

Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air (IEC 60076-3:2000 + Corrigendum 2000)

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EUROPEAN STANDARD

**EN 60076-3**

NORME EUROPÉENNE

EUROPÄISCHE NORM

May 2001

ICS 29.180

Supersedes HD 398.3 S1:1986 + A1:1995

English version

## **Power transformers**

### **Part 3: Insulation levels, dielectric tests and external clearances in air (IEC 60076-3:2000 + corrigendum 2000)**

Transformateurs de puissance  
Partie 3: Niveaux d'isolement, essais  
diélectriques et distances d'isolement  
dans l'air  
(CEI 60076-3:2000 + corrigendum 2000)

Leistungstransformatoren  
Teil 3: Isolationspegel, Spannungs-  
prüfungen und äußere Abstände in Luft  
(IEC 60076-3:2000 + corrigendum 2000)

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This European Standard was approved by CENELEC on 2001-01-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

# **CENELEC**

European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

### Foreword

The text of document 14/347/FDIS, future edition 2 of IEC 60076-3, prepared by IEC TC 14, Power transformers, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60076-3 on 2001-01-01.

This European Standard supersedes HD 398.3 S1:1986 + A1:1995.

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) 2001-10-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2004-01-01

Annexes designated "normative" are part of the body of the standard. Annexes designated "informative" are given for information only. In this standard, annexes D, ZA and ZB are normative and annexes A, B and C are informative.

Annexes ZA and ZB have been added by CENELEC.

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The text of the International Standard IEC 60076-3:2000 + corrigendum December 2000 was approved by CENELEC as a European Standard with the following editorial modification.

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In subclause 12.3, delete note 3.

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## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

| <u>Publication</u>   | <u>Year</u>     | <u>Title</u>  | <u>EN/HD</u>              | <u>Year</u>                |
|----------------------|-----------------|---|---------------------------|----------------------------|
| IEC 60050-421        | — <sup>1)</sup> | International electrotechnical vocabulary (IEV)<br>Chapter 421: Power transformers and reactors | -                         | -                          |
| IEC 60060-1          | — <sup>1)</sup> | High-voltage test techniques<br>Part 1: General definitions and test requirements               | HD 588.1 S1               | 1991 <sup>2)</sup>         |
| IEC 60060-2          | — <sup>1)</sup> | Part 2: Measuring systems   | EN 60060-2<br>+ A11       | 1994 <sup>2)</sup><br>1998 |
| IEC 60071-1          | 1993            | Insulation co-ordination<br>Part 1: Definitions, principles and rules                           | EN 60071-1                | 1995                       |
| IEC 60071-2          | 1976            | Part 2: Application guide   | HD 540.2 S1 <sup>3)</sup> | 1991                       |
| IEC 60076-1<br>(mod) | — <sup>1)</sup> | Power transformers<br>Part 1: General   | EN 60076-1                | 1997 <sup>2)</sup>         |
| IEC 60137            | 1995            | Insulated bushings for alternating voltages above 1 kV  | EN 60137                  | 1996                       |
| IEC 60270            | — <sup>1)</sup> | High-voltage test techniques - Partial discharge measurements                                   | EN 60270                  | 2001 <sup>2)</sup>         |
| IEC 60722            | — <sup>1)</sup> | Guide to the lightning impulse and switching impulse testing of power transformers and reactors | -                         | -                          |
| IEC 60790            | — <sup>1)</sup> | Oscilloscopes and peak voltmeters for impulse tests   | HD 479 S1                 | 1986 <sup>2)</sup>         |

<sup>1)</sup> Undated reference

<sup>2)</sup> Valid edition at date of issue

<sup>3)</sup> HD 540.2 S1 is superseded by EN 60071-2:1997, which is based on IEC 60071-2:1996.

| <u>Publication</u>   | <u>Year</u>     | <u>Title</u>   | <u>EN/HD</u> | <u>Year</u>        |
|----------------------|-----------------|--|--------------|--------------------|
| IEC 61083-1<br>(mod) | — <sup>1)</sup> | Digital recorders for measurements in high-voltage impulse tests<br>Part 1: Requirements for digital recorders                                 | EN 61083-1   | 1993 <sup>2)</sup> |
| IEC 61083-2          | — <sup>1)</sup> | Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms   | EN 61083-2   | 1997 <sup>2)</sup> |
| CISPR 16-1           | 1993            | Specification for radio disturbance and immunity measuring apparatus and methods<br>Part 1: Radio disturbance and immunity measuring apparatus | -            | -                  |

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### Annex ZB (normative)

## iTeh STANDARD PREVIEW (standards.iteh.ai)

**Special national condition:** National characteristic or practice that cannot be changed even over a long period, e.g. climatic conditions, electrical earthing conditions. If it affects harmonization, it forms part of the European Standard or Harmonization Document.

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For the countries in which the relevant special national apply these provisions are normative, for other countries they are informative.

| <u>Clause</u> | <u>Special national condition</u> |
|---------------|-----------------------------------|
|---------------|-----------------------------------|

|      |               |
|------|---------------|
| 12.3 | <b>France</b> |
|------|---------------|

Partial discharge measurements during short-duration a.c. test on non-uniform insulated high-voltage windings are not acceptable.

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# INTERNATIONAL STANDARD

# IEC 60076-3

Second edition  
2000-03

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**Power transformers –**

**Part 3:  
Insulation levels, dielectric tests and  
external clearances in air**

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Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## POWER TRANSFORMERS –

## Part 3: Insulation levels, dielectric tests and external clearances in air

## FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60076-3 has been prepared by IEC technical committee 14: Power transformers.

This second edition cancels and replaces the first edition published in 1980, amendment 1 (1981) and IEC 60076-3-1 (1987).

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

|             |                  |
|-------------|------------------|
| FDIS        | Report on voting |
| 14/347/FDIS | 14/355/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 3.

Annexes A, B and C are for information only.

Annex D forms an integral part of this standard.

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

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

The contents of the corrigendum of December 2000 have been included in this copy.

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## INTRODUCTION

This part of IEC 60076 specifies the insulation requirements and the corresponding insulation tests with reference to specific windings and their terminals. It also recommends clearances in air between live parts of bushings on oil-immersed power transformers and to objects at earth potential (clause 16). Guidance can be obtained from IEC 60071.

The insulation levels and dielectric tests which are specified in clauses 4, 5, 6 and 7 in this standard apply to the internal insulation only. Whilst it is reasonable that the rated withstand voltage values which are specified for the internal insulation of the transformer should also be taken as a reference for its external insulation, this may not be true in all cases. A failure of the non-self-restoring internal insulation is catastrophic and normally leads to the transformer being out of service for a long period, while an external flashover may involve only a short interruption of service without causing lasting damage. Therefore, it may be that, for increased safety, higher test voltages are specified by the purchaser for the internal insulation of the transformer than for the external insulation of other components in the system. When such a distinction is made, the external clearances must be adjusted to fully cover the internal insulation test requirements.

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## POWER TRANSFORMERS –

### Part 3: Insulation levels, dielectric tests and external clearances in air

#### 1 Scope

This International Standard applies to single-phase and three-phase oil-immersed power transformers (including auto-transformers), with the exception of certain small and special transformers, as defined in the scope of IEC 60076-1. It identifies transformer windings to their highest voltage for equipment  $U_m$  associated with their corresponding rated insulation levels and details the relevant applicable dielectric tests and minimum external clearances in air between live parts of bushings and to objects at earth potential.

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

#### 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60076. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60076 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(421), *International Electrotechnical Vocabulary (IEV) – Chapter 421: Power transformers and reactors*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60071-1:1993, *Insulation coordination – Part 1: Definitions, principles and rules*

IEC 60071-2:1976, *Insulation coordination – Part 2: Application guide*

IEC 60076-1, *Power transformers – Part 1: General*

IEC 60137:1995, *Bushings for alternating voltages above 1 000 V*

IEC 60270, *Partial discharge measurements*

IEC 60722, *Guide to the lightning impulse and switching impulse testing of power transformers and reactors*

IEC 60790, *Oscilloscopes and peak voltmeters for impulse tests*

IEC 61083-1, *Digital recorders for measurements in high-voltage impulse tests – Part 1: Requirements for digital recorders*

IEC 61083-2, *Digital recorders for measurements in high-voltage impulse tests – Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms*

CISPR 16-1:1993, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

### 3 Definitions

For the purpose of this part of IEC 60076, the following definitions apply. Other terms used have the meanings ascribed to them in IEC 60076-1 or in IEC 60050(421).

#### 3.1

##### **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

##### **rated insulation level**

a set of standard withstand voltages which characterize the dielectric strength of the insulation

#### 3.3

##### **standard insulation level**

a rated insulation level, the standard withstand voltages of which are associated to  $U_m$  as recommended in tables 2 and 3 of IEC 60071-1

#### 3.4

##### **uniform insulation of a transformer winding**

the insulation of a transformer winding when all its ends connected to terminals have the same rated insulation level

#### 3.5

##### **non-uniform insulation of a transformer winding**

the insulation of a transformer winding when it has a neutral terminal end for direct or indirect connection to earth, and is designed with a lower insulation level than assigned for the line terminal

### 4 General

The insulation requirements for power transformers and the corresponding insulation tests are given with reference to specific windings and their terminals.

For oil-immersed transformers, the requirements apply to the internal insulation only. Any additional requirements or tests regarding external insulation which are deemed necessary shall be subject to agreement between supplier and purchaser, including type tests on a suitable model of the configuration.

If the purchaser intends to make the connections to the transformer in a way which may reduce the clearances provided by the transformer alone, this should be indicated in the enquiry.

When an oil-immersed transformer is specified for operation at an altitude higher than 1 000 m, clearances shall be designed accordingly. It may then be necessary to select bushings designed for higher insulation levels than those specified for the internal insulation of the transformer windings, see clause 16 of this standard and 4.2 of IEC 60137.

Bushings are subject to separate type and routine tests according to IEC 60137, which verify their phase-to-earth insulation, external as well as internal.

It is presupposed that bushings and tap-changers are specified, designed and tested in accordance with relevant IEC standards. The insulation tests on the complete transformer, however, constitute a check on the correct application and installation of these components.

The insulation test shall generally be made at the supplier's works with the transformer approximately at ambient temperature, but at least at 10 °C.

The transformer shall be completely assembled as in service including supervisory equipment. It is not necessary, however, to fit elements which do not influence the dielectric strength of the internal insulation, for example, the external cooling equipment.

If a transformer fails to meet its test requirements and the fault is in a bushing, it is permissible to replace this bushing temporarily with another bushing and continue the test on the transformer to completion without delay. A particular case arises for tests with partial discharge measurements, where certain types of commonly used high-voltage bushings create difficulties because of their relatively high level of partial discharge in the dielectric. When such bushings are specified by the purchaser, it is permitted to exchange them for bushings of a partial discharge free type during the testing of the transformer; see annex A.

Transformers for cable box connection or direct connection to metal-enclosed SF<sub>6</sub> installations should be designed so that temporary connections can be made for insulation tests, using temporary bushings, if necessary. By agreement, oil/SF<sub>6</sub> bushings may for that reason be replaced by appropriate oil/air bushings.

When the supplier intends to use non-linear elements or surge arresters, built into the transformer or externally fitted, for the limitation of transferred overvoltage transients, this shall be brought to the purchaser's attention at the tender and order stage and it is recommended that it be indicated on the transformer rating plate circuit diagram.

## 5 Highest voltage for equipment and insulation level

To each winding of a transformer, both for the line and neutral side, is assigned a value of highest voltage for equipment  $U_m$ , see 3.1.

The rules for coordination of transformer insulation with respect to transient overvoltages are formulated differently depending on the value of  $U_m$ .