacturers of transformers. Their specifications were developed prior to 1953 by the Joint Committee of the Edison Electric Institute and the National Electrical Manufacturers Association on Standards for Distribution Transformers for use with single-phase transformers 100 kVA and smaller and three-phase transformers 112-1/2 kVA and smaller.

At that time, larger transformers were furnished with a bracing lug, rather than support lug C, and the bracing lug was not designed to carry the weight of the transformer. Furthermore, the maximum-size transformer with support lug B was 50 kVA single-phase and 45 kVA three-phase.

During the ensuing years, advances in technology have reduced sizes and weights of distribution transformers, and support lug B is presently furnished with 167 kVA single-phase and 75 kVA three-phase transformers. The availability, from certain pole-line hardware manufacturers, of cluster mounts that include adapter plates for support lug C (see Figure A.1) used in transformer installations, and the utilization of armless pole-line construction with direct pole mounting of transformers with support lugs A and B have virtually eliminated the use of crossarm hangers.

The dimensions used in the figures in this annex have not been converted to metric equivalents due to the limited usage of these materials.

The following is included in this annex as an aid to those users who have transformer installations utilizing the following auxiliary mounting devices:

a) Type-C adapter plates (see Figure A.2) are for direct pole mounting of transformers having Type-C support lugs, subject to the stress limitations of the supporting structure. If such adapter plates are to be used, it is suggested that the user contact the manufacturer for safe loading capacities.

   NOTE—Type-C support lugs were removed from IEEE Std C57.12.20 in 2004.

b) Crossarm hanger T1 (see Figure A.3) is for crossarm mounting of transformers having Type-A support lugs with a vertical spacing of 11-1/4 in.

c) Kicker K1 (see Figure A.3) is for use with crossarm hanger T1.

d) Crossarm hanger T2 (see Figure A.4) is for crossarm mounting of transformers having Type-A or Type-B support lugs with a vertical spacing of 23-1/4 in.

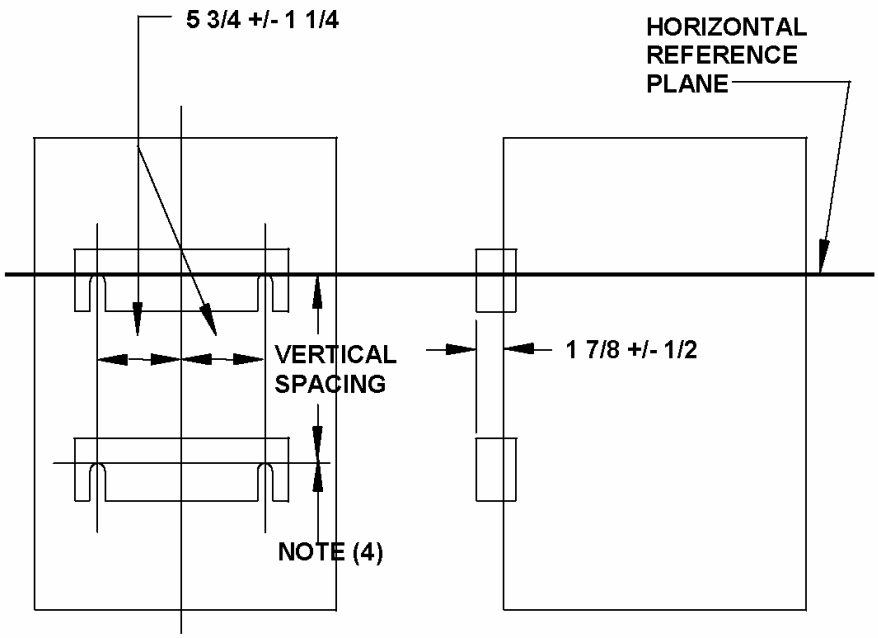
e) Kicker K2 (see Figure A.4) is for use with crossarm hanger T2.

f) Crossarm hanger C1 (see Figure A.5) is for crossarm mounting of transformers having Type-C support lugs with a vertical spacing of 24 in.

g) Crossarm hanger C3 (see Figure A.5) is for crossarm mounting of transformers having Type-C support lugs with a vertical spacing of 36 in.

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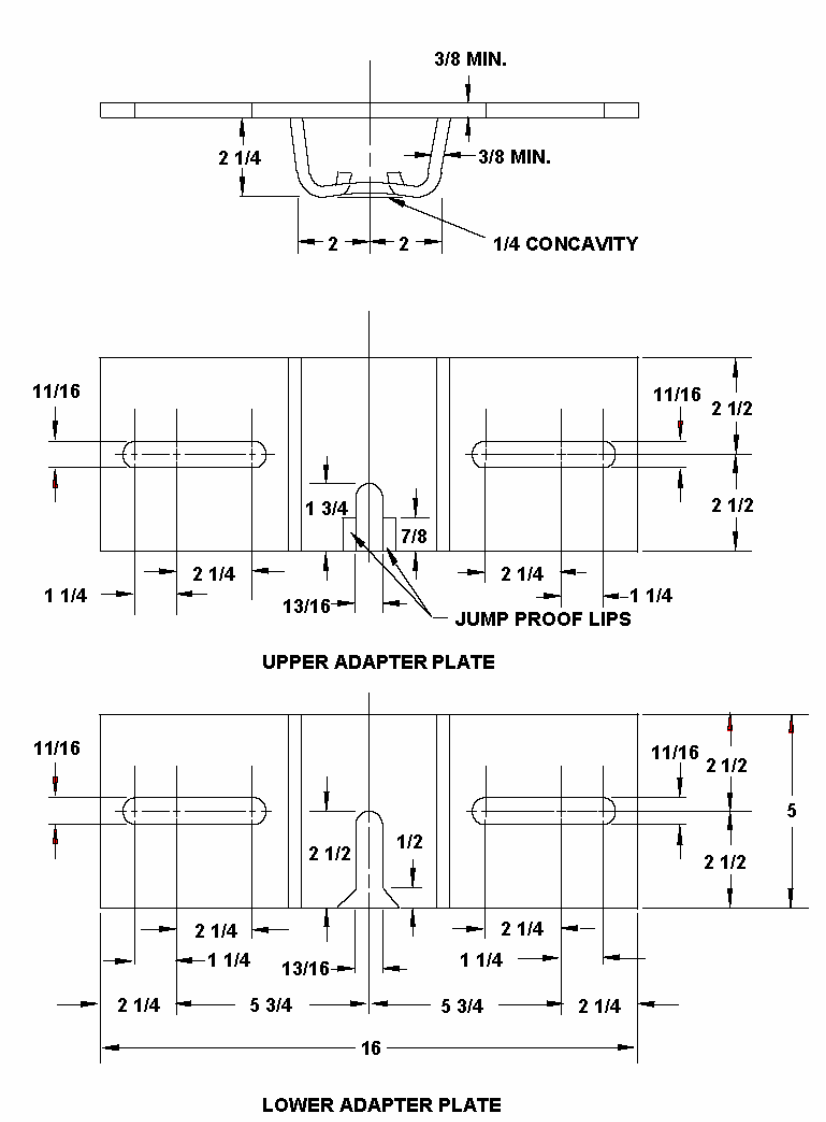


NOTE 1—Support lugs attached to transformer and intended for bolting to adapter plates for direct pole mounting or to conventional crossarm hangers.
NOTE 2—Slots shall be suitable for 5/8 in bolts that are in accordance with the requirements of the latest revision of IEEE Std C135.1.
NOTE 3—Support lug faces shall be in one plane.
NOTE 4—For “vertical spacing" dimension, see Item f)and Item g) in this annex..
NOTE 5—The dimensions shown shall be maintained to obtain a standard mounting and are not intended to show details of construction.
NOTE 6—All dimensions are shown in inches.

Figure A.1—Support lug C

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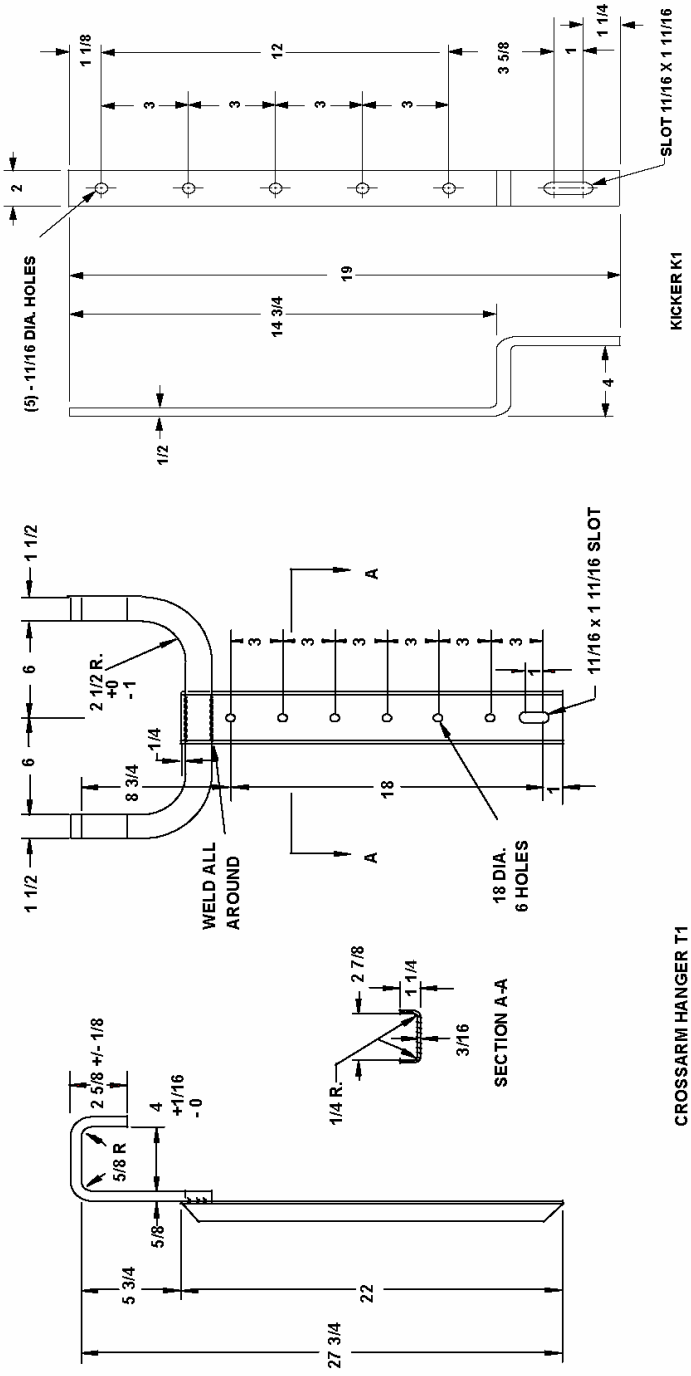


NOTE 1—Upper and lower adapter plates are identical, except bolt slot is 3/4 in longer and jump-proof lips are omitted on lower plate and bottom of slot is chamfered.
NOTE 2—Use 5/8 in bolts to bolt adapter plates to transformer support lugs. Use 3/4 in bolts to bolt adapter plates to pole.
NOTE 3—For ease of inserting pole bolts in adapter plate slots and for tolerance in boring pole bolt holes, the distance between the tops of bolt slots is 3/4 in less than the bolt spacing, and lower edges of slots are chamfered on lower adapter plates.
NOTE 4—Tolerances, except where indicated otherwise, shall be ±1/16 in, except that adapter plate tolerances shall be ±1/64 in.
NOTE 5—Adapter plates, nuts, and bolts shall be hot-dip galvanized, with finished dimensions that are in accordance with the specifications of the latest revision of IEEE Std C135.1
NOTE 6—Adapter plates must provide a safety factor of five as described in 7.5.2.
NOTE 7—All dimensions are shown in inches.

Figure A.2—Type-C adapter plates

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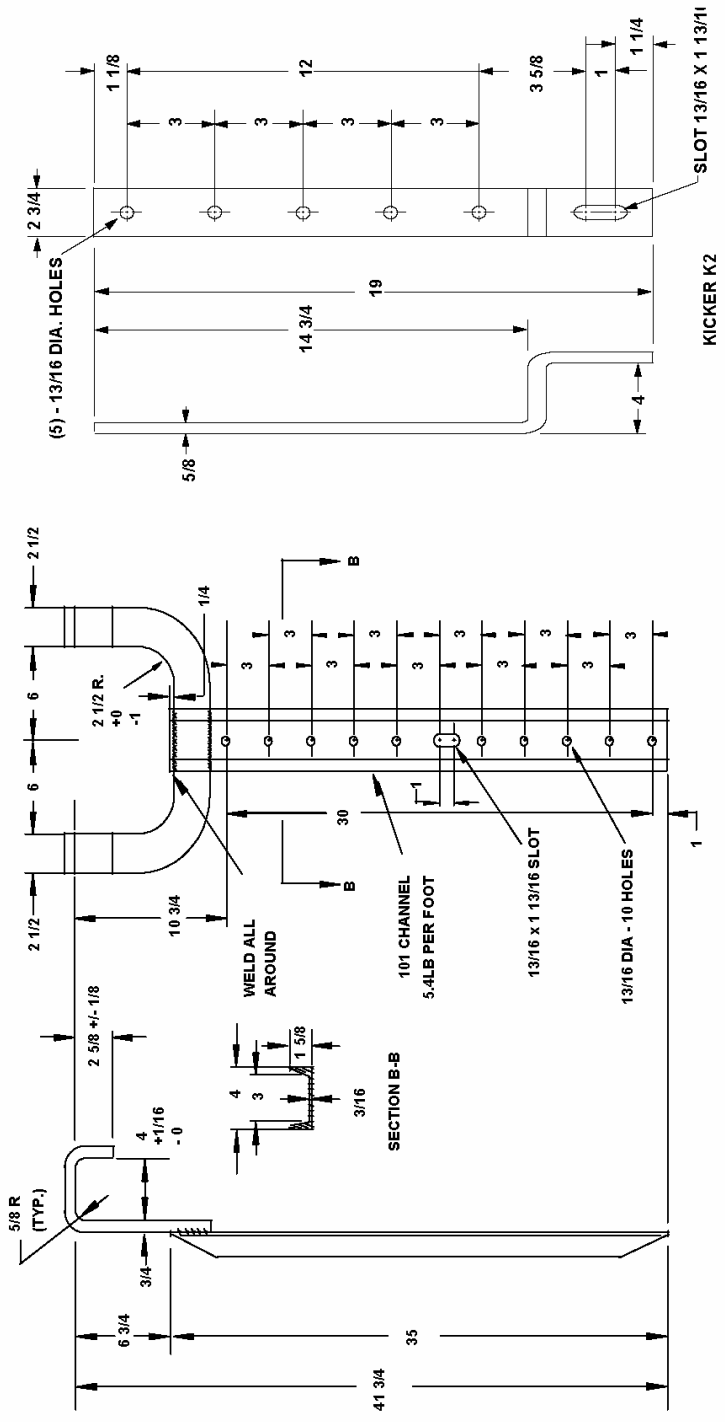
Crossarm hanger	Kicker size	Number of 5/8 inch bolts and nuts	
		Hanger	Kicker
T1	K1	2	1

NOTE 1—Tolerances, except where indicated otherwise, shall be ±1/16 in, except that bolt hole and slot tolerances shall be ±1/64 in.
NOTE 2—All bolts and nuts to be square-headed, NC threads. 5/8 in bolts, 2-1/2 in long, and threaded within 3/16 in or less of bolt head.
NOTE 3—All T-crossarm hangers, kickers, nuts, and bolts shall be hot-dip galvanized.
NOTE 4—All dimensions are shown in inches.

Figure A.3—T-Crossarm hangers and kickers (T1 and K1)

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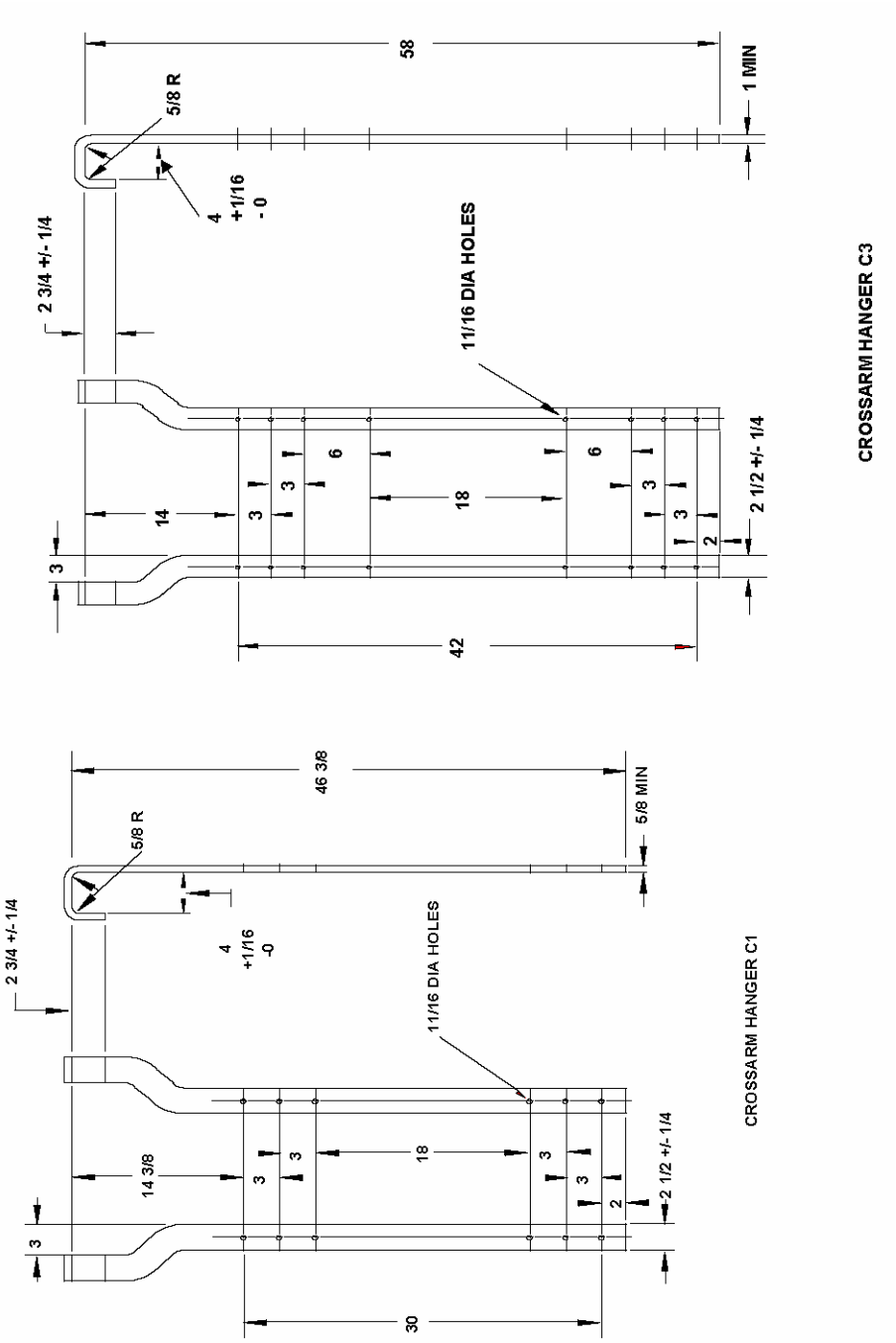
Crossarm hanger	Kicker size	Number of 3/4 inch bolts and nuts	
		Hanger	Kicker
T2	K2	2	1

NOTE 1—Tolerances, except where indicated otherwise, shall be ±1/16 in, except that bolt hole and slot tolerances shall be ±1/64 in.
NOTE 2—All bolts and nuts to be square-headed, NC threads, 3/4 in bolts, 2-1/2 in long, and threaded within 3/8 in or less of bolt head.
NOTE 3—All T-crossarm hangers, kickers, nuts, and bolts shall be hot-dip galvanized.
NOTE 4—All dimensions are shown in inches.

Figure A.4—T-Crossarm hangers and kickers (T2 and K2)

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NOTE 1—Crossarm hangers shall be hot-dip galvanized.
NOTE 2—C1 and C3 crossarm hangers each to be equipped with four 5/8 in NC square head bolts, 2-1/2 in long, and threaded to within 3/16 in or less of bolt head, and square nuts.
NOTE 3—Tolerances, except where indicated otherwise, shall be ±1/16 in, except that bolt hole and slot tolerances shall be ±1/64 in.
NOTE 4—All dimensions are shown in inches.

Figure A.5—Crossarm hangers

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Annex B

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Bibliography

The following related publications are listed for information only and are not essential for the completion of the requirements of this standard: (Latest revision shall apply)

[B1] IEEE 100™, *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition.[1]

[B2] IEEE Std C57.12.80™-2002, IEEE Standard Terminology for Power and Distribution Transformers.

[B3] IEEE Std C135.1™, IEEE Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction.

[B4] MIL-STD-209C, Swinging Eyes and Attachments for Lifting and Tying Down Military Equipment. (Available from Commanding Officer, Naval Publications and Forms).[2]

[B5] NEMA MG2, Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors.[3]

[B6] NEMA TR 1, Transformers, Regulators, and Reactors.

[1] IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).
[2] MIL publications are available from Customer Service, Defense Printing Service, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111-5094, USA.
[3] NEMA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (http://global.ihs.com/).

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