IEEE Std C57.12.23-1992
(Revision of ANSI C57.12.23-1986)

IEEE Standard for Transformers—Underground-Type, Self-Cooled, Single-Phase Distribution Transformers With Separable, Insulated, High-Voltage Connectors; High Voltage (24 940 GrdY/14 400 V and Below) and Low Voltage (240/120 V, 167 kVA and Smaller)

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**Transformers Committee
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Approved March 19, 1992

IEEE Standard Board

Abstract: Electrical, dimensional, and mechanical characteristics and certain safety features of single-phase, 60 Hz, mineral-oil-immersed, self-cooled, distribution transformers with separable insulated high-voltage connectors are covered. Ratings, testing, and construction are discussed. These transformers are generally used for step-down purposes from an underground primary cable supply and are suitable for occasional submerged operation. The intent is to provide a basis for determining their performance, interchangeability, and safety, and for their selection. This standard does not cover the electrical and mechanical requirements of accessory devices that may be supplied with the transformer.
Keywords: distribution, interchangeability, performance, safety, transformers

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Foreword

(This foreword is not a part of IEEE Std C57.12.23-1992, IEEE Standard for Transformers—Underground-Type, Self-Cooled, Single-Phase Distribution Transformers With Separable, Insulated, High-Voltage Connectors; High Voltage [24 940 GrdY/14 400 V and Below] and Low Voltage [240/120 V, 167 kVA and Smaller].)

The Accredited Standards Committee on Transformers, Regulators, and Reactors, C57, has for a number of years been developing and correlating standards on transformers and regulators. The data used in this work has been gathered from many sources, including the standards of the Institute of Electrical and Electronics Engineers and the National Electrical Manufacturers Association, reports of committees of the Edison Electric Institute, and others.

This standard was prepared by the Working Group of the Subcommittee on Distribution Transformers, Overhead and Pad-Mounted, C57.12.2, and is a revision of the 1986 edition. Added to this revision are sections on storage and installation with emphasis being placed on the actual position when stored and the consideration of the angle of tilt when installed.

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Contents

IEEE Standard for Transformers—Underground-Type, Self-Cooled, Single-Phase Distribution Transformers With Separable, Insulated, High-Voltage Connectors; High Voltage (24 940 GrdY/14 400 V and Below) and Low Voltage (240/120 V, 167 kVA and Smaller)

1. Introduction

1.1 Scope. This standard is intended for use as a basis for determining performance, interchangeability, and safety of the equipment covered, and to assist in the proper selection of such equipment.

1.2 Purpose. This standard covers certain electrical, dimensional, and mechanical characterisitics and takes into consideration certain safety features of single-phase, 60 Hz, mineral-oil-immersed, self-cooled, distribution transformers with separable insulated high-voltage connectors. These transformers are rated 167 kVA and smaller, with high voltages of 24 940 Grd Y/14 400 V and below for operation between one phase and grounded neutral and with low voltages of 240/120 V. These transformers are generally used for step-down purposes from an underground primary cable supply and are suitable for occasional submerged operation.

NOTE: Refer to latest federal regulations concerning polychlorinated biphenyl (PCB) contamination in transformers.

1.3 General. This standard does not cover the electrical and mechanical requirements of any accessory devices that may be supplied with the transformer.

2. References

This standard shall be used in conjunction with the following publications. When these publications are superseded by an approved revision, the revision shall apply:

[1] ANSI C57.12.20-1988, American National Standard for Overhead-Type Distribution Transformers, 500 kVA and Smaller: High Voltage, 34 500 Volts and Below; Low Voltage, 7970/13 800 Y Volts and Below.[1]

[2] ANSI C57.12.28-1988, American National Standard for Switchgear and Transformers—Pad-Mounted Equipment—Enclosure Integrity.

[3] ANSI C57.12.70-1978 (Reaff 1987), American National Standard Terminal Markings and Connections for Distribution and Power Transformers.

[4] ICEA S-66-524/NEMA WC7-1991, Standard for Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.[2]

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[1] ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[2] ICEA/NEMA publications are available from ICEA, P.O. Box 411, South Yarmouth, MA 02664, USA, or from the National Electrical Manufacturers Association, 2101 L St., NW, Washington, DC 20037, USA.

[5] IEEE Std C57.12.00-1987, IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers (ANSI).[3]

[6] IEEE Std C57.12.80-1978 (Reaff 1986), IEEE Standard Terminology for Power and Distribution Transformers (ANSI).

[7] IEEE Std C57.12.90-1987, IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers; and Guide for Short-Circuit Testing of Distribution and Power Transformers (ANSI).

[8] IEEE Std C57.91-1981 (Reaff 1991), IEEE Guide for Loading Mineral-Oil-Immersed Overhead and Pad-Mounted Distribution Transformers Rated 500 kVA and Less with 65 °C or 65 °C Average Winding Rise (ANSI).

[9] IEEE Std 386-1985 (Reaff 1991), IEEE Standard for Separable Insulated Connectors for Power Distribution Systems Above 600 V (ANSI).

3. Ratings

3.1 Kilovoltampere Ratings. Kilovoltampere ratings shall be continuous and based on not exceeding an average winding temperature rise of 55 °C and a hottest-spot temperature rise of 70 °C. The temperature rise of the insulating oil shall be measured near the top of the tank and shall not exceed 55 °C. The transformers shall have a temperature-rise insulation system of 65 °C.

Kilovoltampere ratings shall be as follows: 25, 37-1/2, 50, 75, 100, 167

The kilovoltampere ratings for transformers conforming to this standard shall be suitable for continuous operation at the rated kilovoltamperes, provided that the temperature of the cooling air (enclosure ambient temperature) does not exceed 50° C and the average temperature of the cooling air does not exceed 40 °C for any 24-hour period.

3.2 Voltage Ratings and Tap Ratings

3.2.1 Voltage ratings shall be in accordance with Table 1 and 6.2.1.

3.2.2 No taps shall be provided.

4. Basic Lightning Impulse Insulation Levels and Dielectric Test Levels

4.1 Basic lightning impulse insulation levels (BILs) shall be in accordance with Table 1 and 6.2.1.

4.2 Dielectric test levels shall be in accordance with the distribution levels in Section 4 of IEEE Std C57.12.00-1987 [5][4] and IEEE Std C57.12.90-1987 [7].

5. Tests

5.1 General. Except as specified in 5.2, tests shall be performed as specified in IEEE Std C57.12.00-1987 [5] and IEEE Std C57.12.90-1987 [7].

[3]IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P. O. Box 1331, Piscataway, NJ 08855-1331, USA.

[4]The numbers in brackets refer to those of the references in Section 2.

Table 1
Transformer and Connector High-Voltage Ratings and Electrical Characteristics

Transformer		Electrical Characteristics of the Completely Assembled High-Voltage Connectors*			
		High-Voltage Rating†			
High-Voltage Ratings (V)	BIL (kV)	Phase-to-Ground (kV)	Phase-to-Ground/ Phase-to-Phase (kV)	BIL (kV)	60 Hz, Dry, 1 min Withstand (kV)
4 160 Grd Y/2 400	60	8.3	8.3/14.4	95	34
8 320 Grd Y/4 800	75	8.3	8.3/14.4	95	34
12 000 Grd Y/6 930	95	8.3	8.3/14.4	95	34
12 470 Grd Y/7 200	95	8.3	8.3/14.4	95	34
13 200 Grd Y/7 620	95	8.3	8.3/14.4	95	34
13 800 Grd Y/7 970	95	8.3	8.3/14.4	95	34
16 340 Grd Y/9 430	95	8.3 or 15.2‡	8.3/14.4 or 15.2/26.3‡	95 or 125‡	34 or 40‡
22 860 Grd Y/13 200	125	15.2	15.2/26.3	125‡	40
23 900 Grd Y/13 800	125	15.2	15.2/26.3	125	40
24 940 Grd Y/14 400	125	21.1	21.1/36.6	150	40

* For complete connector rating, see IEEE Std 386-1985 [9].

† Transformers are suitable for connectors with phase-to-ground or phase-to-ground/phase-to-phase high-voltage ratings as listed.

‡ The required connector rating is to be specified.

5.2 Dielectric Tests. No applied-potential test is required on high-voltage windings of units designed for use phase to ground.

Induced-potential tests shall be performed by applying between the terminals of one winding a voltage that will develop from the high-voltage line terminals to ground a voltage of 1000 V plus 3.46 times the rates transformer winding voltage, but in no case shall the line-to-ground voltage developed exceed 40 000 V for 125 kV BIL. For this test, the neutral terminal shall be grounded.

6. Construction

6.1 General. The transformers covered in this standard shall include high-voltage bushings and low-voltage terminals as described in 6.2.

Devices such as switch handles, tap changers, separable connectors, and replaceable fuses, which are designed for operation after the transformer is in place, shall be located on the transformer so that they can be operated from above with hot-line tools.

6.1.1 Construction of the units shall be such that they can be lifted and lowered into place in a suitably designed and constructed enclosure having a minimum diameter of 36 inches. To allow for cabling space and proper air flow for cooling, the transformers covered by this standard shall not have overall diameters in excess of 30 inches for sizes 100 kVA and smaller, or overall diameters in excess of 33 inches for 167 kVA.

6.1.2 The transformer tank, cover, and all external appurtenances shall be of corrosion-resistant material, unless they are otherwise rendered corrosion-resistant.

6.1.3 Corrosion-resistant base bars or other suitable means shall be provided on the transformer tank to protect the bottom of the tank while in transit and when installed in the underground enclosure. Minimum bar height is 1.00 inch.

6.1.4 For the purpose of locating terminations and operating devices, the plan view of the transformer is divided into four segments with the segments numbered in a clockwise direction. See Fig 1.

6.1.5 The lifting provisions shall be permanently attached and arranged on the tank to provide a distributive balanced lift in a vertical direction for the completely assembled transformer; they shall be designed to provide a safety factor of 5. This safety factor of 5 is the ratio of the ultimate stress of the material used to the working stress. The working stress is the maximum combined stress developed in the lifting provisions by the static load of the comletely assembled transformer.

6.2 Connectors and Terminals

6.2.1 The electrical characteristics of the completely assembled high-voltage connectors shall be as shown in Table 1. The electrical characteristics and clearance of the completely assembled low-voltage terminals shall be as follows:

Low-voltage rating, 240/120 V
Basic lightning impulse insulation level, 30 kV
60 Hz, dry, 1 min withstand voltage, 10 kV

6.2.3 Separable insulated high-voltage connectors shall be provided for connection to the distribution system. The high-voltage connectors shall consist of either bushing wells, bushing wells with bushing inserts, or integral bushings, as specified. A cable accessory parking stand shall be provided. For specific details concerning high-voltage separable connectors and cable accessory parking stands, refer to IEEE Std 386-1985 [9].

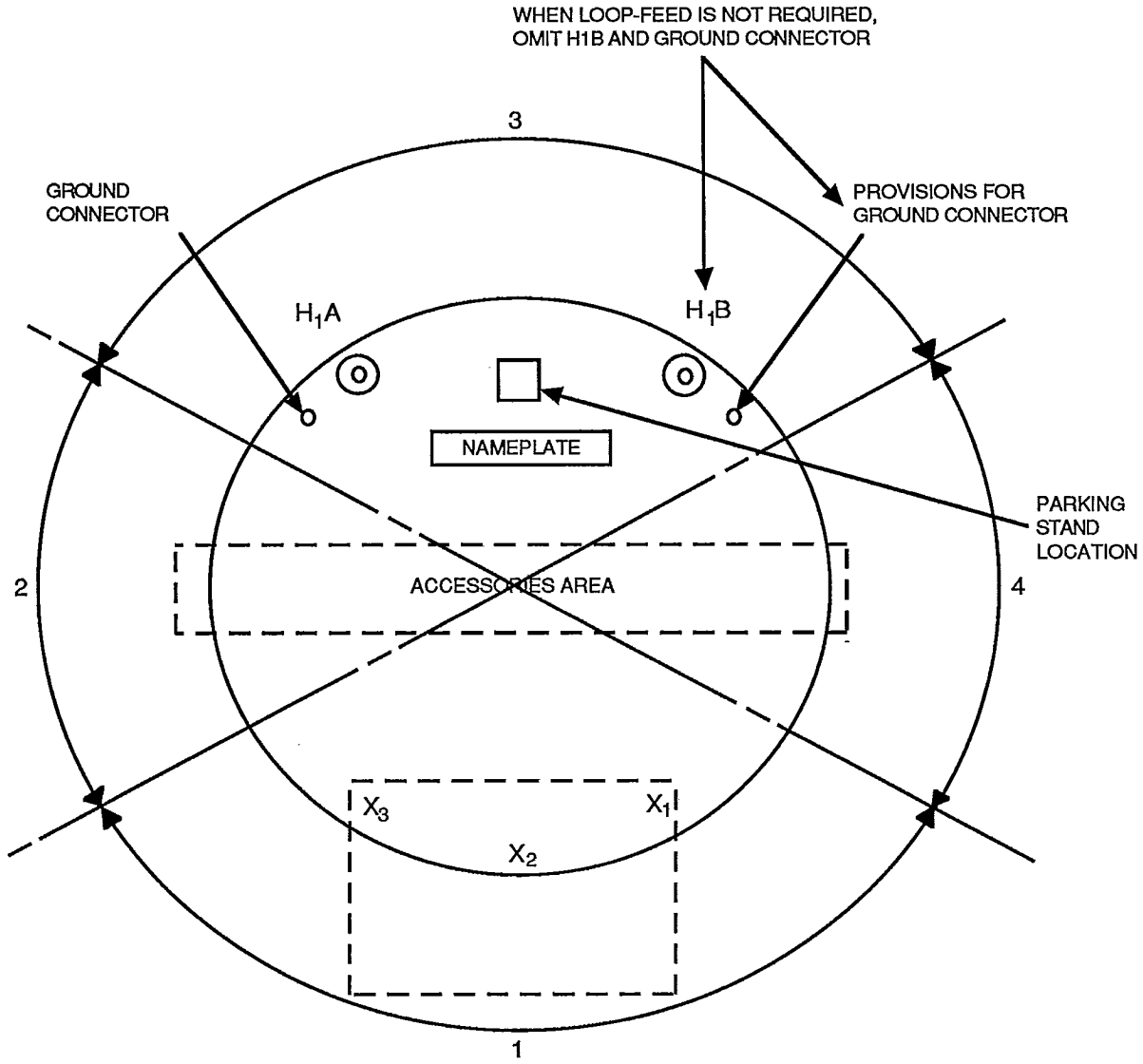
Separable insulated high-voltage connectors that are designed for operation after the transformer is in place shall be located so that they can be operated with hot-line tools.

6.2.4 The H_2 end of the high-voltage winding shall be connected to the tank internally. This connection shall be independent of all other electrical connections.

6.2.5 Three low-voltage cable leads (six for 167 kVA) extending 14 inches above the top of the cover shall be provided and arranged for vertical takeoff. Cable insulation shall be in accordance with ICEA S-66-524/NEMA WC7-1991 [4] or functional equivalent for continuous operation at a minimum of 90 °C and 600 V. Cable flexibility shall be such that bending into an arc having a radius of 12 inches can be accomplished without overstressing the low-voltage bushing. Cable sizes shall be as follows:

kVA Rating	Copper Cable Size
25	2/0 AWG
37-1/2, 50	4/0 AWG
75, 100	500 kcmil
167	500 kcmil (2/terminal)

When spade terminals are specified (one per terminal), they shall be in accordance with Fig 2.



NOTES:

(1) Low voltage shown for additive polarity transformers. Location of X_1 and X_3 are reversed for subtractive polarity. For more information, refer to ANSI C57.12.20-1988 [1].

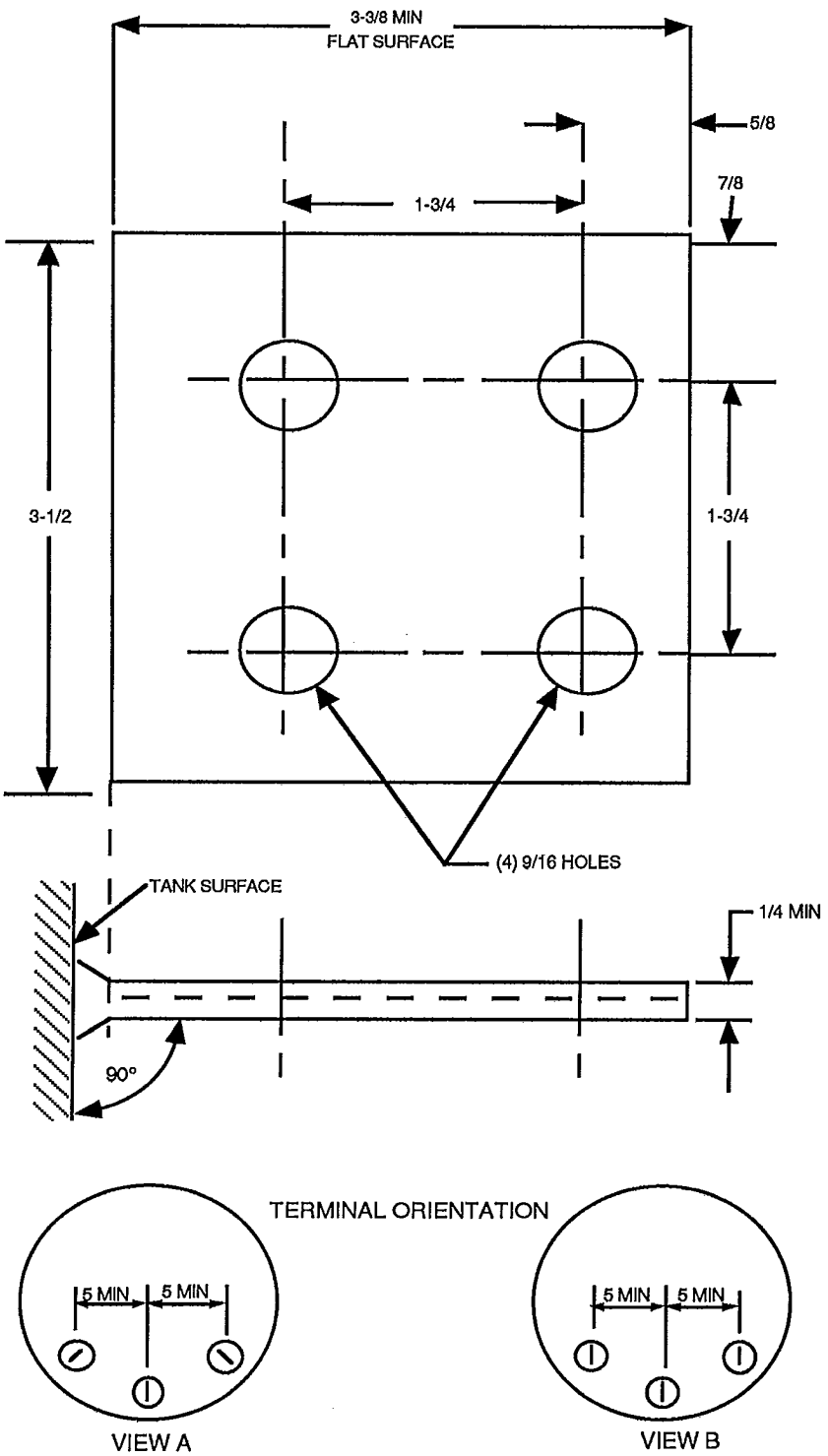
(2) The preferred location for the externally replaceable fuse is in Segment 2 or 4.

(3) The preferred location for the parking stand is in Segment 3.

(4) To maintain adequate mechanical and electrical clearances in Segment 3, it is permissible to encroach upon adjacent segments.

(5) Dashed boxes indicate either side wall or cover location.

Fig 1
Location of High-Voltage and Low-Voltage Connectors and Terminals



NOTE: All dimensions are in inches and are nominal unless otherwise specified.

Fig 2
Spade Terminals

6.2.6 The low-voltage neutral (X_2) connection of the winding shall be made to the tank or cover. When a fully insulated terminal is used for the low-voltage winding connection that is internally connected to the tank or cover, it shall be externally identified as internally connected to the tank or cover at the low-voltage neutral (X_2) termination. Ground connections shall be suitably sized for the short-circuit rating of the transformer as defined in IEEE C57.12.00-1987 [5].

6.2.7 Connector and terminal designations shall be as defined in ANSI C57.12.70-1978 [3]. The high-voltage connector and low-voltage terminal designations and locations are shown in Fig 1. The identification of the connector and terminal connections shall be shown on the instruction nameplate.

6.2.8 The tank grounding connectors as shown in Fig 1 shall be solderless-type connectors that will accommodate AWG conductor size No. 8 solid to No. 2 stranded.

6.3 Instruction Nameplate

6.3.1 The instruction nameplate shall be located on the transformer cover in Segment 3.

6.3.2 The nameplate shall conform to the requirements of nameplate "A" as described in IEEE Std C57.12.00-1987 [5].

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

6.4 Oil Preservation

6.4.1 The transformer shall be of sealed-tank construction. Sealed-tank construction is construction that seals the interior of the tank from the atmosphere, and in which the gas plus the oil volume remains constant. The transformer shall remain effectively sealed for a top oil temperature range of –5 °C to +105 °C continuous under operating conditions as described in IEEE Std C57.91-1981 [8]. An oil-level sight gauge shall be provided.

6.5 Tanks

6.5.1 The tank shall be of sufficient strength to withstand a static internal pressure of 7 lbf/in^2 gauge without permanent distortion and 20 lbf/in^2 gauge without rupturing. A 1/2 inch or larger NPT fitting sized for specified minimum flow rate shall be provided for the installation of a pressure-relief device.

6.5.2 The cover shall be welded in place.

6.5.3 If a handhole is required, it shall be located on the cover, be adequately sized, and be suitably located to permit operation of the internal tap changer.

6.5.4 The completely assembled transformer enclosure shall be capable of passing the fault current tests as defined in ANSI C57.12.20-1988 [1].

6.5.5 Tank grounding provisions shall consist of stainless steel or noncorrosive pads with a 1/2-inch-13-NC tapped hole, 7/16 inch deep, located in Segment 3, as shown in Fig 1.

6.6 Components for Looped Primary Cable System. The minimum current-carrying capabilities of components for looped primary cable systems shall be 200 A (continuous) and 10 000 A rms symmetrical for 0.17 s (short-time current rating) for transformers with or without high-voltage switching.

7. Storage and Installation

7.1 Storage

7.1.1 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.

7.2 Installation

7.2.1 Equipment manufactured to this standard 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 maximum "angle of tilt" part of their specification.

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