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USA Standard

General Requirements for Distribution, Power and Regulating
Transformers, and Shunt Reactors



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USA Standard
General Requirements for
Distribution, Power, and Regulating Transformers,
and Shunt Reactors

Sponsor
Electrical and Electronics Standards Board

Approved March 22, 1968
United States of America Standards Institute

USA Standard

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Foreword

(This Foreword is not a part of USA Standard General Requirements for Distribution, Power, and Regulating Transformers, and Shunt Reactors, C57.12.00-1968.)

For a number of years prior to 1942, the Sectional Committee on Transformers, Regulators, and Reactors, C57, of the American Standards Association* was developing and correlating standards on transformers. The data used in this work was gathered from many sources, including the existing standards and publications of the Institute of Electrical and Electronics Engineers, standards of the National Electrical Manufacturers Association, reports of the Edison Electric Institute, and others. This work resulted in the publication in 1942 of the American Standard for Transformers, Regulators and Reactors.

This standard was revised and greatly expanded in 1948, 1949, and 1956. The 1956 edition was comprised of a revision and editorial consolidation of the preceding standards on distribution, power, and regulating transformers, namely American Standard Requirements for Distribution, Power, and Regulating Transformers, and Reactors Other Than Current-Limiting Reactors, C57.12-1949, American Standard Test Code for Distribution, Power, and Regulating Transformers, C57.22-1948, and American Standard Requirements for Transformers-67,000 Volts and Below; 501 Through 10,000 kva, 3 Phase; 501 Through 5,000 kva, 1 Phase, C57.12a-1954. In addition, in order to eliminate cross-references wherever possible, the consolidation contained excerpts from other standards of the C57 family.

In 1957 two supplements to American Standard C57.12-1956 were approved and published. These were American Standard Requirements for Overhead-Type Distribution Transformers, C57.12c, Section 20, and C57.12d, which also revised certain sections of the 1956 standard.

The 1958 edition was comprised of a revision of American Standard C57.12-1956 and of the two supplements, C57.12c and C57.12d, and, in addition, incorporated, as part of the approved American Standard, Section 30 on three-phase load-tap-changing transformers, which had been published in 1956 as a Proposed American Standard recommended for use by the sectional committee on transformers.

Recognizing that some sections of the standard would require revision sooner than other sections, it was decided to issue each section as a separate standard.

USA Standard C57.12.00-1965 recognized new developments and clarified some of the requirements for transformers. The title was changed to American Standard General Requirements for Distribution, Power, and Regulating Transformers, and Shunt Reactors. The format was modified and the sections renumbered in accordance with the Style Manual. The tables on Insulation Class and Dielectric Tests were rearranged and extended to higher voltages. Other tables were added. Revisions and new material on electrical performance were furnished chiefly by the Transformer Committee of the Institute of Electrical and Electronics Engineers. Other new requirements on performance and construction were furnished by the National Electrical Manufacturers Association, the Edison Electric Institute, and others. The work of consolidation and editing was performed by the Subcommittee on Power Transformers, C57.12.1, and the C57 Committee.

The 1968 revision updates and improves the presentation of the standard and covers IEEE Transformers Committee recommendations for switching surge tests and the requirements for 65°C average winding rise transformers previously published in USA Standard C57.12.00a-1966.

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

*In 1966, the American Standards Association was reconstituted as the United States of America Standards Institute, and all American Standards current at that time are now known as USA Standards.

The organizations which participated in this work and the names of their representatives, as listed at the time this standard was submitted to the USA Standards Committee on Transformers, Regulators, and Reactors, C57, for approval, are as follows:

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USA Standard

General Requirements for Distribution, Power, and Regulating Transformers, and Shunt Reactors

1. Scope

This standard applies to all distribution and power transformers and to shunt reactors except as indicated below:

Instrument Transformers (see USA Standard Requirements, Terminology, and Test Code for Instrument Transformers, C57.13-1968)

Constant-Current Transformers of the Moving-Coil Type (see USA Standard Requirements, Terminology, and Test Code for Constant-Current Transformers of the Moving-Coil Type, C57.14-1964)

Step-Voltage and Induction-Voltage Regulators (see USA Standard Requirements, Terminology, and Test Code for Step-Voltage and Induction-Voltage Regulators, C57.15-1965)

Current-Limiting Reactors (see USA Standard Requirements, Terminology, and Test Code for Current-Limiting Reactors, C57.16-1958)

Specialty Transformers (see USA Standard Requirements and Terminology for Specialty Transformers, C89.1-1961)

Rectifier Transformer Equipment (see USA Standard Requirements, Terminology, and Test Code for Pool-Cathode Mercury-Arc Rectifier Transformers, C57.18-1964)

Arc Furnace Transformers (see USA Standard Requirements for Arc Furnace Transformers, C57.17-1965)

2. General

2.1 Service Conditions

2.1.1 Usual Temperature and Altitude Service Conditions.¹ Apparatus conforming to this

¹For loading under other conditions see Guide for Loading Oil-Immersed Distribution and Power Transformers, Appendix C57.92.

standard shall be suitable for operation at its rated kVA provided that:

(1) If air cooled, the temperature of the cooling air (ambient temperature) does not exceed 40°C and the average temperature of the cooling air for any 24-hour period does not exceed 30°C.²

(2) If water cooled, the temperature of the cooling water (ambient temperature) does not exceed 30°C and the average temperature of the cooling water for any 24-hour period does not exceed 25°C.

(3) The altitude does not exceed 3,300 feet (1,000 meters).

2.1.2 Unusual Temperature and Altitude Service Conditions. Apparatus may be applied at higher ambient temperatures or at higher altitudes than specified in 2.1.1, but its performance may be affected and special consideration should be given to these applications.

2.1.3 Other Unusual Service Conditions. Where unusual conditions other than those discussed in 2.1.2 exist, they should be brought to the attention of those responsible for the design and application of the apparatus. Examples of some of these conditions are:

(1) Damaging fumes or vapors, excessive or abrasive dust, explosive mixtures of dust or gases, steam, salt spray, excessive moisture or dripping water, etc

(2) Abnormal vibration, shocks, or tilting

(3) Excessively high or low ambient temperatures

(4) Unusual transportation or storage conditions

(5) Unusual space limitations

(6) Unusual duty, frequency of operation,

²It is recommended that the average temperature of the cooling air be calculated by averaging 24 consecutive hourly readings. When the outdoor air is the cooling medium, the average of the maximum and minimum daily temperature may be used. The value which is obtained in this manner is usually slightly higher than the true daily average by not more than ½°F.

difficulty of maintenance, poor wave form, unbalanced "voltage," special insulation requirements, etc

(7) Over-excitation exceeding 110 percent rated voltage

(8) Planned short circuits as a part of regular operating or relaying practice

2.2 Effect of Air Density on Sparkover Voltage. The effect of the decreased air density due to high altitude is to decrease the sparkover voltage for a given sparkover distance. See USA Standard Measurement of Voltage in Dielectric Tests, C68.1-1953 (IEEE Publication No. 4-1953), for use of a correction factor with sphere gaps.

2.2.1 Insulation. The dielectric strength of apparatus which depends in whole or in part upon air for its insulation decreases as the altitude increases. The dielectric strength at 3,300 feet or less for a given insulation class should be multiplied by the proper altitude correction factor to obtain the dielectric strength at the required altitude (see Table 1).

Table 1
Dielectric Strength Correction Factors for
Altitudes Greater than 3,300 Feet
(1,000 Meters)

Altitude		Altitude Correction Factor for Dielectric Strength
Feet	Meters	
3,300	1,000	1.00
4,000	1,200	0.98
5,000	1,500	0.95
6,000	1,800	0.92
7,000	2,100	0.89
8,000	2,400	0.86
9,000	2,700	0.83
10,000	3,000	0.80
12,000	3,600	0.75
14,000	4,200	0.70
15,000	4,500	0.67

NOTE: Altitude of 15,000 feet is considered a maximum for apparatus conforming to this standard.

2.3 Frequency. Unless otherwise specified, transformers and shunt reactors shall be designed for operation at a frequency of 60 Hz.

2.4 Operation Above Rated Voltage and Under Varying Ambient Temperatures. Transformers shall be capable of:

(1) Delivering rated output in kVA at 5 per-

cent above rated secondary voltage without exceeding the limiting temperature rise. This requirement applies when the power factor of the load is 80 percent or higher.

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

(3) The foregoing requirements apply to the rated voltage, rated frequency, and rated kVA for any tap.

(4) Shunt reactors, unless otherwise specified, shall be capable of operating at 5 percent above rated voltage, and with the increased current due to this overvoltage, without exceeding the limiting temperature rise.

2.5 Effect of Altitude on Temperature Rise. The effect of the decreased air density due to high altitude is to increase the temperature rise of apparatus which is dependent upon air for the dissipation of its heat losses.

2.5.1 Operation at Rated kVA. Apparatus can be operated at rated kVA at altitudes greater than 3,300 feet (1,000 meters) without exceeding temperature limits provided the average temperature of the cooling air does not exceed the values of Table 2 for the respective altitudes.

2.5.2 Operation at Less than Rated kVA. Apparatus can be operated at altitudes greater than 3,300 feet (1,000 meters) without exceeding temperature limits provided the load to be carried is reduced below rating by the percentages given in Table 3 for each 330 feet (100 meters) that the altitude is above 3,300 feet (1,000 meters).

2.6 Construction. Apparatus shall be suitable for both outdoor and indoor use or for indoor use only depending upon the application. Specific information on the type of construction is contained in the section applying to a particular type of apparatus.

2.6.1 Classes of Apparatus

2.6.1.1 Dry-Type Air-Cooled

- (1) Dry-type, self-cooled (Class AA)
- (2) Dry-type, forced-air-cooled (Class AFA)
- (3) Dry-type, self-cooled/forced-air-cooled (Class AA/FA)

2.6.1.2 Oil-Immersed Air-Cooled

- (1) Oil-immersed, self-cooled (Class OA)
- (2) Oil-immersed, self-cooled/forced-air-cooled (Class OA/FA)

Table 2
Maximum Allowable Average Temperature* of Cooling Air for Carrying Rated kVA

Method of Cooling Apparatus	3,300 Feet (1,000 Meters)	6,600 Feet (2,000 Meters)	9,900 Feet (3,000 Meters)	13,200 Feet (4,000 Meters)
Degrees C				
Oil-Immersed Self-Cooled	30	28	25	23
Oil-Immersed Forced-Air-Cooled	30	26	23	20
Oil-Immersed Forced-Oil-Cooled with Oil-to-Air Cooler	30	26	23	20
Dry-Type Self-Cooled				
(1) 55°C Rise	30	27	24	21
(2) 80°C Rise	30	26	22	18
(3) 150°C Rise	30	22	15	7
Dry-Type Forced-Air-Cooled				
(1) 55°C Rise	30	24	19	14
(2) 80°C Rise	30	22	14	6
(3) 150°C Rise	30	15	0	-15

*Recommended calculation of average temperature is described in Footnote 2 of 2.1.1(1).

Table 3
**Rated kVA Correction Factors for Altitudes
 Greater Than 3,300 Feet (1,000 Meters)**

Types of Cooling	Correction Factor, Percent
Oil-immersed self-cooled	0.4
Oil-immersed water-cooled	0.0
Oil-immersed forced-air-cooled	0.5
Oil-immersed forced-oil-cooled with oil-to-air cooler	0.5
Oil-immersed forced-oil-cooled with oil-to-water cooler	0.0
Dry-type self-cooled	0.3
Dry-type forced-air-cooled	0.5

(3) Oil-immersed, self-cooled/forced-air-cooled/forced-air-cooled (Class OA/FA/FA)

2.6.1.3 Oil-Immersed Air-Cooled/Forced-Oil-Cooled

(1) Oil-immersed, self-cooled/forced-air-cooled/forced-oil-cooled (Class OA/FA/FOA)

(2) Oil-immersed, self-cooled/forced-air-cooled/forced-oil-cooled / forced - air - forced - oil-cooled (Class OA/FOA/FOA)

2.6.1.4 Oil-Immersed Water-Cooled

(1) Oil-immersed, water-cooled (Class OW)

(2) Oil - immersed, water - cooled / self - cooled (Class OW/A)

2.6.1.5 Oil-Immersed Forced-Oil-Cooled

(1) Oil-immersed, forced-oil-cooled with forced-air cooler (Class FOA)

(2) Oil-immersed, forced-oil-cooled with forced-water cooler (Class FOW)

2.6.2 Dielectric Strength of Oil. The dielectric strength of a sample of insulating oil taken from a new apparatus shall not be less than 26 kV, when measured in accordance with USA Standard Method of Testing Electrical Insulating Oils, C59.2-1966.

3. Ratings

3.1 Kilovolt-Ampere Ratings. Kilovolt-ampere ratings are based on rated secondary voltage being maintained by impressing on the primary winding the voltage necessary to compensate for the effect of regulation of the transformer. This rating is based on temperature rise rather than on the total temperature.

3.1.1 Preferred kVA Ratings. Preferred kVA ratings³ of single-phase and three-phase

³See USA Standard Requirements for Transformers, 67,000 Volts and Below, 501 Through 5,000 kva, Single Phase; 501 Through 10,000 kva, Three Phase, C57.12.10-1965; USA Standard Requirements, Terminology, and Test Code for Overhead-Type Distribution Transformers, 67,000 Volts and Below, 500 kva and Smaller, C57.12.20-1964; USA Standard Requirements for Three-Phase Load-Tap-Changing Transformers, 67,000 Volts and Below, 1,000 kva Through 10,000 kva, C57.12.30-1965, for the preferred kVA ratings of various types of power and distribution transformers.