

American National Standard

general requirements for dry-type distribution and power transformers

ANSI/IEEE C57.12.01-1979



american national standards institute, inc.

November 30, 1979

SH06890

An American National Standard
**IEEE Standard General Requirements for
Dry-Type Distribution and
Power Transformers**

Sponsor
Transformers Committee of the
IEEE Power Engineering Society

Approved June 16, 1978
IEEE Standards Board

Secretariat
National Electrical Manufacturers Association
Institute of Electrical and Electronics Engineers

Approved November 28, 1978
American National Standards Institute

Published by
The Institute of Electrical and Electronics Engineers, Inc
345 East 47th Street, New York, NY 10017

American National Standard

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether he has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review and users are cautioned to obtain the latest editions.

CAUTION NOTICE: This American National Standard may be revised or withdrawn at any time.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 to reaffirm, revise, or withdraw this standard no later than five years from the date of publication. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

© Copyright 1979 by

The Institute of Electrical and Electronics Engineers, Inc

*No part of this publication may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.*

Foreword

(This Foreword is not a part of ANSI/IEEE C37.12.01-1979, Standard General Requirements for Dry-Type Distribution and Power Transformers.)

This standard, together with its companion standards documents, represents a new milestone in standards for dry-type transformers, which are becoming increasingly important with the elimination of askarel insulation in new transformers.

Dry-type transformers have been served in the past by a variety of documents, including ANSI/IEEE C57.12.00-1973, General Requirements for Distribution, Power, and Regulating Transformers; ANSI/IEEE C37.12.90-1973, Test Code for Distribution Power and Regulating Transformers; NEMA Pub No TR 27-1965 (R1971, 1976), Commercial, Institutional, and Industrial Dry-Type Transformers; and ANSI/NEMA Pub No ST 20-1972 (R1978), Dry-Type Transformers for General Applications. This standard is the result of an effort encompassing the interests of users, manufacturers, and others dedicated to produce voluntary consensus standards primarily for dry-type transformers.

This new series of standards encompasses dry-type transformers with a high voltage of 601 V and above, and includes product standards through 34.5 kV and 7500 kVA (three-phase, self-cooled). The various new and significant changes include higher BILs (for most voltages), more stringent and meaningful short-circuit requirements, improved descriptions of usual and unusual service conditions, and numerous other improvements. This new standard is arranged in such a way that it should be easier and more efficient to use since it is organized recognizing the sequence in which information is normally needed. ANSI/IEEE C57.12.01-1979 includes customary units and adds metric (SI) units in accordance with the policy of the American National Standards Institute.

This standard was prepared by the Standards Preparation Working Group of the Dry-Type Transformer Subcommittee of the Transformers Committee of the Institute of Electrical and Electronic Engineers, following which it was approved by the IEEE Standards Board and the ANSI C57 Committee for Distribution and Power Transformers and Regulators. The applicable rules and procedures of IEEE and ANSI for the preparation and approval of voluntary consensus standards were followed. These specify procedures for voting, review, and attempted reconciliation of dissenting viewpoints, a 60 day public review period, and a final review and approval by the ANSI Board of Standards Review.

This American National standard is a voluntary consensus standard. Its use may become 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.

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to:

Secretary
IEEE Standards Board
The Institute of Electrical and Electronics Engineers, Inc
345 East 47th Street
New York, NY 10017

At the time it approved this standard, C57 had the following membership:

I. H. Koponen, *Chairman*

C. R. Wilmore, *Secretary*

Organization Represented

Bonneville Power Administration
Electric Light and Power Group

Name of Representative

George W. Iliff
R. R. Bast
I. O. Berkhan
I. H. Koponen
J. P. Markey (Alt)
P. H. Philippidis
B. F. Smith
E. A. Villasuso

Institute of Electrical and Electronics Engineers	S. Bennon W. P. Burt J. C. Dutton D. C. Johnson (Alt) L. W. Long D. E. Massey Leonard W. Johnson
Naval Facilities Engineering Command	L. C. Aicher
National Electrical Manufacturers Association.	W. R. Courtade J. W. Dix J. D. Douglass W. C. Kendall G. W. Mayall (Alt) W. J. McNutt Norman M. Neagle (Alt) R. L. Schwab R. E. Uptegraff, Jr G. C. Wilburn (Alt) J. C. Arnold, Jr
Rural Electrification Administration	L. R. Smith
Tennessee Valley Authority.	W. A. Farquhar (Alt)
Underwriters Laboratories.	E. J. Huber
U.S. Bureau of Reclamation	S. J. Baxter

This standard was developed by a Working Group of the Dry-Type Transformer subcommittee of the IEEE Transformers Committee of the IEEE Power Engineering Society which had the following membership:

J. C. Dutton, *Chairman*

R. Bancroft
W. P. Burt
H. E. Gabel
O. R. Hamilton
E. J. Huber

J. Lazzara
W. A. Muska
J. J. Nay
D. E. Shefka
S. A. Weincek

When this standard was approved June 16, 1978, the IEEE Standards Board had the following membership:

Joseph L. Koepfinger, *Chairman*

Irvin N. Howell, Jr, *Vice Chairman*

Ivan G. Easton, *Secretary*

William E. Andrus
C. N. Berglund
Edward J. Cohen
Warren H. Cook
David B. Dobson
R. O. Duncan
Charles W. Flint

Jay Forster
Ralph I. Hauser
Loering M. Johnson
Irving Kolodny
William R. Kruesi
Thomas J. Martin
John E. May

Donald T. Michael
Voss A. Moore
William S. Morgan
Robert L. Pritchard
Blair A. Rowley
Ralph M. Showers
B. W. Whittington

Contents

SECTION	PAGE
1. Scope	7
2. Terminology	7
3. References	7
3.1 Standards References	7
3.2 Applicable Documents in Preparation	8
4. Service Conditions	8
4.1 Usual Service Conditions	8
4.2 Unusual Service Conditions	8
5. Rating Data	10
5.1 Cooling Classes of Transformers	10
5.2 Frequency	10
5.3 Phases	10
5.4 Rated kVA	10
5.5 Voltage Ratings and Taps	11
5.6 Connections	11
5.7 Polarity, Angular Displacement, and Terminal Markings	11
5.8 Impedance	11
5.9 Losses	11
5.10 Insulation Levels	12
5.11 Temperature Rise and Insulation-System Capability	13
5.12 Nameplates	15
6. Construction	19
6.1 Tank-Pressure Requirements	19
6.2 Finish	19
6.3 Transformer Accessories	19
6.4 Terminals	19
6.5 Grounding	19
7. Short-Circuit Characteristics	19
7.1 Short-Circuit Requirements	19
7.2 Transformer Categories	19
7.3 Short-Circuit-Current Duration and Magnitude	20
7.4 System Zero-Sequence Data	21
7.5 Application Conditions Requiring Special Consideration	21
7.6 Components	21
7.7 Base kVA and Base Currents	22
7.8 Effects of Temperature on Transformer Windings During Short-Circuit Conditions	22
7.9 Calculation of Winding Temperature During a Short Circuit	22
8. Testing and Calculations	23
8.1 General	23
8.2 Test Classifications	23
8.3 Routine, Design, and Other Tests	23
8.4 Calculations	23
9. Tolerances	23
9.1 Ratio	23
9.2 Impedance	23
9.3 Losses	24
10. Connection of Transformers for Shipment	25

FIGURES

Fig 1 Phase Relation of Terminal Designations for Three-Phase Transformers.	11
Fig 2 Designation of Voltage Ratings of Single- and Three-Phase Windings.	17

TABLES

Table 1 Dielectric-Strength Correction Factors for Altitudes Greater than 3300 ft (1000 m). . .	9
Table 2 Preferred Continuous kVA Ratings.	10
Table 3 Insulation Levels for Dry-Type Transformers.	12
Table 4 Limits of Temperature Rise for Continuously Rated Transformers	14
Table 5 Nameplate Information	16
Table 6 Values of K	21
Table 7 Dry-Type Transformer Tests.	24
Table 8 Tolerances for Single-Phase and Three-Phase Transformer Losses.	24

APPENDIX

Unusual Temperature and Altitude Conditions	27
A1. Unusual Temperature and Altitude Service Conditions.	27
A2. Effect of Altitude on Temperature Rise.	27
A3. Operation at Rated kVA.	27
A4. Operation at Less than Rated kVA.	27

APPENDIX TABLES

Table A1. Maximum 24H Average Temperature of Cooling Air	27
Table A2. Rated kVA Derating Factors for Altitudes Greater than 3300 ft (1000 m).	27

An American National Standard

IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers

1. Scope

1.1 This standard is intended as a basis for the establishment of performance, interchangeability, and safety requirements of equipment described; and for assistance in the proper selection of such equipment.

1.2 This standard describes electrical, mechanical, and safety requirements of ventilated, nonventilated, and sealed dry-type distribution and power transformers or autotransformers; single and polyphase, with a voltage of 601 V or higher in the highest voltage winding.

1.3 This standard applies to all dry-type transformers except as indicated below:

- (1) Instrument transformers
- (2) Step-voltage and induction voltage regulators
- (3) Arc furnace transformers
- (4) Rectifier transformers
- (5) Specialty transformers
- (6) Mine transformers

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 or permissive, but not mandatory.

NOTE: The Foreword of this voluntary consensus standard describes the circumstances under which the standard may be used on a mandatory basis.

2. Terminology

Standard transformer terminology available in ANSI/IEEE C57.12.80-1978, Terminology for Power and Distribution Transformers, shall apply. Other electrical terms are defined in ANSI/IEEE Std 100-1977, Dictionary of Electrical and Electronics Terms.

3. References

3.1 **Standards References.** When the following American National standards and guides referred to in this standard are superseded by a revision approved by the American National Standards Institute, the latest revision shall apply.

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

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

ANSI C57.12.91-1979, Test Code for Dry-Type Distribution and Power Transformers

ANSI C57.94 (1958 ed), Guide for Installation and Maintenance of Dry-Type Transformers (Appendix to ANSI C57.12 standards)

ANSI C57.96 (1959 ed), Guide for Loading Dry-Type Distribution and Power Transformers (Appendix to ANSI C57.12 standards)

ANSI/IEEE C57.98-1968, Guide for Transformer Impulse Tests (Appendix to ANSI C57.12.90)

ANSI C62.2-1969, Guide for Application of Valve-Type Lightning Arresters for Alternating-Current Systems (including revised Appendix A-1972)

ANSI C84.1-1977, Voltage Ratings for Electric Power Systems and Equipment (60 Hz)

IEEE Std 99-1970, Guide for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment

ANSI/IEEE Std 100-1977, Dictionary of Electrical and Electronics Terms

ANSI/IEEE Std 315-1975, Graphic Symbols for Electrical and Electronics Diagrams

ANSI/ASME Boiler and Pressure Vessel Code (BPV), 1977 Edition. (Refer to Section VIII, Pressure Vessels, Division 1 or 2.)

3.2 Applicable Documents in Preparation¹

4. Service Conditions

4.1 Usual Service Conditions

4.1.1 General. Transformers conforming to this standard shall be suitable for operation at rated kVA under the following usual service conditions.

4.1.2 Temperature

4.1.2.1 The temperature of the cooling air (ambient temperature) shall not exceed 40°C, and the average temperature of the cooling air for any 24 h period shall not exceed 30°C.

4.1.2.2 The minimum ambient temperature shall not be less than -30°C.

4.1.3 Altitude. The altitude shall not exceed 3300 ft (1000 m).

4.1.4 Supply Voltage. The supply-voltage wave shape shall be approximately sinusoidal, and the phase voltages supplying a polyphase transformer shall be approximately equal in magnitude and of approximately equal time phase displacement.

4.1.5 Load Current. The load current shall be approximately sinusoidal. The harmonic factor shall not exceed 0.05 per unit.

NOTE: "Harmonic factor" is defined in ANSI/IEEE C57.12.80-1978.

4.1.6 Operation above Rated Voltage

4.1.6.1 Transformers shall be capable of:
(1) Delivering rated output in kVA at 5% above rated secondary voltage without exceed-

¹When the following documents are completed, approved, and published, they become part of this listing.

[1] Requirements for Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase; and 15 to 500 kVA, Three-Phase, with High-Voltage 2400-34 500 Volts, C57.12.50.

[2] Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High-Voltage 2400-34 500 Volts, C57.12.51.

[3] Requirements for Sealed Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High-Voltage 2400-34 500 Volts, C57.12.52.

[4] Thermal Evaluation of Insulation Systems for Dry-Type Transformers (To be published in the ANSI C57 Series).

ing the limiting temperature rise, when the power factor of the load is 80% or higher

(2) Operating at 10% above rated secondary voltage at no load without exceeding the limiting temperature rise

(3) Fulfilling the foregoing requirements for rated voltage, rated frequency, and rated kVA for any tap

4.1.6.2 The maximum continuous transformer operating voltage should not exceed the levels specified in ANSI C84.1-1977, Voltage Ratings for Electric Power Systems and Equipment (60 Hz).

NOTE: System conditions may require voltage transformation ratios involving tap voltages higher than the maximum system voltage for regulation purposes. However, the appropriate maximum system voltage should be observed under operating conditions.

4.1.7 Location

4.1.7.1 Sealed dry-type transformers shall be suitable for either indoor, outdoor, or indoor and outdoor operation, as specified.

4.1.7.2 Unless otherwise specified, ventilated and nonventilated dry-type transformers shall be suitable for indoor operation only.

4.1.8 Step-Down Operation. Unless otherwise specified, dry-type transformers shall be for step-down operation.

NOTE: See also Table 5, Note 9.

4.1.9 Tank or Enclosure Finish. Temperature limits and tests shall be based on the use of a pigment coating finish.

4.2 Unusual Service Conditions

4.2.1 General. Conditions other than those described in 4.1 are considered unusual service and when prevalent should be brought to the attention of those responsible for the design and application of the apparatus.

4.2.2 Unusual Loading. ANSI C57.96 (1959 ed), Guide for Loading Dry-Type Distribution and Power Transformers, provides guidance for loading under unusual conditions including:

(1) Ambient temperatures higher or lower than the basis of rating

(2) Short-time loading in excess of nameplate kVA with normal life expectancy

(3) Loading that results in reduced life expectancy

NOTE: ANSI C57.96 (1959 ed) is not a standard. It provides the best known general information for the loading of transformers under various conditions based on typical winding insulation systems, and is based