American National Standard Requirements for Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts

Approved 8/15/80

American National Standards Institute, Inc.

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

Print: ISBN 0-7381-3643-3 SH95118
PDF: ISBN 0-7381-3644-1 SS95118

American National Standard

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria for approval have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether he has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

CAUTION NOTICE: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this standard. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Foreword

(This Foreword is not a part of American National Standard Requirements for Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts, ANSI C57.12.50-1981.)

This new dry-type transformer standard describes ventilated dry-type transformers with self-cooled kVA ratings 1–500, and high voltages 2400–34 500 volts. (Forced-air-cooled ratings for certain sizes are listed in Part Il.) It is also applicable from 601–2400 volts, but not for high voltages 600 volts and below, since American National Standards Committee C89 on Specialty Transformers has responsibility for transformers with high voltages 600 volts and below. This standard is part of a new series of standards for dry-type transformers that also includes American National Standard General Requirements for Dry-Type Distribution and Power Transformers, ANSI/IEEE C57.12.01-1979; American National Standard Test Code for Dry-Type Distribution and Power Transformers, ANSI/IEEE C57.12.91-1979; American National Standard Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High Voltage 601–34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts, ANSI C57.12.51-1981; and American National Standard Requirements for Sealed Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High-Voltage 601–34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts, ANSI C57.12.52-1981.

Dry-type transformers have been covered in the past by a variety of documents, including American National Standard General Requirements for Distribution, Power, and Regulating Transformers, ANSI C57.12.00-1973; American National Standard Test Code for Distribution, Power, and Regulating Transformers, ANSI C57.12.90-1973; American National Standard Dry-Type Transformers for General Applications, ANSI/NEMA ST 20-1972; and Commercial, Institutional, and Industrial Dry-Type Transformers, NEMA TR 27-1965 (R1976). The new standards are the result of an effort encompassing the interests of users, manufacturers, and others dedicated to developing voluntary consensus standards primarily for dry-type transformers. They have various significant changes, including higher BILs (for most voltages), more stringent and meaningful short-circuit requirements, improved descriptions of “usual” and “unusual” service conditions, and numerous other improvements. The new standards should be easier and more efficient to use, since they are arranged according to the sequence in which information is normally needed. ANSI C57.12.50-1981 includes customary units and metric (SI) units, in accordance with ANSI policy. Sound levels were discussed in the preparation of this standard, but are not included at present. As a matter of information, NEMA TR 1-1974, Transformers, Regulators, and Reactors, includes data concerning dry-type transformer sound levels.

It should be noted that ANSI C57.12.50-1981 covers some of the scope of ANSI C89.2-1972 (NEMA ST 20-1972). It is understood from the chairman of American National Standards Committee on Specialty Transformers, C89, that the committee will delete that portion of the scope of C89.2 relating to transformers 601 volts and above to eliminate duplication.

This standard is a voluntary consensus standard. Its use is mandatory only when required by a duly constituted legal authority or when specified in a contractual relationship. To meet specialized needs and to allow innovation, specific changes are permissible when mutually determined by the user and the producer, provided such changes do not violate existing laws and are considered technically adequate for the function intended.

When this document is used on a mandatory basis, the word “shall” indicates mandatory requirements, and words “should” and “may” refer to matters which are recommended and permitted, respectively, but not mandatory.

The applicable ANSI rules and procedures for the preparation and approval of voluntary consensus standards have been followed. These specify procedures for voting, review and attempted reconciliation of dissenting viewpoints, a 60-day public review period, and final review and approval by the ANSI Board of Standards Review.

Suggestions for improvement of this standard will be welcome. They should be sent to the American National Standards Institute, Inc, 1430 Broadway, New York, N.Y. 10018.

This standard was processed and approved for submittal to ANSI by American National 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. At the time it approved this standard, the C57 Committee had the following members:

I. H. Koponen, *Chair*
C. R. Willmore, *Secretary*

Organization Represented	*Name of Representative*
Bonneville Power Administration	G. W. Iliff
Electric Light and Power Group	R. R. Bast R. L. Ensign I. H. Koponen J. P. Markey *(Alt)* B. F. Smith E. A. Villasuso, Jr
Institute of Electrical and Electronics Engineers	S. Bennon J. C. Dutton D. C. Johnson L. W. Long D. E. Massey R. L. Simpson
National Electrical Manufacturers Association	L. C. Aicher W. R. Courtade J. W. Dix J. D. Douglass W. C. Kendall K. Lindsley *(Alt)* W. J. McNutt N. M. Neagle *(Alt)* R. L. Schwab R. J. Stahara *(Alt)* R. E. Uptegraff, Jr
Naval Facilities Engineering Command	H. P. Stickley
Rural Electrification Administration	J. C. Arnold, Jr
Tennessee Valley Authority	L. R. Smith
Underwriters Laboratories	W. A. Farquhar *(Alt)* E. J. Huber
U.S. Bureau of Reclamation	S. J. Baxter
U.S. Department of Energy	M. Smith, Jr

Subcommittee C57.12.5 on Dry-Type Transformers, which developed this standard, had the following members:

John C. Dutton, *Chair*
Charles H. White, *Secretary*

B. F. Allen *(Alt)*
L. G. Ananian *(Alt)*
R. Bancroft
J. A. Berseth
D. R. Brown
F. J. Brutt
C. C. Dixon
R. Endicott
H. E. Gabel, Jr
R. H. Hollister *(Alt)*
P. Hopkinson
E. J. Huber
F. J. Klecic *(Alt)*
N. J. Melton
M. Mingoia *(Alt)*
J. J. Nay *(Alt)*
W. J. Neiswender
R. E. Rothrock
R. L. Simpson
S. G. Vargo
E. Villasuso, Jr
S. A. Wiencek

CLAUSE PAGE

CLAUSE PAGE

American National Standard Requirements for Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts

1. Scope

1.1

This standard is intended to set forth characteristics relating to performance, limited electrical and mechanical interchangeability, and safety of the equipment described, and to assist in the proper selection of such equipment.

1.2

This standard describes certain electrical and mechanical characteristics and takes into consideration certain safety features of 60-Hz, two-winding, ventilated dry-type transformers with self-cooled ratings 1 to 500 kVA, single-phase, and 15 to 500 kVA, three-phase, inclusive; high-voltage 601 to 34 500 volts, and low-voltage 120 to 600 volts, inclusive; generally used for step-down purposes. (Forced-air-cooled ratings for certain sizes are listed in Part II.)

1.3

This standard does not apply to other types of transformers, such as specialty, ventilated dry-type 501 kVA and larger, sealed dry-type, pad-mounted dry-type, liquid immersed, instrument, regulating, furnace, mine, and rectifier transformers. Transformers with high voltage 600 volts or less are excluded.

1.4

When this standard is used on a mandatory basis, the word “shall” indicates mandatory requirements, and the words “should” and “may” refer to matters that are recommended and permitted, respectively, but not mandatory.

NOTE — The Foreword of this standard describes the circumstances under which the document may be used on a mandatory basis.

1.5

Part I of this standard describes basic electrical and mechanical requirements. Part II describes other requirements or alternatives which may be specified for some applications.

2. Related Standards and Guides

2.1 General.

All requirements, definitions, and tests, except as specifically covered in this standard, shall be in accordance with the American National Standards listed below (see 2.3). When referred to in this document, standards are identified by designation and year (for example, ANSI/IEEE C57.12.01-1979):

American National Standard Dictionary of Electrical & Electronics Terms, ANSI/IEEE 100-1977

American National Standard General Requirements for Dry-Type Distribution and Power Transformers, ANSI/IEEE C57.12.01-1979

American National Standard Guide for Application of Transformer Connections in Three-Phase Distribution Systems, ANSI/IEEE C57.105-1978

American National Standard Guide for Application of Valve-Type Lightning Arresters for Alternating-Current Systems, ANSI C62.2-1980

American National Standard National Electrical Code, ANSI/NFPA 70-1981

American National Standard Guide for Installation and Maintenance of Dry-Type Transformers, ANSI Appendix C57.94 (1958)

American National Standard Requirements for Instrument Transformers, ANSI/IEEE C57.13.1978

American National Standard Requirements for Sealed Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase; with High-Voltage 601-34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts, ANSI C57.12.52-1981

American National Standard Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase; with High-Voltage 601–34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts, ANSI C57.12.51-1981

American National Standard Terminal Markings and Connections for Distribution and Power Transformers, ANSI C57.12.70-1978

American National Standard Terminology for Distribution and Power Transformers, ANSI/IEEE C57.12.80-1978

American National Standard Test Code for Dry-Type Distribution and Power Transformers, ANSI/IEEE C57.12.91-1979

American National Standard for Unified Inch Screw Threads (UN and UNR Thread Forms). ANSI B1.1-1974

American National Standard Voltage Ratings for Electric Power Systems and Equipment (60 Hz), ANSI C84.1-1977 and C84.1a-1980

2.2 Terminology.

Standard transformer terminology available in ANSI/IEEE C57.12.80-1978 shall apply. Other electrical terms are defined in ANSI/IEEE 100-1977.

2.3 Revision of American National Standards Referred to in This Document.

When an American National Standard referred to in this document is superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply.

Part I: Basic Electrical and Mechanical Requirements

(See Part II for other requirements or alternatives that may be specified for some applications.)

3. Usual Service Conditions

Service conditions shall be in accordance with those described in ANSI/IEEE C57.12.01-1979.

4. Ratings and Characteristics

4.1 Kilovolt-Ampere Ratings

4.1.1

Kilovolt-ampere ratings are continuous and based on not exceeding a 150°C average winding temperature rise, as measured by resistance (220°C limiting temperature).

4.1.2

Self-cooled (AA) kilovolt-ampere sizes shall be as shown in Table 1.

Table 1— Self-Cooled Kilovolt-Ampere Sizes

Single-Phase		Three-Phase	
1	50	15	150
3	75	30	225
5	100	45	300
7.5	167	75	500
10	250	112.5	
15	333		
25	500		
37.5			

4.2 Kilovolt-Ampere and Voltage Ratings.

Kilovolt-ampere and voltage ratings for single- and three-phase self-cooled (AA) transformers shall be as shown in Tables 2 and 3.

NOTE — At voltages 15 kV and above, Y–Y design transformers (described in Part II of this standard) may be required by utility users because of special system requirements.

Table 2— Range of Kilovolt-Ampere and Voltage Ratings for Single-Phase (AA) Step-Down Transformers

Rated High Voltage (volts)	Kilovolt-Ampere Ratings for Low Voltages 120/240, 240/120, 480
2 400– 4 160Y (Note 2)	1–500
4 160/7 200Y (Note 2)	1–500
4 800/8 320Y (Note 2)	1–500
6 930/12 000Y (Note 2)	5–500
7 200/12 470Y (Notes 2, 4)	5–500
7 620/13 200Y (Note 2)	5–500
7 970/13 800Y (Note 2)	5–500
12 000 (Note 4)	25–500
13 200 (Note 4)	25–500
13 800	25–500
22 860GrdY/13 200 (Notes 2, 5)	25–500
23 000	25–500
24 940GrdY/14 400 (Notes 2, 5)	25–500
34 500	25–500
34 500GrdY/19 920 (Notes 2, 5)	25–500

NOTES:

1 — All voltages are Δ unless otherwise indicated.

2 — See ANSI/IEEE C57.105-1978 for problems that may result if the high-voltage neutral is grounded with the high voltage Y-connected and the low voltage Δ-connected.

3 — Kilovolt-ampere ratings separated by a dash indicate that all intervening ratings specified in 4.1.2 are included.

4 — Although this voltage is not a “standard” single-phase voltage as provided by ANSI C84.1-1977 and ANSI C84.1a-1980, it is a commonly used voltage and is found in many other transformer product standards

5 — These voltage values appear in ANSI C84.1-1977 and ANSI C84.1a-1980, although they axe not shown therein as grounded.

Table 3— Range of Kilovolt-Ampere and Voltage Ratings for Three-Phase (AA) Step-Down Transformers

Rated High Voltage (volts)	Kilovolt-Ampere Ratings for Low Voltages 208Y/120, 480Y/277
2 400	15–500
4 160	15–500
4 800	15–500
6 900	15–500
7 200	15–500
12 000	75–500
13 200	75–500
13 800	75–500
23 000	300–500
34 500	300–500

NOTES:
1 — All voltages are Δ unless otherwise indicated.
2 — Kilovolt-ampere ratings separated by a dash indicate that all intervening ratings specified in 4.1.2 are included.

4.3 Taps.

Four high-voltage winding rated kilovolt-ampere taps shall be provided as follows: two that are 2.5% above rated voltage, and two that are 2.5% below rated voltage.

4.4 Insulation Levels.

High-voltage line terminal insulation levels shall be as shown in Tables 4 and 5. Low. voltage line terminal insulation levels shall be as shown in Table 6.

Table 4— High-Voltage Line Terminal Insulation Levels (Single-Phase)

Rated High-Voltage (volts)	Basic Lightning Impulse Insulation Level (BIL) (kV)	Low-Frequency Voltage Insulation Level (kV, rms)
2 400– 4 160Y*	30	12
4 160/ 7 200Y*	30	12
4 800/ 8 320Y*	45	19
6 930/12 000Y*	60	31
6 900	60	31
7 200	60	31
7 200/12 470Y*	60	31
7 620/13 200Y	60	31
12 000	60	31
13 200	60	31
13 800	60	31
22 860GrdY/13 200 (Note 2)	95	34
23 000	110	37
24 940GrdY/14 400 (Note 2)	110	37
34 500GrdY/19 920 (Note 2)	125	40
34 500	150	50

NOTES:
1 — All voltages are Δ unless otherwise indicated.
2 — These voltage values appear in ANSI C84.1-1977 and ANSI C84.1a-1980, although they are not shown therein as grounded.

*.An ungrounded circuit is assumed.

Table 5— High-Voltage Line Terminal Insulation Levels (Three-Phase)

Rated High-Voltage (volts)	Basic Lightning Impulse Insulation Level (BIL) (kV)	Low-Frequency Voltage Insulation Level (kV, rms)
2 400	20	10
4 160	30	12
4 800	30	12
6 900	30	12
7 200	30	12
12 000	60	31
13 200	60	31
13 800	60	31
23 000	110	37
34 500	150	50

NOTE — All voltages are Δ unless otherwise indicated.

Table 6— Low-Voltage Line Terminal Insulation Levels

Rated Low-Voltage, (volts)		Basic Lightning Impulse Insulation Level (BIL) (kV)	Low-Frequency Voltage Insulation Level (kV,rms)
Single-Phase	Three-Phase		
120/240	208Y/120	10	4
240/120		10	4
480	480	10	4
	408Y/277	10	4

NOTE — All voltages are Δ unless otherwise indicated.

4.5 Polarity, Angular Displacement, and Terminal Markings

4.5.1 Polarity of Single-Phase Transformers.

Single-phase transformers shall have “subtractive polarity” as described in ANSI/IEEE C57.12.01-1979.

4.5.2 Angular Displacement of Three-Phase Transformers.

The angular displacement between high-voltage and low-voltage terminal voltages of three-phase transformers with Δ–Δ connections shall be 0 degrees.

The angular displacement between high-voltage and low-voltage terminal voltages of three-phase transformers with Δ–Y connections shall be 30 degrees, with the low voltage lagging the high voltage as shown in Fig. 1; phasor relations shall be as shown in Fig. 1.

4.5.3 External Terminal Designation.

The terminal designation shall be in accordance with ANSI C57.12.70-1978.

4.6 Impedance Voltage.

Percent impedance voltages are not specified in this standard.

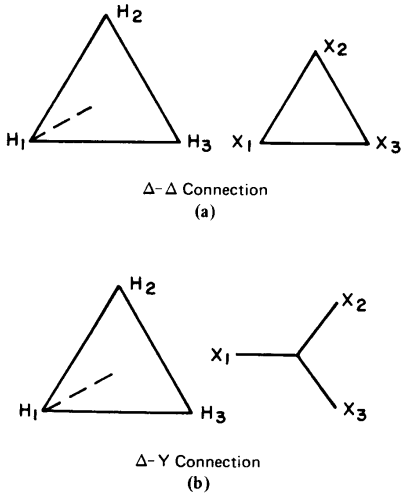


Figure 1— Angular Displacement

5. Construction (See Fig. 2)

5.1 Insulation System.

The insulation system of the transformer shall be suitable for operation at the limiting temperature associated with the kVA rating (see Section 4 or 8, as appropriate).

5.2 Accessory Location.

Preferred locations of accessories, connections, compartments, and the like, are given in Fig. 2 and its referenced paragraphs.

5.3 Nameplate.

A nameplate shall be provided in accordance with the requirements of ANSI/IEEE C57.12.01-1979 and shall be located on the front wall in segment 1.

5.4 Transformer Connections

5.4.1 Preferred Locations for Transformers.

High-voltage line connections or leads are located in segment 2. Low-voltage line connections or leads are located in segment 4. (See Fig. 2.)

5.4.2 Neutral Connections.

The neutral shall be either a blade connected directly to the housing or frame or a terminal insulated for the appropriate low-frequency voltage insulation level shown in Table 6. Connection size shall be adequate for the ground conductor requirements of ANSI/NFPA 70-1981.

When the neutral terminal is connected directly to the housing or frame, provision shall be made for disconnecting the winding neutral.

When a grounded-Y winding is involved, the connection from the neutral terminal to ground shall be furnished by the manufacturer as a part of the associated equipment, such as switchgear or terminal compartments. (See 9.1.3, 9.1.4, 9.1.5, 9.2.3, 9.2.4, and 9.2.5.)

5.4.3 Cable Connections

5.4.3.1

The space for field cable connections within the enclosure of a transformer shall be sufficient to provide ample room for the distribution of the maximum size supply and load cables required for the proper wiring of the transformer, as based on 125% of the kilovolt-ampere rating of the transformer.

5.4.3.2

Unless otherwise specified, cable sizes for application at 600 volts and below shall be based on 60°C-rated cable for 100 amperes or less and 75°C-rated cable for more than 100 amperes when the ampacity is determined in accordance with 5.4.3.1.

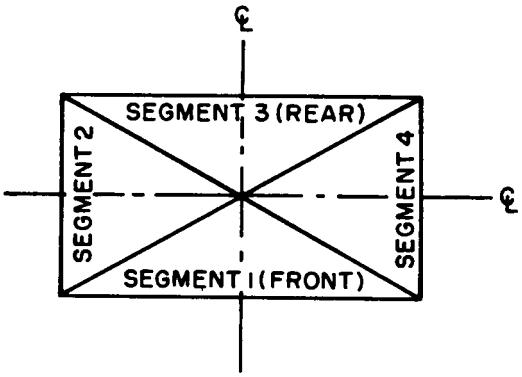
Unless otherwise specified, cable sizes for applications 601 volts and higher shall be based on 90°C-rated cable when the ampacity is determined in accordance with 5.4.3.1.

5.4.3.3

The field wiring space shall be so located that with full rated load on the transformer the

temperature rise on the field-installed cables or any part within the wiring space that the cables might contact does not exceed 20°C for 60°C-rated cable or 35°C for 75°C-rated cable.

NOTE — These temperature rises shall include the heat from field-installed cables, and the user's specification should describe the cables to be installed.



Items	Paragraph Reference
Nameplate	5.3
High-voltage connections	5.4.1
Low-voltage connections	5.4.1
Tap-changing facilities	5.5
Grounding facilities	5.7
Temperature device*	9.5.1
Terminal Block*	9.10
Jacking facilities*	9.12.1

*When specified; see Part II.

Figure 2— Top (Plan) View

5.4.3.4

The field wiring space for 600-volt cables shall be such that the distance between the end of a pressure-type cable connector for connection of a field-installed cable and the wall of the enclosure toward which the cable will be directed upon leaving the connection will be no less than that indicated in Table 7 or as specified in 5.4.3.5.

If field-installed cable is restricted by barriers or other means from being bent where it leaves the connector, the distance shall be measured from the barrier instead.

Table 7— Cable Bending Space

Size of Cable (AWG or MCM)	Minimum Bending Space* (inches)				
	1 Cable	2 Cables	3 Cables	4 Cables	5 Cables
14–16	1–1/2	–	–	–	–
4– 3	2	–	–	–	
2	2–1/2	–	–	–	–
1	3	–	–	–	–
1/0–2/0	3–1/2	5	7	–	–
3/0–4/0	4	6	8	–	–
250	4–1/2	6	8	10	–
300–350	5	8	10	12	–
400–500	6	8	10	12	14
600–700	8	10	12	14	16
750–900	8	12	14	16	18
1000–1250	10	12	15	–	–
1500–2000	12	15	–	–	–

*.See 5.4.3.4

5.4.3.5

The high-voltage field-installed cable, rated more than 600 volts, shall not be bent to a radius less than 8 times the overall diameter of the insulated cable for nonshielded cable, or 12 times the overall diameter for shielded cable.

5.5 Tap Changing.

Facilities shall be furnished for changing taps with the transformer de-energized, shall be located in segment 1 (see Fig. 2), and shall be either physically marked or described on the nameplate.

5.6 Lifting Facilities and Stability

5.6.1 Safety Factor.

Lifting facilities shall be designed to provide a safety factor of five or more. The safety factor 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 facilities by the static load of the component being lifted or moved.

5.6.2 Lifting Facilities.

A minimum of two lifting points shall be provided for lifting the core and coil assembly separately, using one lifting cable at each lifting point.

Lifting facilities shall be provided for lifting the complete transformer. Removal of the cover may be required. Lifting facilities shall be designed for lifting from a minimum of two points using one lifting cable at each lifting point, and with a maximum cable angle of 30 degrees with respect to the vertical. Lifting points shall provide a balanced lift to prevent overturning. The bearing surfaces of the lifting facilities shall be free from sharp edges and shall be provided with a hole having a minimum diameter of 5/8 inch (15.8 mm).

5.6.3 Tilting.

The points of support shall be so located that the center of gravity of the transformer as prepared for shipment will not fall outside these points of support for a tilt of the base of 15 degrees or less from the horizontal.

5.7 Grounding Facilities

5.7.1 Transformers 150 kVA and Smaller.

A grounding provision shall be furnished, including a corrosion-resistant connection of size adequate for the ground conductor requirements of ANSI/NFPA 70-1981.

5.7.2 Transformers Larger Than 150 kVA.

A grounding provision shall be furnished consisting of a steel pad welded to the base or housing with a corrosion-resistant metallic surface with a 1/2-inch- 13-NC-thread tapped hole, 7/16 inch (11.1 mm) deep, in accordance with ANSI B1.1-1974. The ground pad shall be located in the same segment as the low-voltage terminals.

5.8 Transformer Enclosure.

The enclosure shall be noncombustible and moisture resistant, shall be protected against corrosion, and shall be self-supporting, and all enclosure parts shall be fastened to other enclosure parts. Panels of the two sides shall be removable to permit inspection, cleaning, maintenance, and maintenance testing of the core and coil assembly.

A ventilating opening in an enclosure shall prevent the insertion of a straight rod having a diameter of 0.500 inch (12.7 mm), except that if the distance between the opening and the nearest not fully insulated live part is greater than the clearance indicated in Table 8, the opening may permit the entry of a rod having a diameter greater than 0.500 inch (12.7 mm), but not greater than 0.750 inch (19.0 mm). A barrier may be placed between an opening and live parts to comply with this requirement.

Table 8— Clearance

	Clearance	
kV Class	**Inches**	**Millimeters**
1.2	4	102
2.5	5	127
5	5.5	140
8.7	6.5	165
15	8	203
25	11	279
34.5	15	381

If used, a barrier shall be so located that it intercepts all live parts from the line of sight through the opening protected.

Exception: An opening above the upper edge of the enclosure side wall, but under the overhang of the top, is acceptable if by means of its size, barrier, and the like, it will prevent a straight rod 0.500 inch (12.7 mm) in diameter from approaching any uninsulated live part inside the enclosure by a distance not less than the clearance indicated in Table 8.

6. Routine Tests

Routine tests shall be made in accordance with ANSI/IEEE C57.12.01-1979.

7. Tolerances

Tolerances on ratio, impedance, and losses shall be in accordance with ANSI/IEEE C57.12.01-1979.

Part II: Other Requirements or Alternatives That May Be Specified for Some Applications

(See Part I for basic electrical and mechanical requirements.)

NOTE — Certain specific applications have transformer requirements not covered in Part I. Part II comprises descriptions of the most frequently used requirements for such transformers. They shall be provided only when specified in conjunction with Part I requirements or, where applicable, as alternatives to Part I requirements.

8. Other Ratings and Characteristics

8.1 Other Kilovolt-Ampere Ratings.

When specified, forced-air-cooled (AA/FA) kilovolt-ampere ratings for transformers shall be as shown in Table 9.

Kilovolt-ampere ratings are continuous and based on not exceeding the specified winding temperature rise limits described in 4.1, 8.2, or 8.3.

Table 9— Self-and Forced-Air-Cooled Ratings

Number of Phases	Self-Cooled (AA) Ratings (kVA)	Forced-Air-Cooled (AA/FA) Ratings (kVA)
1	250	333
	333	444
	500	667
3	300	400
	500	667

8.2 40°C Average Ambient Temperature Conditions.

When specified, the transformer shall be designed for operation in a location in which the maximum temperature of the cooling air (ambient temperature) does not exceed 50°C at any time and the average temperature of the cooling air for any 24-hour period does not exceed 40°C.

When this increased ambient temperature is specified, the kilovolt-ampere continuous rating of 4.1 shall be based on not exceeding 140°C average winding temperature rise, as measured by resistance (220°C limiting temperature).

8.3 Other Winding Temperature Rises

8.3.1

When specified, the kilovolt,ampere continuous rating shall be based on not exceeding 80°C average winding temperature rise, as measured by resistance (150°C limiting temperature).

When increased ambient temperature is specified in accordance with 8.2, this kilovolt-ampere continuous rating shall be based on not exceeding 70°C average winding temperature rise, as measured by resistance (150°C limiting temperature).

8.3.2

When specified, the kilovolt-ampere continuous rating shall be based on not exceeding 115°C average winding temperature rise, as measured by resistance (185°C limiting temperature).

When increased ambient temperature is specified in accordance with 8.2, this kilovolt-ampere continuous rating shall be based on not exceeding 105°C average winding temperature rise, as measured by resistance (185°C limiting temperature).

8.4 Other Insulation Systems

8.4.1

When specified, transformers designed for an 80°C average winding temperature rise, as measured by resistance, shall be provided with a 150°C-rise insulation system (220°C limiting temperature), as defined in 4.11 of ANSI/IEEE C57.12.01-1979.

8.4.2

When specified, transformers designed for an 115°C average winding temperature rise, as measured by resistance, shall be provided with a 150°C-rise insulation system (220°C limiting temperature), as defined in 4.11 of ANSI/IEEE C57.12.01-1979.

8.5 Other High-Voltage Ratings and Connections

8.5.1 High-Voltage Windings without Taps.

When specified, the high-voltage winding shall be furnished without taps.

8.5.2 Other High-Voltage Ratings.

When specified, high-voltage ratings may be selected within the range of other high-voltage ratings listed in Table 10. These are rated high voltages (line-to-line) and are alternates to the high-voltage ratings listed in Tables 2 and 3.

The rated voltage should be the midtap voltage, and all performance characteristics shall be based on the rated voltage.

Four rated kilovolt-ampere equally-spaced voltage taps, two above rated voltage and two below rated

voltage, should be provided for high voltages selected from Table 10. The total tap voltage range should not exceed 10%.

The percent tap voltage range shall be calculated as follows:

$$\text{Percent tap voltage range} = \frac{(\text{maximum tap voltage} - \text{minimum tap voltage})100}{\text{rated tap voltage}}$$

Table 10— Range of Other High-Voltage Ratings

Basic Lightning Impulse Insulation Level (BIL) (kV)	Range of Other Voltage Ratings (Line-to-Line) (volts)
20	2160 – 2500
30	2501 – 7200
45	7201 – 8320
60	8 321 –13 800
95	13 801 –18 000*
110	18 001*–23 000
125	23 001 –27 600*
150	27 601*–34 500

NOTES:
1 — All voltages are Δ.

2 — Voltages separated by a dash indicate that all intervening voltages are included.

3 — It is suggested that when voltages higher than those listed in ANSI/IEEE C57.12.01-1979, Table 3, or grounded-Y voltages are involved, the surge protection be reviewed (in accordance with ANSI/IEEE C57.12.01-1979, Table 3, and ANSI C62.2-1980) and appropriate changes made in BIL, if necessary.

*.Nonpreferred voltage, as listed in ANSI C84.1-1977 and ANSI C84.1a-1980.

8.5.3 Y-Connected High-Voltage Windings with Δ-Connected Low-Voltage Windings

NOTE — See ANSI/IEEE C57.105-1978 for problems that malt result if the high-voltage neutral is grounded with the high voltage Y-connected and the low voltage Δ-connected. (For Y–Y connected transformers, see 8.6.)

8.5.3.1

When specified, single-phase transformers with high voltage rated in accordance with Table 10 shall be furnished. The neutral insulation shall be in accordance with ANSI/IEEE C57.12.01-1979.

8.5.3.2

When specified, three-phase transformers with high voltage rated in accordance with Table 10 shall be furnished. The neutral insulation shall be in accordance with ANSI/IEEE C57.12.01-1979.

8.5.3.3 Angular Displacement of Y-Δ Connected Transformers.

The angular displacement between high-voltage and low-voltage terminal voltages of three-phase transformers shall be 30 degrees, and the phasor relation shall be as shown in Fig. 3.

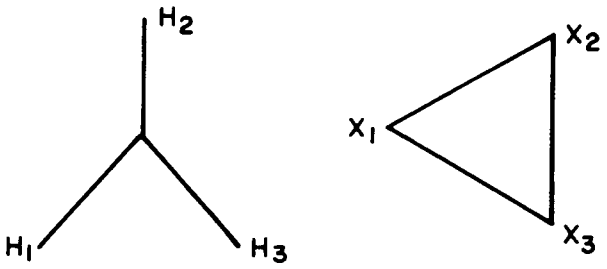


Figure 3— Y-Δ Connection

8.6 Y–Y Connected Transformers

8.6.1 Kilovolt-Ampere, Voltage, and BIL Combinations.

When specified, Y–Y connected transformers shall be furnished with the kilovolt-ampere and voltage combinations described in Table 11. Basic lightning impulse insulation levels (BIL) shall be furnished as described in Tables 12 and 6.

NOTE — ANSI/IEEE C57.105-1978 includes extensive discussion of Y–Y connection characteristics.

Table 11— Range of Kilovolt-Ampere and Voltage Ratings for Three-Phase (AA) Transformers Connected Y–Y

Rated High-Voltage (volts)	Kilovolt-Ampere Ratings for Low Voltages 208Y/120, 480Y/277
4 160GrdY/2 400	15–500
12 000GrdY/6 930	75–500
12 470GrdY/7 200	75–500
13 200GrdY/7 620	75–500
13 800GrdY/7 970	75–500
22 860GrdY/13 200	300–500
24 940GrdY/14 400	300–500
34 500GrdY/19 920	300–500

NOTE — Kilovolt-ampere ratings separated by a dash indicate that all the intervening ratings listed in 4.1.2 are included.

Table 12— High-Voltage Line Terminal Insulation Levels (Three-Phase, Y–Y Connected)

Rated High-Voltage (volts) (Note 1)	Basic Lightning Impulse Insulation Level (BIL) (kV)	Low-Frequency Voltage Insulation Level (kV, rms), (Notes 1, 2)
4 160GrdY/2 400	20	10
12 000GrdY/6 930	60	10
12 470GrdY/7 200	60	10
13 200GrdY/7 620	60	10
13 800GrdY/7 920	60	10
22 860 GrdY/13 200	95	10
24 940GrdY/14 400	110	10
34 500GrdY/19 920	125	10

NOTES:
1 — Neutrals are insulated for low-frequency applied voltage test equal to that of winding line terminal or 10 kV, whichever is lower.
2 — Windings shall be capable of withstanding an induced voltage test of two times rated voltage (with neutral grounded) from line terminals to ground and between line terminals, in accordance with ANSI/IEEE C57.12.91-1979.

8.6.2 Unsymmetrical Excitation or Loading.

Unsymmetrical excitation or loading of Y–Y connected units may cause heating of their enclosures in excess of that which would be produced by balanced conditions. To reduce the probability of this enclosure heating, such units shall be provided, when specified, with a construction that will not cause magnetic core saturation when 33° zero-sequence voltage is applied.

8.6.3 Angular Displacement of Y–Y Connected Transformers.

The angular displacement between high-voltage and low-voltage terminal voltages of three-phase transformers with Y–Y connections shall be 0 degrees, and the phasor relation shall be as shown in Fig. 4.

8.6.4 Neutral Connections.

For Y–Y connected units, the high-voltage neutral shall be connected to the low-voltage neutral internally, with provision for opening this connection for testing, or the high-voltage neutral shall be brought out through a separate lead or bushing and grounded externally.

8.7 Increased Neutral Insulation.

When specified, increased neutral insulation shall be provided for ratings which normally have reduced neutral insulation, but shall not exceed the insulation level of the line terminals of the winding involved.

8.8 Other Basic Lightning impulse Insulation Levels (BILs).

When specified, other basic impulse insulation levels shall be provided in accordance with Table 13.

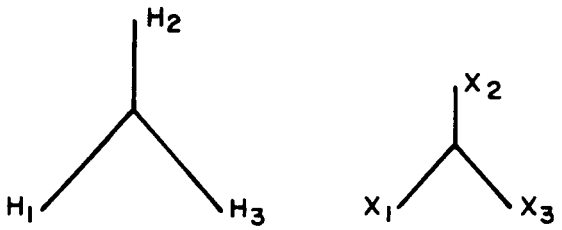


Figure 4— Y–Y Connection

Table 13— Other Basic Lightning Impulse Insulation Levels (BILs) Applicable to Windings

BIL* (kV)	Other BIL (kV)
20	30, 45
30	45, 60
45	60, 95
60	95, 110
95	110, 125
110	125,150
125	150

*.BILs corresponding to rated voltages listed in Tables 4, 5, 10 or 12, or Table 3 of ANSI/IEEE C57.12.01-1979.

9. Other Construction (See Fig. 2)

9.1 High-Voltage Connection Arrangements

9.1.1

When specified, high-voltage terminals or leads shall be located in segment 3.

9.1.2

When specified, high-voltage terminals shall be located on the cover in segment 3, or at the top of end walls in segments 2 or 4.

9.1.3

When an air-filled terminal compartment is specified, it shall be located adjacent to segment 2 or 4. When the transformer high voltage is connected grounded Y, a removable ground strap shall be provided between the neutral terminal and the ground pad.

9.1.4

When a flange for connection to switchgear is specified, it shall be located adjacent to segment 2 or 4.

9.1.5

When a fused or unfused air interrupter switch or a current-limiting fuse is specified, it shall be located adjacent to segment 2 or 4.

9.1.6

When specified, provision shall be made in segment 3 or 1 for connection to cables.

NOTE — Design limitations may preclude placing both high-voltage and low-voltage cables together in a single segment.

9.1.7

When specified, a second grounding facility as described in 5.7 shall be provided and located in the same segment as the high-voltage compartment.

9.2 Low-Voltage Connection Arrangements

9.2.1

When specified, low-voltage terminals or leads shall be located in segment 1.

9.2.2

When specified, low-voltage terminals shall be located on the cover in segment 1, or at the top of the end walls in segments 2 or 4.

9.2.3

When an air-filled terminal compartment is specified, it shall be located adjacent to segment 4 or 2. When the transformer low voltage is connected grounded Y, a removable ground strap shall be provided between the neutral terminal and the ground pad.

9.2.4

When a flange for connection to switchgear is specified, it shall be located adjacent to segment 4 or 2.

9.2.5

When a circuit-breaker panel is specified, it shall be located adjacent to segment 4 or 2.

9.2.6

When specified, provision shall be made in segment 1 or 3 for connection to cables.

NOTE — Design limitations may preclude placing both high-voltage and low-voltage cables together in a single segment.

If high-voltage and low-voltage cables are in the same segment, they shall be separated.

9.3 Surge Arresters.

When high-voltage or low-voltage surge arresters are specified, they shall be provided with connections to ground.

9.4 Unit Substation Application.

When specified for application as part of a unit substation, the arrangement of terminals, accessories, and the like, for "standard" and "reverse" units (or "right-" and "left-hand") shall be as described in ANSI C57.12.70-1978.

The tap-changing facilities of a "reverse" unit may be located on the opposite side of the transformer as compared to the location on a "standard" unit.

9.5 Temperature Devices

9.5.1 Winding Temperature Simulator or Hot-Spot Device.

When specified, a winding temperature simulator or hot-spot device shall be furnished.

9.5.2 Adjustable Contacts.

When specified, adjustable contacts shall be provided.

9.5.2.1

When specified, a contact for control of fans shall be included and shall (unless otherwise specified) be set to close when the winding temperature is not less than 10°C below the rated average winding temperature rise, plus maximum ambient.

9.5.2.2

When specified, an alarm contact shall be included and shall (unless otherwise specified) be set to close when the winding temperature is not more than 5°C higher than the rated average winding temperature rise plus maximum ambient.

9.5.2.3

When specified, other fan control and alarm contact settings shall be furnished. The range for alternate contact settings shall be within ±15°C of the sum of the rated average winding temperature rise and the maximum ambient temperature.

9.6 Forced-Air Cooling.

When specified, fans and equipment for automatic control of fans from a winding temperature simulator or hot-spot device shall be furnished.

The preferred voltage for fan motors shall be 230 volts single phase. Fan motors shall be furnished without a centrifugal switch. Fans and their circuits shall be protected by an overcurrent device, furnished by the user.

9.7 Provision for Future Forced-Air Cooling.

When specified, class-AA transformers shall be designed with provision for the future addition of fans to obtain the kilovolt-ampere ratings of 8.1 and shall include a temperature device for control of fans.

9.8 Space Heaters.

When specified, manually switched space heaters shall be provided.

9.9 Current Transformers (or Provision for Their Addition in the Future).

When specified, current transformers shall be provided and shall be in accordance with ANSI/IEEE C57.13-1978. There shall be a maximum of two per line.

Two secondary leads per current transformer shall be brought to a terminal block. Provision for short circuiting shall be supplied.

9.10 Terminal Blocks.

When specified, enclosed terminal block(s) shall be provided and located in segment 1 of Fig. 2 or in the low-voltage segment.

9.10.1

A terminal block shall be provided for alarm circuits.

9.10.2

A terminal block shall be provided for current transformer secondaries, allowing for two leads per current transformer.

9.11 Contacts.

Nongrounded contacts for instruments and alarms shall be suitable for interrupting:

1) 0.02-ampere direct-current inductive load;
2) 0.20-ampere direct-current noninductive load;
3) 2.5-ampere alternating-current (noninductive or inductive) load;
4) 250 volts minimum in all cases.

9.12 Jacking and Moving Facilities

9.12.1

When specified, jacking facilities shall be provided in the vicinity of the four corners of the base.

9.12.2

When specified, the base structure shall be designed for moving the transformer by rolling or skidding in either direction parallel to the centerlines of the transformer.

10. Other Tests

When specified, other tests shall be made in accordance with ANSI/IEEE C57.12.01-1979.