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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Power transformers –
Part 1: General

Transformateurs de puissance –
Partie 1: Généralités

IEC 60076-1:2011

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POWER TRANSFORMERS –

Part 1: General

FOREWORD

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International Standard IEC 60076-1 has been prepared by IEC technical committee 14: Power transformers.

This third edition cancels and replaces the second edition published in 1993, and its Amendment 1(1999). It is a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– addition of a definition of harmonic content;
– addition of a subclause on transport;
– addition of functional method of specification;
– addition of connection symbols for single phase transformers;
– addition of safety and environmental requirements;
– addition of requirements for liquid preservation systems;

- addition of a clause on DC currents;
- addition of vacuum, pressure and leak tests on tanks;
- the requirements formerly in Annex A are now incorporated in the text and Annex A is now an informative checklist;
- informative annexes have been added on facilities for condition monitoring and environmental and safety considerations.

The text of this standard is based on the following documents:

FDIS	Report on voting
14/675/FDIS	14/682/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60076 series can be found, under the general title *Power transformers*, on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

POWER TRANSFORMERS –

Part 1: General

1 Scope

This part of IEC 60076 applies to three-phase and single-phase power transformers (including auto-transformers) with the exception of certain categories of small and special transformers such as:

– single-phase transformers with rated power less than 1 kVA and three-phase transformers less than 5 kVA;
– transformers, which have no windings with rated voltage higher than 1 000 V;
– instrument transformers;
– traction transformers mounted on rolling stock;
– starting transformers;
– testing transformers;
– welding transformers;
– explosion-proof and mining transformers;
– transformers for deep water (submerged) applications.

When IEC standards do not exist for such categories of transformers (in particular transformer having no winding exceeding 1000 V for industrial applications), this part of IEC 60076 may still be applicable either as a whole or in part.

This standard does not address the requirements that would make a transformer suitable for mounting in a position accessible to the general public.

For those categories of power transformers and reactors which have their own IEC standards, this part is applicable only to the extent in which it is specifically called up by cross-reference in the other standard. Such standards exist for:

– reactors in general (IEC 60076-6);
– dry-type transformers (IEC 60076-11);
– self-protected transformers (IEC 60076-13);
– gas-filled power transformers (IEC 60076-15);
– transformers for wind turbine applications (IEC 60076-16);
– traction transformers and traction reactors (IEC 60310);
– converter transformers for industrial applications (IEC 61378-1);
– converter transformers for HVDC applications (IEC 61378-2).

At several places in this part it is specified or recommended that an 'agreement' should be reached concerning alternative or additional technical solutions or procedures. Such agreement is made between the manufacturer and the purchaser. The matters should preferably be raised at an early stage and the agreements included in the contract specification.

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.

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

IEC 60076-3:2000, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60076-5:2006, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-10:2001, *Power transformers – Part 10: Determination of sound levels*

IEC 60076-11:2004, *Power transformers – Part 11: Dry-type transformers*

IEC 60137:2008, *Insulated bushings for alternating voltages above 1 000 V*

IEC 60214-1:2003, *Tap-changers – Part 1: Performance requirements and test methods*

IEC 60296:2003, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60721-3-4:1995, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 4: Stationary use at non-weatherprotected locations*

ISO 9001:2008, *Quality management systems – Requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE Other terms use the meanings ascribed to them in the International Electrotechnical Vocabulary (IEV).

3.1 General

3.1.1
power transformer
a static piece of apparatus with two or more windings which, by electromagnetic induction, transforms a system of alternating voltage and current into another system of voltage and current usually of different values and at the same frequency for the purpose of transmitting electrical power

[IEC 60050-421:1990, 421-01-01, modified]

3.1.2
auto-transformer
a transformer in which at least two windings have a common part

[IEC 60050-421:1990, 421-01-11]

NOTE Where there is a need to express that a transformer is not auto-connected, use is made of terms such as separate winding transformer, or double-wound transformer (see IEC 60050-421:1990, 421-01-13).

3.1.3
series transformer
a transformer, other than an autotransformer, of which one winding is intended to be connected in series with a circuit in order to alter its voltage and/or shift its phase. The other winding is an energizing winding

[IEC 60050-421:1990, 421-01-12, modified]

NOTE Series transformers were called booster transformers in earlier editions of this standard.

3.1.4
liquid-immersed type transformer
a transformer in which the magnetic circuit and windings are immersed in liquid

3.1.5
dry-type transformer
a transformer in which the magnetic circuit and windings are not immersed in an insulating liquid

[IEC 60050-421:1990, 421-01-16]

3.1.6
liquid preservation system
system in a liquid-filled transformer by which the thermal expansion of the liquid is accommodated.

NOTE Contact between the liquid and external air may sometimes be diminished or prevented.

3.1.7
specified value
the value specified by the purchaser at the time of order

3.1.8
design value
the expected value given by the number of turns in the design in the case of turns ratio or calculated from the design in the case of impedance, no-load current or other parameters

3.1.9
highest voltage for equipment U_m applicable to a transformer winding
the highest r.m.s. phase-to-phase voltage in a three-phase system for which a transformer winding is designed in respect of its insulation

3.2 Terminals and neutral point

3.2.1
terminal
a conducting element intended for connecting a winding to external conductors

3.2.2
line terminal
a terminal intended for connection to a line conductor of a network

[IEC 60050-421:1990, 421-02-01]

3.2.3
neutral terminal
a) for three-phase transformers and three-phase banks of single-phase transformers:

the terminal or terminals connected to the common point (the neutral point) of a star-connected or zigzag connected winding

b) for single-phase transformers:

the terminal intended for connection to a neutral point of a network

[IEC 60050-421:1990, 421-02-02, modified]

3.2.4
neutral point
the point of a symmetrical system of voltages which is normally at zero potential

3.2.5
corresponding terminals
terminals of different windings of a transformer, marked with the same letter or corresponding symbol

[IEC 60050-421:1990, 421-02-03]

3.3 Windings

3.3.1
winding
the assembly of turns forming an electrical circuit associated with one of the voltages assigned to the transformer

[IEC 60050-421:1990, 421-03-01, modified]

NOTE For a three-phase transformer, the 'winding' is the combination of the phase windings (see 3.3.3).

3.3.2
tapped winding
a winding in which the effective number of turns can be changed in steps

3.3.3
phase winding
the assembly of turns forming one phase of a three-phase winding

[IEC 60050-421:1990, 421-03-02, modified]

NOTE The term 'phase winding' should not be used for identifying the assembly of all coils on a specific leg.

3.3.4
high-voltage winding
HV winding*
the winding having the highest rated voltage

[IEC 60050-421:1990, 421-03-03]

3.3.5
low-voltage winding
LV winding*
the winding having the lowest rated voltage

[IEC 60050-421:1990, 421-03-04]

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* The winding which receives active power from the supply source in service is referred to as a 'primary winding', and that which delivers active power to a load as a 'secondary winding'. These terms have no significance as to which of the windings has the higher rated voltage and should not be used except in the context of direction of active power flow (see IEC 60050-421:1990, 421-03-06 and 07). A further winding in the transformer, usually with lower value of rated power than the secondary winding, is then often referred to as 'tertiary winding', see also definition 3.3.8.

NOTE For a series transformer, the winding having the lower rated voltage may be that having the higher insulation level.

3.3.6
intermediate-voltage winding*
a winding of a multi-winding transformer having a rated voltage intermediate between the highest and lowest winding rated voltages

[IEC 60050-421:1990, 421-03-05]

3.3.7
auxiliary winding
a winding intended only for a small load compared with the rated power of the transformer

[IEC 60050-421:1990, 421-03-08]

3.3.8
stabilizing winding
a supplementary delta-connected winding provided in a star-star-connected or star-zigzag-connected transformer to decrease its zero-sequence impedance, see 3.7.3

[IEC 60050-421:1990, 421-03-09, modified]

NOTE A winding is referred to as a stabilizing winding only if it is not intended for three-phase connection to an external circuit.

3.3.9
common winding
the common part of the windings of an auto-transformer

[IEC 60050-421:1990, 421-03-10]

3.3.10
series winding
the part of the winding of an auto-transformer or the winding of a series transformer which is intended to be connected in series with a circuit

[IEC 60050-421:1990, 421-03-11, modified]

3.3.11
energizing winding (of a series transformer)
the winding of a series transformer which is intended to supply power to the series winding

[IEC 60050-421:1990, 421-03-12, modified]

3.3.12
auto-connected windings
the series and common windings of an auto-transformer

3.4 Rating

3.4.1
rating
those numerical values assigned to the quantities which define the operation of the transformer in the conditions specified in this part of IEC 60076 and on which the manufacturer's guarantees and the tests are based

3.4.2
rated quantities
quantities (voltage, current, etc.), the numerical values of which define the rating

NOTE 1 For transformers having tappings, rated quantities are related to the principal tapping (see 3.5.2), unless otherwise specified. Corresponding quantities with analogous meaning, related to other specific tappings, are called tapping quantities (see 3.5.9).

NOTE 2 Voltages and currents are always expressed by their r.m.s. values, unless otherwise specified.

3.4.3
rated voltage of a winding
***U*r**
the voltage assigned to be applied, or developed at no-load, between the terminals of an untapped winding, or of a tapped winding connected on the principal tapping (see 3.5.2), for a three-phase winding it is the voltage between line terminals

[IEC 60050-421:1990, 421-04-01, modified]

NOTE 1 The rated voltages of all windings appear simultaneously at no-load when the voltage applied to one of them has its rated value.

NOTE 2 For single-phase transformers intended to be connected in star to form a three-phase bank or to be connected between the line and the neutral of a three phase system, the rated voltage is indicated as the phase-to-phase voltage, divided by $\sqrt{3}$ for example $400/\sqrt{3}$ kV.

NOTE 3 For single phase transformers intended to be connected between phases of a network, the rated voltage is indicated as the phase-to-phase voltage.

NOTE 4 For the series winding of a three-phase series transformer, which is designed as an open winding (see 3.10.5), the rated voltage is indicated as if the windings were connected in star.

3.4.4
rated voltage ratio
the ratio of the rated voltage of a winding to the rated voltage of another winding associated with a lower or equal rated voltage

[IEC 60050-421:1990, 421-04-02, modified]

3.4.5
rated frequency
***f*r**
the frequency at which the transformer is designed to operate

[IEC 60050-421:1990, 421-04-03, modified]

3.4.6
rated power
***S*r**
conventional value of apparent power assigned to a winding which, together with the rated voltage of the winding, determines its rated current

NOTE Both windings of a two-winding transformer have the same rated power which by definition is the rated power of the whole transformer.

3.4.7
rated current
***I*r**
the current flowing through a line terminal of a winding which is derived from rated power S_r and rated voltage U_r for the winding

[IEC 60050-421:1990, 421-04-05, modified]

NOTE 1 For a three-phase winding the rated current I_r is given by:

$$I_r = \frac{S_r}{\sqrt{3} \times U_r}$$

NOTE 2 For single-phase transformer windings intended to be connected in delta to form a three-phase bank, the rated current is indicated as line current divided by $\sqrt{3}$,

$$I_r = \frac{I_{line}}{\sqrt{3}}$$

NOTE 3 For a single phase transformer not intended to be connected to form a three phase bank, the rated current is

$$I_r = \frac{S_r}{U_r}$$

NOTE 4 For open windings (see 3.10.5) of a transformer, the rated current of the open windings is the rated power divided by the number of phases and by the rated voltage of the open winding:

$$I_r = \frac{S_r}{\text{No. of phases} \times U_r}$$

3.5 Tappings

3.5.1
tapping
in a transformer having a tapped winding, a specific connection of that winding, representing a definite effective number of turns in the tapped winding and, consequently, a definite turns ratio between this winding and any other winding with a fixed number of turns

NOTE One of the tappings is the principal tapping, and other tappings are described in relation to the principal tapping by their respective tapping factors. See definitions of these terms below.

3.5.2
principal tapping
the tapping to which the rated quantities are related

[IEC 60050-421:1990, 421-05-02]

3.5.3
tapping factor (corresponding to a given tapping)
the ratio:

$\frac{U_d}{U_r}$ (tapping factor) or $100\ \frac{U_d}{U_r}$ (tapping factor expressed as a percentage)

where

U_r is the rated voltage of the winding (see 3.4.3);

U_d is the voltage which would be developed at no-load at the terminals of the winding, at the tapping concerned, by applying rated voltage to an untapped winding

NOTE For series transformers, the tapping factor is the ratio of the voltage of the series winding corresponding to a given tapping to U_r.

[IEC 60050-421:1990, 421-05-03, modified]

3.5.4
plus tapping
a tapping whose tapping factor is higher than 1

[IEC 60050-421:1990, 421-05-04]