

Dry-type power transformers

The European Standard EN 60726:2003 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN 60726:2003. It was derived by CENELEC from IEC 60726:1982. It supersedes BS 7806:1995 which is withdrawn.

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by common modification tags  .

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- monitor related international and European developments and promulgate them in the UK.

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de type sec
(CEI 60726:1982 + A1:1986, modifiée)

Trockentransformatoren
(IEC 60726:1982 + A1:1986, modifiziert)

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of the International Standard IEC 60726:1982 and its amendment 1:1986, prepared by IEC TC 14, Power transformers, together with the common modifications prepared by the Technical Committee CENELEC TC 14, Power transformers, was approved by CENELEC as HD 464 S1 on 1988-06-28.

This Harmonization Document, together with its amendments A1 to A5, was submitted to a formal vote for conversion into a European Standard and was approved by CENELEC as EN 60726 on 2002-11-01 and was approved by CENELEC as EN 60726 on 2002-11-01.

This European Standard supersedes HD 464 S1:1988 + A2:1991 + A3:1992 + A4:1995 + A5:2002.

As soon as IEC 60076-11 is endorsed by CENELEC this document will be withdrawn.

The common modifications indicated in this document correspond to those included in HD 464 S1:1988 with additional minor modifications.

The reference of clauses, subclauses, notes, figures and annexes which are in addition to those in IEC 60726 is prefixed with the letter Z.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2003-11-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) -

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, Annexes A, B, ZA, ZB, ZC and ZE are normative and Annex ZD is informative.

Annexes ZA, ZB, ZC, ZD and ZE have been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60726:1982 and its amendment 1:1986 was approved by CENELEC as a European Standard with agreed common modifications.

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DRY-TYPE POWER TRANSFORMERS

SECTION ONE — GENERAL

1. Scope

This standard applies to dry-type power transformers (including auto-transformers) having values of highest voltage for equipment up to and including 36 kV.

The following small and special dry-type transformers are not covered by this standard:

- single-phase transformers rated at less than 1 kVA and polyphase transformers rated at less than 5 kVA;
- ☐ — transformers having no windings with rated voltage U_r higher than 1 000 V; ☐
- instrument transformers (covered by IEC Publications 185: Current Transformers, and 186: Voltage Transformers);
- transformers for static convertors (covered by IEC Publications 84: Recommendations for Mercury-arc Convertors, 119: Recommendations for Polycrystalline Semiconductor Rectifier Stacks and Equipment, and 146: Semiconductor Convertors);
- 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.

☐ NOTE 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. ☐

With the publication of this standard, the requirements of IEC Publication 76 apply to dry-type transformers only in so far as they are referred to in this standard.

Where reference is made to specific clauses and sub-clauses of various parts of IEC Publication 76, it is to be understood that the editions are as follows:

76-1, 76-2, 76-4, 76-5: 1976.
76-3: 1980.

2. Service conditions

2.1 Normal service conditions

This standard gives detailed requirements for transformers for use under the following conditions:

a) Altitude:

A height above sea-level not exceeding 1 000 m (3 300 feet).

Note. — For greater altitudes, see Sub-clause 2.2.

b) Temperature of cooling air:

Never exceeding 40 °C and never below:

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

Ⓔ NOTE Both outdoor and indoor dry-type transformers are suitable for transport and storage at ambient temperatures down to –25 °C. Ⓔ

In addition, an ambient air temperature never exceeding the following values:

- 30 °C average in any one day;
- 20 °C average in any one year.

Note. — For higher temperatures, see Sub-clause 2.2.

c) Wave-shape of supply voltage:

A supply voltage of which the wave-shape is approximately sinusoidal.

d) Symmetry of polyphase supply voltages:

For polyphase transformers, supply voltages which are approximately symmetrical.

2.2 Provision for unusual service conditions

The purchaser shall specify in his enquiry any service conditions not covered by the normal service conditions in Sub-clause 2.1 (see Appendix B).

Supplementary requirements, within defined limits, for the rating and testing of transformers designed for other than normal service conditions listed in Sub-clause 2.1, such as high temperature of cooling air or altitude above 1 000 m (3 300 feet) are given in Sub-clauses 10.2, 10.3 and 11.2.

For temperature conditions outside the limits covered by the supplementary requirements and special operating conditions, for example restricted cooling air circulation, the temperature rise is to be subject to agreement between the manufacturer and the purchaser.

3. Definitions

For the purpose of this standard, the following definitions apply. Other terms used have the meanings ascribed to them in IEC Publications 76-1: Power Transformers, Part 1: General, or 50: International Electrotechnical Vocabulary (I.E.V.).

3.1 Dry-type transformer

A transformer in which the core and windings are not immersed in an insulating liquid.

Note. — The cooling of a dry-type transformer may be natural, natural/forced or forced circulation (see Clause 9).

3.1.1 Encapsulated-winding dry-type transformer

A dry-type transformer having one or more windings encapsulated with solid insulation.

3.1.2 Non-encapsulated-winding dry-type transformer

A dry-type transformer having none of the windings encapsulated with solid insulation.

3.2 Terms relating to the containment of a dry-type transformer

3.2.1 Sealed dry-type transformer

An air or gas-immersed dry-type transformer within a sealed protective enclosure so constructed that there can be no interchange between its contents and the external atmosphere, i.e. the transformer is non-breathing.

Note. — The gas in a gas-immersed transformer remains in a gaseous state throughout the range of transformer operations.

3.2.2 Totally enclosed dry-type transformer

An air immersed dry-type transformer within a protective enclosure so constructed that the ambient air does not circulate to cool the core and windings, but which can breathe to atmosphere.

3.2.3 Enclosed dry-type transformer

A dry-type transformer within a protective enclosure so constructed that the ambient air may circulate so as to cool the core and windings directly.

3.2.4 Non-enclosed dry-type transformer

A dry-type transformer without a protective enclosure in which the core and windings are cooled by ambient air.

4. Tappings

As in Section One of IEC Publication 76-4: Power Transformers, Part 4: Tappings and Connections, but where tappings are required the preferred tapping range is $\pm 5\%$ in 2.5% steps, i.e. $\pm 2.5\%$, $\pm 5\%$, by means of off-circuit  links to tap-selectors. 

5. Connections

See Section Two of IEC Publication 76-4.

6. Ability to withstand short circuit

IEC Publication 76-5: Power Transformers, Part 5: Ability to Withstand Short Circuit, applies to the transformers covered by this standard.

SECTION TWO — RATING

7. Rating

7.1 General

The manufacturer shall assign ratings to the transformer, which shall be marked on the rating plate (see Clause 8). 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 Section Three, assuming that the applied voltage is equal to the rated voltage and that the supply is at rated frequency.

7.2 Rated power

The rated power shall take into account service conditions corresponding to those specified in Clause 2 and shall be related to the product of rated voltage, rated current and the appropriate phase factor given in Table I.

TABLE I
Phase factors

Number of phases	Phase factor
1	1
3	$\sqrt{3}$

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

7.3 Preferred values of rated power

As Sub-clause 4.3 of IEC Publication 76-1.

7.4 Operation at higher than rated voltage

As Sub-clause 4.4 of IEC Publication 76-1.

8. Rating plates

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 (i.e. by etching, engraving or stamping).

- Kind of transformer (see definitions given in Clause 3).
- Number and year of this standard.
- Manufacturer's name.
- Manufacturer's serial number.
- Year of manufacture.
- Insulation system temperature and maximum permissible temperature rise for all windings, or for each individual winding, if applicable (see Sub-clause 10.1).
- Number of phases.
- Rated power for each kind of cooling.
- Rated frequency.
- Rated voltages, including tapping voltages, if any.
- Rated currents for each kind of cooling.
- Connection symbol.
- Impedance voltage at rated current determined according to Sub-clause 8.4 of IEC Publication 76-1.

- n) Type of cooling.
- o) Type of filling.
- p) Operating pressure range.
- q) Maximum and minimum absolute pressures for which the enclosure is designed
- r) Pressure and temperature of filling medium at the time of sealing.
- s) Total mass.
- t) Insulation levels.

} applicable only to sealed units.

(The rated withstand voltages for all windings shall appear on the rating plate. The principles of the standard notation are illustrated in Clause 3 of IEC Publication 76-3: Power Transformers, Part 3: Insulation Levels and Dielectric Tests.)

- Ⓒ za) Degree or degrees of protection IP in accordance with IEC 60529 when an enclosure is provided.
- zb) Statements of environmental, climatic and fire behaviour classes (see Annex B) to which the complete transformer complies, as follows: EX - CX - FX according to Table B.Z1. Ⓒ

SECTION THREE — COOLING METHODS AND TEMPERATURE RISE

9. Identification according to cooling method

9.1 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 II.

TABLE II
Letter symbols

Kind of cooling medium	Symbol
Air	A
Gas	G
Kind of circulation	
Natural	N
Forced	F

9.2 Arrangement of symbols

Transformers without protective enclosures or within enclosures through which the cooling air can circulate are identified by two symbols only for the cooling medium (air) which is in contact with the windings or the surface coating of the windings.

All other transformers shall be identified by four symbols for each cooling method for which a rating is assigned by the manufacturer.

The order in which the symbols are used shall be as given in Table III. Oblique strokes shall be used to separate the group of symbols for different cooling methods for the same piece of equipment.

TABLE III
Order of symbols

1st letter	2nd letter	3rd letter	4th letter
Indicating the cooling medium that is in contact with the windings		Indicating the cooling medium that is in contact with the external cooling system	
Kind of cooling medium	Kind of circulation	Kind of cooling medium	Kind of circulation

For example, the cooling method of a transformer without a protective enclosure or within an enclosure through which the cooling air can circulate and with natural air cooling is designated by:

AN

For a transformer within a protective enclosure through which the cooling air cannot circulate, with natural air cooling inside and outside the enclosure, the designation is:

ANAN

For a transformer in a sealed enclosure with natural nitrogen cooling inside and alternatives of natural or forced air cooling outside the enclosure, the designation is:

GNAN/GNAF

10. Temperature-rise limits

10.1 Normal temperature-rise limits

The temperature rises of the windings, core and metal parts of transformers designed for operation at altitudes not exceeding those given in Item *a*) of Sub-clause 2.1 and with external cooling air temperature as described in Item *b*) of Sub-clause 2.1 shall not exceed the limits specified in Table IV when tested in accordance with Clause 21.

The hot spot temperatures given in column 2 are approved for the winding temperature rises specified in column 3 only when used in the insulation of apparatus within the scope of this standard.

Insulating materials may be used separately or in a combination providing that, in any application, each system will not be continuously subjected to a temperature in excess of that for which it is suitable when operating under rated conditions.

Furthermore, the electrical and mechanical properties of the insulated winding must not be impaired by the application of the hot-spot temperature permitted for the specific insulation system.

Note. — In column 2 of Table IV the letters refer to temperature classifications given in IEC Publication 85: Recommendations for the Classification of Materials for the Insulation of Electrical Machinery and Apparatus in Relation to Their Thermal Stability in Service.

TABLE IV
Temperature-rise limits

1	2	3
Part	Insulation system temperature (°C)	Maximum temperature rise (K)
Windings (temperature rise measured by the resistance method)	105 (A) 120 (E) 130 (B) 155 (F) 180 (H) [C] 200 220	60 75 80 100 125 135 150 [C]
Core, metallic parts and adjacent materials		The temperature shall, in no case, reach a value that will damage the core itself, other parts or adjacent materials

10.2 *Reduced temperature rises for transformers designed for high cooling air temperatures or special air cooling conditions*

If the transformer is designed for service where the temperature of the cooling air exceeds one of the maximum values specified in Item *b)* of Sub-clause 2.1 by no more than 10 K, the allowable temperature rises for the windings shall be reduced:

- by 5 K if the excess temperature is less than or equal to 5 K;
- by 10 K if the excess temperature is greater than 5 K and less than or equal to 10 K.

Where the excess temperature exceeds one of the values specified in Item *b)* of Sub-clause 2.1 by more than 10 K, the allowable temperature rises require an agreement between the manufacturer and the purchaser.

Any site conditions which may either impose restrictions on the cooling air or produce high ambient air temperatures should be stated by the purchaser.

[C] NOTE When a transformer has windings of different insulation system temperatures, the reference temperature relating to the winding having the higher insulation system temperature shall be used.

For some applications, a lower maximum temperature rise may be chosen from values given in column 3 of Table IV.

Reference temperatures for load loss and short-circuit impedance should be in accordance with the newly assigned temperature rises (e.g. it should be possible to specify an unit belonging to class F having a maximum temperature rise of 80 K instead of 100 K). [C]

10.3 *Reduced temperature rises for transformers designed for high altitudes*

Unless otherwise agreed between the manufacturer and the purchaser, for transformers designed for operation at an altitude greater than 1 000 m but tested at normal altitudes, the limits of temperature rise given in Table IV are reduced by the following amounts for each 500 m by which the intended working altitude exceeds 1 000 m:

- natural-air-cooled transformers: 2.5%;
- forced-air-cooled transformers: 5%.

Note. — If transformers which are designed for operation below 1 000 m are tested at altitudes above 1 000 m, the measured temperature rises are to be reduced by the above-mentioned amounts for each 500 m by which the test altitude exceeds 1 000 m.

SECTION FOUR — INSULATION LEVELS

11. Insulation levels

11.1 General

When transformers are intended for general power distribution in public or industrial systems, the insulation levels shall be those given in Table V, List 1 or 2. The choice between Lists 1 and 2 should be made by considering the degree of exposure to lightning and switching overvoltages, the type of system neutral earthing and, where applicable, the type of over-voltage protective device (see IEC Publication 71: Insulation Co-ordination).

However, for application in particular systems where the insulation requirements are lower than in general and where the transformers are not required to be tested with lightning impulse withstand voltages, the power frequency test voltage applied may be below the value specified in Table V where experience has proved this to be permissible. No definite figures are recommended here.

TABLE V
Insulation levels

Highest voltage for equipment U_m (r.m.s.) (kV)	Rated short duration power frequency withstand voltage (r.m.s.) (kV)	Rated lightning impulse withstand voltage (peak value) (kV)	
		List 1	List 2
≤ 1.1	3	—	—
3.6	10	20	40
7.2	20	40	60
12	28	60	75
17.5	38	75	95
24	50	95	125
36	70	145	170

11.2 Transformers for use at high altitudes

When the transformers are specified for operation at altitudes between 1 000 m and 3 000 m above sea-level, but tested at normal altitude, the rated short duration power frequency withstand voltage shall be increased by 6.25% for each 500 m by which the altitude of the installation exceeds 1 000 m.

Note. — The above does not apply to sealed dry-type transformers but special consideration should be given to bushings.

SECTION FIVE — TESTS

12. General requirements for tests

Transformers shall be subjected to tests as specified below.

Tests shall be made at the manufacturer's works, unless otherwise agreed between the manufacturer and the purchaser.