



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

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(Revision of
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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

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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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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/>).

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.

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

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.

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).

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) $\pm$ 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 pressure⁶

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

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