



IEEE Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High-Voltage, 34.5 kV Nominal System Voltage and Below; Low-Voltage, 15 kV Nominal System Voltage and Below

IEEE Power and Energy Society

Developed by the
Transformers Committee

IEEE Std C57.12.34™-2022
(Revision of IEEE Std C57.12.34-2015)



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Approved 23 September 2022

IEEE SA Standards Board

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Abstract: Certain electrical, dimensional, and mechanical characteristics are set forth, as well as certain safety features of three-phase, 60 Hz, liquid-immersed, self-cooled, pad-mounted, compartmental-type distribution transformers. These transformers are rated 10 MVA and smaller, with the high-voltage limit of 34.5 kV nominal system voltage and below, and with low-voltage limit of 15 kV nominal system voltage and below. This standard covers the connector, bushing, and terminal arrangements for radial or loop-feed systems. This standard does not cover the electrical and mechanical requirements of any accessory devices that may be supplied with the transformer.

Keywords: compartmental, connector arrangements, IEEE C57.12.34™, loop, pad-mounted, pad-mount distribution transformers, radial, three phase, transformer

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

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PDF: ISBN 978-1-5044-9174-7 STD25770
Print: ISBN 978-1-5044-9175-4 STDPD25770

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Introduction

This introduction is not part of IEEE Std C57.12.34–2022, IEEE Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High-Voltage, 34.5 kV Nominal System Voltage and Below; Low-Voltage, 15 kV Nominal System Voltage and Below.

This standard was first published in 2004 as a revision and combination of ANSI Std C57.12.22™-1993 “American National Standard for Transformers—Pad-Mounted, Compartmental-Type, Self-Cooled Three-Phase Distribution Transformers with High-Voltage Bushings, 2500 kVA and Smaller: High Voltage, 34 500 Grd Y/19 920 Volts and Below; Low Voltage, 480 Volts and Below—Requirements” and IEEE Std C57.12.26™-1992 “IEEE Standard for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors (34 500 Grd Y/19 920 V and Below; 2500 kVA and Smaller).” This resulted in a single standard that brought together pad-mounted transformers with either high-voltage bushing or separable connectors.

In 2009, the standard was revised and two significant changes to the scope were made. First, the size of the units was increased to 5 MVA, and second, the low-voltage rating was changed from 480 V and below to 15 kV and below. This facilitated the development of standard requirements for pad-mounted transformers that could be used for step-down as well as distribution service and required substantial updating of most figures and tables.

In 2015, the scope of the standard was expanded to include pad-mounted transformers up to 10 MVA. To reflect this change, a new figure was added and many tables and figures were updated to include the characteristics and dimensions of the larger units. In addition, many figures were updated to include optional high-voltage neutral bushings, and the standard was generally revised. The standard was also updated to current style requirements.

In this version, a new detailed informative [Annex A](#) was added to reflect the various internal accessories that could be specified. [Annex B](#) was added to provide clarification of the horizontal angle of loading.

This standard was prepared by the Working Group of the Subcommittee on Distribution Transformers, for Three-Phase, Pad-Mounted Transformers.

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1. Overview

1.1 Scope

This standard covers certain electrical, dimensional, and mechanical characteristics and takes into consideration certain safety features of three-phase, 60 Hz, liquid-immersed filled, self-cooled, pad-mounted, compartmental-type distribution transformers. These transformers are rated 10 MVA and smaller, with the high-voltage limit of 34.5 kV system nominal voltage and below, and with low-voltage limit of 15 kV system nominal voltage and below. These transformers are generally used for step-down purposes from an underground primary cable supply. This standard covers the connector, bushing, and terminal arrangements for radial or loop-feed systems. Either certain minimum dimensions or certain specific dimensions shall be specified. This standard does not cover the electrical and mechanical requirements of any accessory devices that may be supplied with the transformer.

1.2 Purpose

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.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{1, 2}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

¹The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

²The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

ASME B30.9TM, Slings: Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings.

IEEE Std 386 ²⁰⁰⁶TM, [IEEE Standard for](#) Separable Insulated Connector Systems for Power Distribution Systems above 600 V.^{3,4} ~~1,2~~

IEEE Std C57.12.00TM ²⁰²¹, [IEEE Standard for](#) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

IEEE Std C57.12.28TM, [IEEE Standard for](#) Pad-Mounted Equipment—Enclosure Integrity.

[IEEE Std C57.12.29TM, IEEE Standard for Pad-Mounted Equipment—Enclosure Integrity for Coastal Environments.](#)

[IEEE Std C57.12.39TM, IEEE Standard for Requirements for Distribution Transformer Tank Pressure Coordination](#)

IEEE Std C57.12.70TM, [IEEE Standard for Standard](#) Terminal Markings and Connections for Distribution and Power Transformers.

IEEE Std C57.12.90TM, [IEEE Standard](#) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.

[IEEE Std C57.91TM, IEEE Guide for Loading Mineral-Oil-Immersed Transformers.](#)

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3. Definitions

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safety factor: The ratio of the ultimate stress of the material used in the lifting, moving, and jacking provisions to the working stress.

specific dimensions: The concept of a universal face plate is established where the size and location of certain key product features are enumerated. The purpose is to provide a consistent front panel or face plate design from manufacturer to manufacturer so that operating practices of the purchaser can be maintained, and a transformer built under IEEE Std C57.12.34TM ~~this standard~~ can work as a replacement in the field for another transformer built under this standard.

working stress: The maximum combined stress developed in the lifting provisions by the static load of the completely assembled transformer.

4. Ratings

4.1 Kilovolt-ampere ratings

Kilovolt-ampere ratings are for continuous balanced, three-phase operation and based on not exceeding either a 65 °C average winding temperature rise or an 80 °C hot-spot conductor temperature rise. The temperature rise of the insulating liquid oil ~~oil~~ shall not exceed 65 °C when measured near the top of the tank. These kilovolt-ampere ratings are based on the usual temperature and altitude service conditions specified in IEEE Std C57.12.00-2021⁶ ~~TM~~. The kilovolt-ampere ratings shall be as in Table 1.³

⁵ ~~3~~ ³IEEE Standards Dictionary Online ~~subscription~~ is available at: http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

⁶Information on references can be found in Clause 2.

Table 1—Kilovolt-ampere ratings

45	1000
75	1500
112.5	2000
150	2500
225	3750
300	5000
500	7500
750	10 000

4.2 Voltage ratings

Voltage ratings shall be in accordance with Table 3 ~~of this standard~~.

4.3 Tap ratings

When specified, high-voltage taps shall be composed of two 2.5% above the high-voltage rating and two 2.5% below the high-voltage rating. Transformers with a 208Y/120 low-voltage rating may be specified with four 2.5% taps below the high-voltage rating. The tap changer handle or the area next to the handle in the terminating compartment shall be marked indicating suitability for de-energized operation only.

5. Impedance voltage

5.1 Nominal percent impedance voltage

The percent impedance voltage, as measured on the rated voltage connection, shall be as shown in Table 2.

Table 2—Nominal percent impedance voltage

Rating (kVA)	For low-voltage rating 600 V and below	For low-voltage rating 2400 Δ through 4800 Δ	For low-voltage rating 6900 Δ through 13 800 Grd Y/7970 or 13 800 Δ
45	2.70–5.75 ^a	2.70–5.75 ^a	2.70–5.75 ^a
75	2.70–5.75 ^a	2.70–5.75 ^a	2.70–5.75 ^a
112.5	3.10–5.75 ^a	3.10–5.75 ^a	3.10–5.75 ^a
150	3.10–5.75 ^a	3.10–5.75 ^a	3.10–5.75 ^a
225	3.10–5.75 ^a	3.10–5.75 ^a	3.10–5.75 ^a
300	3.10–5.75 ^a	3.10–5.75 ^a	3.10–5.75 ^a
500	4.35–5.75 ^a	4.35–5.75 ^a	4.35–5.75 ^a
750	5.75	5.75	5.75
1000	5.75	5.75	5.75
1500	5.75	5.75	5.75
2000	5.75	5.75	5.75
2500	5.75	5.75	5.75
3750	5.75	5.75	6.00
5000		6.00	6.50
7500		6.00	6.50
10 000		6.00	6.50

^aThese impedance values were designed to meet [clause 7.1.4.1 and 7.1.4.2](#) ~~Table 15~~ of IEEE Std C57.12.00-[2021](#), ~~2010~~ which defines the maximum per-unit short-circuit withstand capability. [Distribution transformers are designed as Category I and Category II transformers even though the kVA rating is higher than specified in these clauses.](#) It is recommended that the end user evaluate other requirements such as voltage regulation, system impedance, or available fault current when using these values.

5.2 Tolerance on impedance voltage

The tolerance on nominal impedance voltages shall be as specified in ~~subclause~~ 9.2 of IEEE Std C57.12.00-[2021](#) ~~2010~~.

5.3 Tolerance on impedance voltage on a tap

The percent departure of the tested impedance voltage on any tap from the tested impedance voltage at rated voltage shall not be greater than the total tap voltage range and shall be expressed as a percentage of the rated voltage.

6. Basic lightning impulse insulation levels

Minimum basic lightning impulse insulation levels (BILs) shall be in accordance with Table 3-~~of this standard~~.

7. Tests

7.1 General

Except as specified in 7.2 and 7.3-~~of this standard~~, tests shall be performed as specified in IEEE Std C57.12.00-[2021](#) and IEEE Std C57.12.90~~TM~~.

Table 3—Range of kVA and voltage ratings

High-voltage rating (V)	Minimum BIL (kV)	Rating ^a (kVA)			
		For low-voltage rating 208Y/120 ^c or 240 V	For low-voltage rating 480Y/277 ^c , 480, 600Y/347 ^c , or 600 V	For standard low-voltage rating 4800 Δ through 2400 Δ ^c as specified in the high-voltage rating column of this table	For standard low-voltage rating 13 800 Grd Y/7970 or 13 800 Δ through 6900 Δ ^c as specified in the high-voltage rating column of this table
2400 Δ	45	45–750	45–750		
4160 Grd Y/2400 or 4160 Δ ^c	60	45–1000	45–1500		
4800 Δ	60	45–1000	45–2000		
6900 Δ	75	45–1000	45–2000	750–10 000	
8300 Grd Y/4800 ^c	75	45–1000	45–3750	750–10 000	
12 000 Grd Y/6930 ^c or 12 000 Δ	95	45–1000	45–3750	750–10 000	
12 470 Grd Y/7200 ^c	95	45–1000	45–3750	750–10 000	
13 200 Grd Y/7620 ^c	95	45–1000	45–3750	750–10 000	
13 800 Grd Y/7970 ^c or 13 800 Δ	95	45–1000	45–3750	750–10 000	
16 340 Δ	95	45–1000	45–3750	750–10 000	
20 780 Grd Y/12 000 ^c	125	45–1000	45–3750	750–10 000	750–10 000
22 860 Grd Y/13 200 ^c	125	45–1000	45–3750	750–10 000	750–10 000
23 000 Δ	125	45–1000	45–3750	750–10 000	750–10 000
23 900 Grd Y/13 800 ^c	125	45–1000	45–3750	750–10 000	750–10 000
24 940 Grd Y/14 400 ^c	125	45–1000	45–3750	750–10 000	750–10 000
34 500 Grd Y/19 920 ^{c,4}	150	75–1000	75–3750	750–10 000	750–10 000
34 500 Δ ^b	150	75–1000	75–3750	750–10 000	750–10 000

^aKilovolt-ampere ratings which are separated by a dash indicate that all ratings covered in this range as shown in 4.1 are included.

^bThe highest BIL level for separable insulated connectors is 150 kV BIL. If 200 kV BIL level is required, bushings shall be used.

^cUnsymmetrical excitation or loading of Y-Y connected units may cause heating of their tanks in excess of that which would be produced by balanced conditions. To reduce the probability of tank heating, such units shall be provided with a core construction that will not saturate when 33% zero-sequence voltage is applied.

^dWhen specifying 125 kV BIL, adequate grounding and surge protection studies should be made.

^eCare should be taken in that some of these kVA ranges result in providing over 200 A at the rated voltage, thus requiring a 600 A connector. Consult IEEE Std 386-~~2006~~TM for complete connector ratings.

7.2 Dielectric tests

For wye-wye connected transformers, no applied voltage test is required on a winding greater than 600 V. An induced voltage test shall be performed as specified in IEEE Std C57.12.90. The voltage induced between the line terminals of a winding with a voltage greater than 600 V and ground shall be the lower of the following values:

- a) 3.46 times the rated winding voltage plus 1000 V, ~~or~~
- b) The applied voltage test values provided in [Table 3 of IEEE Std C57.12.00-2021](#) ~~2010, Table 4.~~

When high- or low-voltage terminations are used that fall under IEEE Std 386, they may not be suitable for chopped wave testing; therefore, when terminations that conform to IEEE Std 386 are used (bushing wells, 600 A integral bushings, etc.) chopped wave tests are not required.

7.3 Dielectric test levels

Dielectric test levels shall be in accordance with the distribution levels in Table [3](#) ~~4~~ of IEEE Std C57.12.00-~~2010~~²⁰²¹.

8. Construction

8.1 General

A pad-mounted, compartmental-type transformer shall consist of a tank with high-voltage and low-voltage cable terminating compartments, as shown in this standard. The compartment shall be separated by a barrier of metal or other rigid material.

8.2 Compartment configuration

The high-voltage and low-voltage compartments shall be located side-by-side on one side of the transformer tank. When viewed from the front, the lower-voltage compartment shall be on the right.

8.3 Access

Each compartment shall have a door so constructed as to provide access to the higher-voltage compartment only after the door to the lower-voltage compartment has been opened. There shall be one or more additional captive fastening devices that must be disengaged before the higher-voltage door can be opened. If the lower-voltage compartment has exposed live parts that are over 600 V, a non-hygroscopic barrier shall be placed so as to require its removal or opening before access to the lower-voltage compartment can be attained. Where the lower-voltage compartment door is of a flat panel design, the door shall have three-point latching with a handle provided for a locking device. The compartment doors shall be of sufficient size to provide adequate operating and working space when removed or open. The doors shall either be equipped for latching in the open position or designed for manual removal.

8.4 Enclosure security and coating system

The transformer tank and compartment shall conform to IEEE Std C57.12.28TM or [IEEE Std C57.12.29TM](#) ~~[B2]~~¹, as appropriate and be so constructed as to limit disassembly, breakage, and prying open of any doors, panels, and sills when the doors are in the closed and locked position.

8.5 Pad attachment

The bottom edges of the compartments shall be so constructed as to provide for the use of hold-down devices ~~that which~~ are accessible only from the inside of the compartments.

8.6 Lifting

The construction of the unit shall be such that it can be lifted, skidded, or slid, or any combination of these, into place on the mounting surface without disturbing the high-voltage or low-voltage cables.

- a) Jack bosses or jacking facilities shall be provided on the tank for transformers rated 500 kVA or larger. The vertical clearance for a jack shall be 38 mm (1.5 in) minimum, 165 mm (6.5 in) maximum.
- b) The transformer shall be arranged for rolling in two directions ~~—;~~ parallel to and at right angles to one side of the transformer.
- c) The transformer shall be provided with lifting provisions permanently attached and arranged on the tank to provide a distributed balanced lift ~~in a vertical direction~~ for the completely assembled transformer. ~~It and~~ shall be in a vertical direction and designed to provide a safety factor of five when the horizontal angle of loading ~~is on the lifting sling does~~ not less than ~~exceed~~ 30° ~~as described in ASME B30.9.~~⁷

8.7 Connectors, bushings, and terminals

8.7.1 Electrical characteristics

The electrical characteristics of the completely assembled high-voltage connectors, high-voltage bushings, and low-voltage terminals shall be as shown in Table 4 and Table 5.^{8,9}

⁷[Refer to Annex B for further clarification of the horizontal angle of loading.](#)

^{8,9}Footnotes to tables and figures contain mandatory requirements.

⁹Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

Table 4—Electrical characteristics and minimum electrical clearances of high-voltage bushings and low-voltage terminals

Transformer voltage	BIL ^{b, c} (kV)	60-Hz dry-1-min withstand ^{b, c} (kV)	Minimum clearance—live parts ^a		
			Phase to ground ^c	Phase to phase ^c	Phase to non- hygroscopic insulating barrier
208Y/120, 240	30	10	25 (1.0)	25 (1.0)	
480Y/277, 480	30	10	25 (1.0)	25 (1.0)	
600Y/347, 600	30	10	25 (1.0)	25 (1.0)	
2400	45	15	51 (2.0)	51 (2.0)	
4160 to 4800	60	21	64 (2.5)	64 (2.5)	
7200	75	27	89 (3.5)	102 (4.0)	76 (3.0)
12 000 to 13 800	95	35	127 (5.0)	140 (5.5)	76 (3.0)
22 860 Grd Y to 24 940 Grd Y	125	42	146 (5.75)	159 (6.25)	76 (3.0)
34 500 Grd Y ^b	150	70	203 (8.0)	229 (9.0)	102 (4.0)

NOTE—These dimensions should be increased wherever possible to allow for ease in making connections by the user.

(New)

Transformer voltage	BIL ^{b, c} (kV)	60-Hz dry-one- minute withstand ^{b, c} (kV)	Minimum clearance—live parts ^a		
			Phase to ground ^c	Phase to phase ^c	Phase to non-hygroscopic insulating barrier
208Y/120, 240	30	10	25 (1.0) ^a	25 (1.0)	
480Y/277, 480	30	10	25 (1.0)	25 (1.0)	
600Y/347, 600	30	10	25 (1.0)	25 (1.0)	
2400	45	15	51 (2.0)	51 (2.0)	
4160 to 4800	60	21	64 (2.5)	64 (2.5)	
7200	75	27	89 (3.5)	102 (4.0)	76 (3.0)
12 000 to 13 800	95	35	127 (5.0)	140 (5.5)	76 (3.0)
22 860 Grd Y to 24 940 Grd Y	125	42	146 (5.75)	159 (6.25)	76 (3.0)
34 500 Grd Y ^b	150	70	203 (8.0)	229 (9.0)	102 (4.0)

NOTE—These dimensions should be increased wherever possible to allow for ease in making connections by the user.²

(Deleted)

^aAll dimensions are in millimeters (inches).³

^bThe use of barriers shall not reduce these electrical characteristics.

^cWhere clearances are less than those shown, an adequate non-hygroscopic insulating barrier shall be provided.

Table 5—Electrical characteristics and ratings of high-voltage connectors

Transformer		Electrical characteristics of completely assembled high-voltage connectors ^c			
High-voltage ratings (V)	BIL (kV)	High-voltage ratings		BIL (kV)	60-Hz Dry-1-min withstand (kV)
		Phase to ground (kV)	Phase to ground/Phase to phase (kV)		
2400	45	8.3	8.3/14.4	95	34
4160 to 4800	60	8.3	8.3/14.4	95	34
7200	75	8.3	8.3/14.4	95	34
12 000 to 13 800 ^a	95	8.3 or	8.3/14.4 or	95 or	34 or
		15.2	15.2/26.3	125	40
22 860 Grd Y to 24 940 Grd Y	125	15.2	15.2/26.3	125	40
34 500 Grd Y ^b	150	21.1	21.1/36.6	150	50

(New)

Transformer		Electrical characteristics of completely assembled high-voltage connectors ^c			
High-voltage ratings (V)	BIL (kV)	High-voltage ratings		BIL (kV)	60-Hz Dry-one-minute withstand (kV)
		Phase to ground (kV)	Phase to ground/Phase to phase (kV)		
2400	45	8.3	8.3/14.4	95	34
4160 to 4800	60	8.3	8.3/14.4	95	34
7200	75	8.3	8.3/14.4	95	34
12 000 to 13 800 ^a	95	8.3 or	8.3/14.4 or	95 or	34 or
		15.2	15.2/26.3	125	40
22 860 Grd Y to 24 940 Grd Y	125	15.2	15.2/26.3	125	40
34 500 Grd Y ^b	150	21.1	21.1/36.6	150	50

(Deleted)

^aThe required connector rating should be specified.

^bWhen specifying 125 kV BIL, adequate grounding and surge protection studies should be made.

^cIEEE Std 386 should be consulted for complete connector ratings.

8.7.2 Terminals greater than 600 V

8.7.2.1 General

The number, location, and arrangement of the terminals described by this [subclause section](#) shall be as shown in Figure 1, Figure 2, Figure 3, Figure 5, Figure 6, Figure 7, Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, Figure 14, Figure 15, Figure 16, Figure 17, or Figure 18.

8.7.2.2 Bushing replacement

The terminals described by this subclause, whether bushing wells and bushing inserts, integral bushings, or bushings shall be externally replaceable. The inside terminal connections shall be externally removable through the connector's opening in the transformer tank, or accessible through a handhole to permit removal and replacement.

8.7.2.3 Voltage terminals using separable insulated high-voltage connectors

The high-voltage connectors shall consist of either 200 A bushing wells and bushing inserts, or 200 A, 600 A, or 900 A integral bushings, as specified. Cable accessory parking stands shall be provided. For specific details concerning high-voltage separable connectors and cable accessory parking stands, refer to IEEE Std 386. Separable 200 A 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 hotline tools.

8.7.2.4 Voltage terminals using high-voltage bushings

Bushings shall have either tin-plated copper alloy clamp-type connectors or a two-hole spade terminal, both being arranged for a vertical take-off. The clamp connectors shall accommodate No. 6 AWG solid to 250 kcmil stranded conductors. The holes in the spade terminal shall be on the same plane, of a diameter of 14.3 ± 0.8 mm (0.56 ± 0.03 in) typical and be 44.5 ± 0.8 mm (1.75 ± 0.03 in) center to center.

8.7.3 600 V and below terminals

8.7.3.1 General

The phase and neutral terminals shall be in accordance with Figure 4 or Figure 8 of this standard and arranged for vertical take-off. Terminal dimensions shall be as shown in Figure 19 of this standard or, if specified, Figure 20 of this standard.