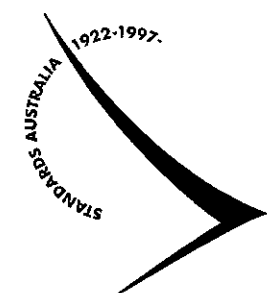


Australian Standard[®]

Power transformers

Part 2: Temperature rise

[Based on and including the full text of IEC 76-2:1993]



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Australian Standard[®]

Power transformers

Part 2: Temperature rise

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PREFACE

This Standard was prepared by the Standards Australia Committee EL/8, Power Transformers to supersede AS 2374.2—1982, *Power transformers, Part 2: Temperature rise*.

It is based on but not equivalent to, and has been reproduced from, IEC 76-2:1993, *Power transformers, Part 2: Temperature rise*, with the exception that Appendices ZZ and ZA have been added.

Appendix ZZ lists the Australian variations to IEC 76-2. The changes are indicated with marginal bars against the relevant clause, note, table, figure or part thereof. Note that reference to Appendix ZZ is especially critical in cases where additional text or clauses have been introduced.

This Standard is Part 2 of a series, comprising:

AS

2374	Power transformers
2374.1	Part 1: General
2374.2	Part 2: Temperature rise
2374.3.0	Part 3.0: Insulation levels and dielectric tests—General requirements
2374.3.1	Part 3.1: Insulation levels and dielectric tests—External clearances in air
2374.5	Part 5: Ability to withstand short-circuit
2374.6	Part 6: Determination of transformer and reactor sound levels

Significant differences between this Standard and the previous edition include the following:

- This Standard requires tests to be carried out on the maximum current tap. The previous edition required tests to be carried out on the maximum loss tap. It is noted that in some cases, including autotransformers, the two are not the same.
- For air cooled transformers, this Standard uses the hottest monthly average temperature. The previous edition used the maximum daily average temperature.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

As this Standard is reproduced from an international Standard, the following applies:

- Its number does not appear on each page of text and its identity is shown only on the cover and title pages.
- In the source text, 'this International Standard' should read 'this Australian Standard'.
- A full point substitutes for a comma when referring to a decimal marker.

References to international Standards should be replaced by references to the following Australian Standards:

<i>Reference to International Standards</i>		<i>Australian Standard</i>	
IEC		AS	
76	Power transformers	2374	Power transformers
76-1	Part 1: General	2374.1	General
85	Thermal evaluation and classification of electrical insulation	2768	Electrical insulating materials—Evaluation and classification based on thermal endurance
279	Measurement of the winding resistance of an a.c. machine during operation at alternating voltage	—	

IEC		AS	
354	Loading guide for oil-immersed power transformers	1078	Guide to loading of oil-immersed transformers
606	Application guide for power transformers	2421	Guide to the selection and use of power transformers
726	Dry-type power transformers	2735	Dry-type power transformers
905	Loading guide for dry-type power transformers	3953	Loading guide for dry-type power transformers
ISO		—	
2592	Petroleum products—Determination of flash and fire points—Cleveland open-cup method		

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AUSTRALIAN STANDARD

POWER TRANSFORMERS

Part 2: Temperature rise

1 Scope

This part of International Standard IEC 76 identifies transformers according to their cooling methods, defines temperature-rise limits and details the methods of test for temperature-rise measurements. It applies to transformers as defined in the scope of IEC 76-1.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 76. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 76 are encouraged to investigate the possibility of applying the most recent edition of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 76-1: 1993, *Power transformers – Part 1: General*

IEC 85: 1984, *Thermal evaluation and classification of electrical insulation*

IEC 279: 1969, *Measurement of the winding resistance of an a.c. machine during operation at alternating voltage*

IEC 354: 1991, *Loading guide for oil-immersed power transformers*

IEC 606: 1978, *Application guide for power transformers*

IEC 726: 1982, *Dry-type power transformers*

IEC 905: 1987, *Loading guide for dry-type power transformers*

ISO 2592: 1973, *Petroleum products – Determination of flash and fire points – Cleveland open-cup method*

3 Identification symbols according to cooling method

Transformers shall be identified according to the cooling method employed. For oil-immersed transformers this identification is expressed by a four-letter code as described below. Corresponding codes for dry-type transformers are given in IEC 726.

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First letter: Internal cooling medium in contact with the windings:

- O mineral oil or synthetic insulating liquid with fire point* ≤ 300 °C;
- K insulating liquid with fire point* > 300 °C;
- L insulating liquid with no measurable fire point.

Second letter: Circulation mechanism for internal cooling medium:

- N *natural* thermosiphon flow through cooling equipment and in windings;
- F *forced* circulation through cooling equipment, thermosiphon flow in windings;
- D forced circulation through cooling equipment, *directed* from the cooling equipment into at least the main windings.

Third letter: External cooling medium:

- A air;
- W water.

Fourth letter: Circulation mechanism for external cooling medium:

- N natural convection;
- F forced circulation (fans, pumps).

NOTE - In a transformer designated as having forced directed oil circulation (second code letter D), the rate of oil flow through the main windings is determined by the pumps and is not, in principle, determined by the loading. A minor fraction of the flow of oil through the cooling equipment may be directed as a controlled bypass to provide cooling for core and other parts outside the main windings. Regulating windings and/or other windings having relatively low power may also have non-directed circulation of bypass oil.

In a transformer with forced, non-directed cooling, on the other hand (second code letter F), the rates of flow of oil through all the windings are variable with the loading, and not directly related to the pumped flow through the cooling equipment.

A transformer may be specified with alternative cooling methods. The specification and the nameplate shall then carry information about the power figures at which the transformer fulfils the temperature-rise limitations when these alternatives apply, see 7.1 m) of IEC 76-1. The power figure for the alternative with the highest cooling capacity is the rated power of the transformer (or of an individual winding of a multi-winding transformer, see 4.1 of IEC 76-1). The alternatives are conventionally listed in rising order of cooling capacity.

* "Cleveland open-cup" test method, see ISO 2592.

Examples:

ONAN/ONAF. The transformer has a set of fans which may be put in service as desired at high loading. The oil circulation is by thermosiphon effect only – in both cases.

ONAN/OFAF. The transformer has cooling equipment with pumps and fans but is also specified with a reduced power-carrying capacity under natural cooling (for example, in case of failure of auxiliary power).

4 Temperature-rise limits**4.1 General**

Temperature-rise limitations for transformers are specified according to different options.

- A set of requirements apply which refer to continuous rated power. These requirements are given in 4.2.
- When explicitly specified, an additional set of requirements is imposed which is related to a specified loading cycle. This procedure is described in 4.4. It is applicable mainly to large system transformers for which emergency loading conditions deserve particular attention, and should not be regularly used for small and medium-size standardized transformers.

It is assumed throughout this part of IEC 76 that the service temperatures of different parts of a transformer can each be described as the sum of a cooling medium temperature (ambient air or cooling water) and a temperature rise of the transformer part.

The cooling medium temperature and the altitude (with regard to cooling air density) are characteristic of the installation site. When normal service conditions in these respects prevail, see 2.1 of IEC 76-1, then normal values of temperature rise for the transformer will result in allowable service temperatures.

The values of temperature rise are characteristics of the transformer which are subject to guarantees and to tests under specified conditions. Normal temperature-rise limits apply unless the enquiry and contract indicate 'unusual service conditions'. In such cases the limits of temperature rise shall be modified as indicated in 4.3.

No plus tolerance is permitted on temperature-rise limits.

4.2 Normal temperature-rise limits at continuous rated power

When a transformer has a tapped winding with a tapping range exceeding $\pm 5\%$ then the temperature-rise limits shall apply to every tapping at the appropriate tapping power, tapping voltage and tapping current, see 5.6 of IEC 76-1. The load losses are different for different tappings and sometimes also the no-load losses, namely within tapping ranges where variable flux voltage variation is specified.

If a temperature-rise type test is to be made on such a transformer it will, unless otherwise specified, be carried out on the 'maximum current tapping', see 5.3 of IEC 76-1.

NOTE - In a separate-winding transformer, the maximum current tapping is normally the tapping with the highest load loss.

In an auto-transformer with tapplings, the choice of tapping for the temperature-rise test will be dependent on how the tapplings are arranged.

For a multi-winding transformer, the temperature-rise requirements refer to rated power in all windings simultaneously if the rated power of one winding is equal to the sum of the rated powers of the other windings. If this is not the case, one or more particular loading combinations have to be selected and specified for the temperature-rise test, see 5.2.3.

In transformers with concentric winding arrangement, two or more separate windings may be situated one above the other. In this case, the winding temperature limit shall apply to the average of the readings for the stacked windings, if they are of equal size and rating. If they are not, the evaluation shall be subject to agreement.

The temperature-rise limits given below are valid for transformers with solid insulation designated as 'Class A' according to IEC 85, and immersed in mineral oil or synthetic liquid with fire point not above 300 °C (first code letter: O).

Temperature-rise limits of transformers which have a more temperature-resistant insulation system and/or are immersed in a less flammable liquid (code letter K or L) are subject to agreement.

Temperature-rise limits for dry-type transformers with different insulation systems are given in IEC 726.

The following limits for temperature rise in oil-immersed transformers (code letter O) are referred to steady state under continuous rated power. They are valid only when normal service conditions with regard to cooling apply, see 4.3.1 below.

- Top oil temperature rise, see 5.3.1 60 K

Average winding temperature rise (by resistance measurement, see 5.4)

- For transformers identified as ON . . or OF . . 65 K
- For transformers identified as OD . . 70 K

No numerical limits are specified for the temperature rise of the core, of electrical connections outside the windings or of structural parts in the tank. It is a self-evident requirement, however, that such parts shall not reach temperatures which will cause damage to adjacent parts or undue ageing of the oil. For large transformers this may be investigated by special testing, see annex B.

4.3 Modified requirements because of unusual service conditions

If the service conditions at the intended installation site do not fall within the limits of 'normal service conditions', then the limits of temperature rise for the transformer shall be modified accordingly.

Rules for dry-type transformers are given in 2.2 of IEC 726.

4.3.1 Oil-immersed, air-cooled transformers

Normal ambient temperature limits ($-25\text{ }^{\circ}\text{C}$ and $+40\text{ }^{\circ}\text{C}$) for power transformers are given in 2.1 of IEC 76-1. With regard to cooling of air-cooled transformers the temperature conditions at the intended installation site should neither exceed:

- + $30\text{ }^{\circ}\text{C}$ monthly average, of the hottest month; nor
- + $20\text{ }^{\circ}\text{C}$ yearly average.

If the temperature conditions at site exceed one of these limits, the specified temperature-rise limits for the transformer shall all be reduced by the same amount as the excess. The figures shall be rounded to nearest whole numbers of degrees.

NOTE - The average temperatures are to be derived from meteorological data as follows (IEC 76-1, definition 3.12).

Monthly average temperature:

half the sum of the average of the daily maxima and the average of the daily minima during a particular month, over many years;

Yearly average temperature:

one-twelfth of the sum of the monthly average temperatures.

If the installation site is more than 1 000 m above sea-level but the factory is not, then the allowable temperature rise during the test in the factory shall be reduced as follows.

For a naturally cooled transformer (. . AN), the limit of average winding temperature rise shall be reduced by 1 K for every interval of 400 m by which the installation's altitude exceeds 1 000 m.

For a forced-cooled transformer (. . AF), the reduction shall be 1 K for every 250 m.

A corresponding reverse correction may be applied in cases where altitude of the factory is above 1 000 m and the altitude of the installation site is below 1 000 m.

Any altitude correction shall be rounded to the nearest whole number of degree.

When the specified temperature-rise limits of a transformer have been reduced, either because of high cooling medium temperature or because of high-altitude installation, this shall be indicated on the rating plate, see 7.2 of IEC 76-1.

NOTE - When standardized transformers are to be applied at high altitudes, a reduced figure of power may be calculated, which from the point of view of cooling and temperature rise corresponds to service with rated power under normal ambient conditions.