

Australian Standard™

Power transformers

Part 11: Dry-type transformers



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Part 11: Dry-type transformers

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PREFACE

This Standard was prepared by the Standards Australia Committee EL-008, Power Transformers to supersede AS 2735—1984 on publication.

The objective of this Standard is to provide designers, manufacturers, test laboratories, purchasers and users with requirements for general purpose dry-type transformers. These requirements cover dry-type transformers with at least one winding operating at a voltage of at least 1.1 kV and no winding operating at a voltage greater than 36 kV.

This Standard is identical with, and has been reproduced from IEC 60076-11, Ed.1.0 (2004), *Power transformers Part 11: Dry-type transformers*.

The AS 60076 series, *Power transformers* consists of the following parts:

AS

60076.1 Part 1: General

60076.4 Part 4: Guide to the lightning impulse and switching impulse testing—Power transformers and reactors

60076.11 Part 11: Dry-type transformers (this Standard)

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- (a) Its number does not appear on each page of text and its identity is shown only on the cover and title page.
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- (c) A full point should be substituted for a comma when referring to a decimal marker.

The terms 'normative' and 'informative' are used to define the application of the annex to which they apply. A normative annex is an integral part of a standard, whereas an informative annex is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard**Power transformers**
Part 11: Dry-type transformers

1 Scope

This part of IEC 60076 applies to dry-type power transformers (including auto-transformers) having values of highest voltage for equipment up to and including 36 kV and at least one winding operating at greater than 1,1 kV. The standard applies to all construction technologies.

This standard does not apply to:

- gas-filled dry type transformers where the gas is not air;
- single-phase transformers rated at less than 5 kVA;
- polyphase transformers rated at less than 15 kVA;
- instrument transformers (see IEC 60044 and IEC 60186);
- starting transformers;
- testing transformers;
- traction transformers mounted on rolling stock;
- flameproof and mining transformers;
- welding transformers;
- voltage regulating transformers;
- small power transformers in which safety is a special consideration.

Where IEC standards do not exist for the transformers mentioned above or for other special transformers, this standard may be applicable as a whole or in parts.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

References to international standards that are struck through in this clause are replaced by references to Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is identified as such.

IEC 60050 (all parts), *International electrotechnical vocabulary (IEV)*

IEC 60071 (all parts), *Insulation co-ordination*

~~IEC 60076-1:1993, *Power transformers – Part 1: General*~~
~~Amendment 1 (1999)~~

AS 60076.1, *Power transformers – Part 1: General*

IEC 60076-2, *Power transformers – Part 2: Temperature rise*

IEC 60076-3, *Power transformers – Part 3: Insulation levels and dielectric tests*

IEC 60076-5, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-10, *Power transformers – Part 10: Determination of sound levels*

IEC 60085, *Thermal evaluation and classification of electrical insulation*

~~IEC 60270, *High-voltage test techniques – Partial discharge measurements*~~

AS 60270, *High-voltage test techniques—Partial discharge measurements* (identical to IEC 60270:2000)

IEC 60332-3-10, *Tests on electric cables under fire conditions – Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus*

~~IEC 60529, *Degrees of protection provided by enclosures (IP Code)*~~

AS 60529, *Degrees of protection provided by enclosures (IP Code)* (identical to IEC 60529:2004)

~~IEC 60905, *Loading guide for dry-type power transformers*~~

AS 3953, *Loading guide for dry-type power transformers* (identical to IEC 60905:1987)

~~IEC 61330, *High-voltage/low voltage prefabricated substations*~~

AS 61330, *High-voltage/low voltage prefabricated substations* (identical to IEC 61330:1995)

3 Terms and definitions

For the purpose of this part of IEC 60076, the following terms and definitions apply.

3.1

dry-type transformer

transformer of which the magnetic circuit and windings are not immersed in an insulating liquid

3.2

totally enclosed dry-type transformer

transformer in an un-pressurised enclosure cooled by the circulation of the internal air

3.3

enclosed dry-type transformer

transformer in a ventilated enclosure cooled by the circulation of the external air

3.4

non-enclosed dry-type transformer

transformer supplied without a protective enclosure cooled by natural or forced air ventilation

4 Service conditions

4.1 General

The requirements of IEC 60076-1 apply to dry-type transformers only in so far as they are referred to in this standard.

4.2 Normal service conditions

4.2.1 General

Unless otherwise stated, the service conditions in 4.2.2 to 4.2.6 apply. When transformers are required to operate outside the normal service conditions, de-rating in accordance with 11.2 and/or 11.3 applies.

4.2.2 Altitude

A height above sea level not exceeding 1 000 m.

4.2.3 Temperature of cooling air

The temperature of cooling air not exceeding:

- 40 °C at any time;
- 30 °C monthly average of the hottest month;
- 20 °C yearly average.

and not below:

- 25 °C in the case of outdoor transformers;
- 5 °C in the case of indoor transformers.

where the monthly and yearly averages are as defined in 3.12 of IEC 60076-1.

4.2.4 Wave-shape of supply voltage

A supply voltage of which the waveshape is approximately sinusoidal.

NOTE This requirement is normally not critical in public supply systems but may have to be considered in installations with considerable converter loading. In such cases, there is a conventional rule that the deformation shall neither exceed 5 % total harmonic content nor 1 % even harmonic content, see IEC 61000-2-4. Also note the importance of current harmonics for load loss and temperature rise, see IEC 61378-1.

4.2.5 Symmetry of polyphase supply voltages

For three-phase transformers, a set of three-phase supply voltages which are approximately symmetrical.

4.2.6 Humidity

The relative humidity of the surrounding air shall be less than 93 %. No drops of water shall be present on the surface of the coils.

4.3 Electromagnetic compatibility (EMC)

Transformers shall be considered as passive elements in respect to emission and immunity to electromagnetic disturbances.

4.4 Provision for unusual service conditions

The purchaser shall identify in his enquiry any service conditions not covered by the normal service conditions in 4.2. Examples of such conditions are:

- high or low ambient temperature outside the limits prescribed in 4.2.3;
- restricted ventilation;
- altitude in excess of the limit prescribed in 4.2.2;
- damaging fumes and vapours;
- steam;
- humidity in excess of the limit prescribed in 4.2.6;
- dripping water;
- salt spray;
- excessive and abrasive dust;
- high harmonic content of the load current;
- distortion of the supply voltage waveform;
- fast transient overvoltages over the limits prescribed in 12.1 and Clause 21;
- associated power factor correction and method of capacitor switching to limit inrush current;
- superimposed DC current;
- seismic qualification which would otherwise require special considerations in the design;
- extreme mechanical shock and vibrations;
- transport and storage conditions not covered by the normal condition described in 4.5.

Transformer specification for operation under such abnormal conditions shall be subject to agreement between the supplier and purchaser.

Supplementary requirements, within defined limits, for the rating and testing of transformers designed for other than normal service conditions listed in 4.2, such as high temperature of cooling air or altitude above 1 000 m are given in 11.2 and 11.3.

4.5 Transport and storage conditions

All transformers shall be suitable for transportation and storage at ambient temperatures down to -25°C .

The supplier shall be informed of anticipated high levels of shock, vibration and inclination during transportation to site.

5 Tappings

The requirements in IEC 60076-1 Clause 5 applies. The preferred tapping range is either:

- $\pm 5\%$ in steps of $2,5\%$ (5 tap positions);
- or
- $\pm 5\%$ (3 tap positions).

Tapping selection shall be made off-circuit by the use of bolted links or off-circuit tap-changers.

6 Connections

Unless otherwise specified by the purchaser, transformer connections shall be Dyn with clock hour figure 5 or 11 in accordance with Clause 6 of IEC 60076-1. The neutral connection shall be capable of carrying full phase rated current.

7 Ability to withstand short circuit

Transformers shall fulfil the requirements in IEC 60076-5. If the purchaser requires a test to demonstrate this fulfilment, this shall be stated in the contract.

8 Rating

8.1 General

The manufacturer shall assign ratings to the transformer, which shall be marked on the rating plate, see Clause 9. These ratings shall be such that the transformer can deliver its rated current under steady loading conditions without exceeding the limits of temperature rise specified in Clause 11, assuming that the applied primary voltage is equal to the rated voltage and that the supply is at rated frequency.

8.2 Rated power

The transformer shall have an assigned rated power for each winding which shall be marked on the rating plate. The transformer shall be fully rated when supplied in an enclosure. The rated power refers to continuous loading. This is a reference value for guarantees and tests concerning load losses, temperature rises and short-circuit impedance.

NOTE A two-winding transformer has only one value of rated power, identical for both windings. When the transformer has rated voltage applied to the primary winding, and rated current flows through the terminals of that winding, the transformer receives the relevant rated power for both windings.

The rated power corresponds to continuous duty; nevertheless, dry-type transformers complying with this standard can be overloaded and guidance on overloads is given in IEC 60905.

8.3 Preferred values of rated power

The preferred values shall be in accordance with 4.3 of IEC 60076-1 starting from 50 kVA.

8.4 Operation at higher than rated voltage

Within the prescribed value of U_m , a transformer shall be capable of service without damage under conditions of overfluxing where the ratio of voltage over frequency exceeds the corresponding ratio at rated voltage and rated frequency by no more than 5 %.

NOTE This requirement is not meant to be systematically utilised in normal service. The consequential increase in iron losses under these conditions will have adverse effects and such operation should be of limited duration. This condition should be reserved for relatively rare cases of service under limited periods of time, for example emergency service or extreme peak loading.

8.5 Operation with fan cooling

When additional cooling by means of fans is provided, the nominal power rating with and without fans shall be subject to agreement between purchaser and supplier.

The rating plate shall indicate both the power rating without fans and the maximum power rating with fan cooling.

8.6 Operation in an enclosure

For operation in an enclosure that is not provided or later provided by the manufacturer of the transformer, see Annex D of IEC 61330 and IEC 60905.

9 Rating plate

9.1 Rating plate fitted to the transformer

Each transformer shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the items indicated below. The entries on the plate shall be indelibly marked (that is, by etching, engraving, stamping or by a photo-chemical process).

- a) dry-type transformer;
- b) number and year of this part of IEC 60076;
- c) manufacturer's name;
- d) manufacturer's serial number;
- e) year of manufacture;
- f) insulation system temperature for each winding. The first letter shall refer to the high voltage winding, the second letter shall refer to the low voltage winding. When more than two windings are present, the letters shall be placed in the order of the windings from the high voltage to the low voltage;
- g) number of phases;
- h) rated power for each kind of cooling;
- i) rated frequency;
- j) rated voltages, including tapping voltages, if any;
- k) rated currents for each kind of cooling;
- l) connection symbol;
- m) short-circuit impedance at rated current and at the appropriate referenced temperature;
- n) type of cooling;
- o) total mass;
- p) insulation levels;
- q) degree of protection;
- r) environmental class;
- s) climatic class;
- t) fire behaviour class.

The rated withstand voltages for all windings shall appear on the rating plate. The principles of the standard notation are illustrated in Clause 5 of IEC 60076-3.

9.2 Rating plate fitted to the transformer enclosure

Each transformer enclosure shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the items indicated in 9.1. The entries on the plate shall be indelibly marked (that is, by etching, engraving, stamping or by a photo-chemical process).

10 Identification according to cooling method

10.1 Identification symbols

Transformers shall be identified according to the cooling method employed. Letter symbols for use in connection with each cooling method shall be as given in Table 1.

Table 1 – Letter symbols

		Symbol
Type of cooling medium	Air	A
Type of circulation	Natural	N
	Forced	F

10.2 Arrangement of symbols

Transformers shall be identified by two symbols for each cooling method for which a rating is assigned by the manufacturer, typically as follows:

- A transformer designed for natural air ventilation is designated AN.
- A transformer designed for natural air ventilation up to specified rating and with forced cooling to a higher rating is designated AN/AF.

11 Temperature-rise limits

11.1 Normal temperature-rise limits

The temperature rise of each winding of the transformer, designed for operation at normal service conditions, shall not exceed the corresponding limit specified in Table 2 when tested in accordance with Clause 23.

The maximum temperature occurring in any part of the winding insulation system is called the hot-spot temperature. The hot spot temperature shall not exceed the rated value of the hot-spot winding temperature specified in Table 1 of IEC 60905. This temperature could be measured, however an approximate value for practical purposes can be calculated by using equation 1 in 4.2.4 of IEC 60905 with the values for Z and q given in 7.2 of IEC 60905.

Components used as insulating material may be used separately or in combination providing that their temperature does not exceed the values given for the appropriate insulation system temperature in accordance with the requirements as prescribed in the left hand column of Table 2.

The temperature of the core, metallic parts and adjacent materials shall not reach a value that will cause damage to any part of the transformer.