Power transformers Part 5: Ability to withstand short-circuit

Power transformers Part 5: Ability to withstand short-circuit

EESTI STANDARDI EESSÕNA **NATIONAL FOREWORD**

Käesolev Eesti standard EVS-EN 60076-5:2006 sisaldab Euroopa standardi EN 60076-5:2006 ingliskeelset teksti. Käesolev dokument on jõustatud 22.09.2006 ja selle kohta on avaldatud teade Eesti standardiorganisatsiooni ametlikus väljaandes. Standard on kättesaadav Eesti standardiorganisatsioonist.	This Estonian standard EVS-EN 60076-5:2006 consists of the English text of the European standard EN 60076-5:2006. This document is endorsed on 22.09.2006 with the notification being published in the official publication of the Estonian national standardisation organisation. The standard is available from Estonian standardisation organisation.

Käsitlusala: This part of IEC 60076 identifies the requirements for power transformers to sustain without damage the effects of overcurrents originated by external short circuits. It describes the calculation procedures used to demonstrate the thermal ability of a power transformer to withstand such overcurrents and both the special test and the theoretical evaluation method used to demonstrate the ability to withstand the relevant dynamic effects.	**Scope:** This part of IEC 60076 identifies the requirements for power transformers to sustain without damage the effects of overcurrents originated by external short circuits. It describes the calculation procedures used to demonstrate the thermal ability of a power transformer to withstand such overcurrents and both the special test and the theoretical evaluation method used to demonstrate the ability to withstand the relevant dynamic effects.

ICS 29.180

Võtmesõnad:

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60076-5

June 2006

ICS 29.180

Supersedes EN 60076-5:2000

English version

Power transformers
Part 5: Ability to withstand short-circuit
(IEC 60076-5:2006)

Transformateurs de puissance
Partie 5: Tenue au court-circuit
(CEI 60076-5:2006)

Leistungstransformatoren
Teil 5: Kurzschlussfestigkeit
(IEC 60076-5:2006)

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

Ref. No. EN 60076-5:2006 E

Foreword

The text of document 14/518/FDIS, future edition 3 of IEC 60076-5, prepared by IEC TC 14, Power transformers, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60076-5 on 2006-04-01.

This European Standard supersedes EN 60076-5:2000.

This European Standard includes the following significant technical changes with respect to EN 60076-5:2000:

a) introduction of Annex A (informative) "Theoretical evaluation of the ability to withstand the dynamic effects of short circuit", in place of previous Annex B (normative) "Calculation method for the demonstration of the ability to withstand short circuit" (blank);

b) introduction of Annex B (informative) "Definition of similar transformer", in place of previous Annex A (informative) "Guidance for the identification of a similar transformer".

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)	2007-01-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2009-04-01

Annex ZA has been added by CENELEC.

_____

Endorsement notice

The text of the International Standard IEC 60076-5:2006 was approved by CENELEC as a European Standard without any modification.

_____

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

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

Publication	Year	Title	EN/HD	Year
IEC 60076-1 (mod) + corr. June + A1	1993 1997 1999	Power transformers - Part 1: General	EN 60076-1 + A1 + A11 + A12	1997 2000 1997 2002
IEC 60076-3 + corr. December	2000 2000	Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air	EN 60076-3	2001
IEC 60076-8	1997	Power transformers - Part 8: Application guide	-	-
IEC 60076-11	2004	Power transformers - Part 11: Dry-type transformers	EN 60076-11	2004

INTERNATIONAL STANDARD

IEC 60076-5

Third edition
2006-02

Power transformers –

Part 5:
Ability to withstand short circuit

*This **English-language** version is derived from the original **bilingual** publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*

Reference number
IEC 60076-5:2006(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**

- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (www.iec.ch/searchpub) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (www.iec.ch/online_news/ justpub) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

  Email: custserv@iec.ch
  Tel: +41 22 919 02 11
  Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

IEC 60076-5

Third edition
2006-02

Power transformers –

Part 5:
Ability to withstand short circuit

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE W

For price, see current catalogue

CONTENTS

FOREWORD 5

1 Scope 9
2 Normative references 9
3 Requirements with regard to ability to withstand short circuit 9
3.1 General 9
3.2 Overcurrent conditions 11
4 Demonstration of ability to withstand short circuit 17
4.1 Thermal ability to withstand short circuit 17
4.2 Ability to withstand the dynamic effects of short circuit 23

Annex A (informative) Theoretical evaluation of the ability to withstand the dynamic effects of short circuit 41
Annex B (informative) Definition of similar transformer 71

Figure 1 – Star/delta connected transformer 29
Figure 2 – Star/star auto-transformer 31

Table 1 – Recognized minimum values of short-circuit impedance for transformers with two separate windings 13
Table 2 – Short-circuit apparent power of the system 13
Table 3 – Maximum permissible values of the average temperature of each winding after short circuit 21
Table 4 – Values for factor $k \times \sqrt{2}$ 25
Table A.1 – Comparison of forces and stresses in core-type transformers 61
Table A.2 – Comparison of forces and stresses in shell-type transformers 65
Table A.3 — Values for factor K_3 69
Table A.4 — Values for factor K_4 69

INTERNATIONAL ELECTROTECHNICAL COMMISSION

POWER TRANSFORMERS –

Part 5: Ability to withstand short circuit

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 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 IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60076-5 has been prepared by IEC technical committee 14: Power transformers.

This third edition cancels and replaces the second edition published in 2000. This third edition constitutes a technical revision.

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

a) introduction of Annex A (informative) – "Theoretical evaluation of the ability to withstand the dynamic effects of short circuit", in place of previous Annex B (normative) – "Calculation method for the demonstration of the ability to withstand short circuit" (blank);
b) introduction of Annex B (informative) – "Definition of similar transformer", in place of previous Annex A (informative) – "Guidance for the identification of a similar transformer".

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

FDIS	Report on voting
14/518/FDIS	14/523/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.

IEC 60076 consists of the following parts, under the general title *Power transformers*:

Part 1: General
Part 2: Temperature rise
Part 3: Insulation levels, dielectric tests and external clearances in air
Part 4: Guide to the lightning impulse and switching impulse testing – Power transformers and reactors
Part 5: Ability to withstand short circuit
Part 6: Reactors [1]
Part 7: Loading guide for oil-immersed power transformers
Part 8: Application guide
Part 10: Determination of sound levels
Part 10-1: Determination of sound levels – Application guide
Part 11: Dry-type transformers
Part 12: Loading guide for dry-type power transformers[1]
Part 13: Self-protected liquid-filled transformers
Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials
Part 15: Gas-filled-type power tranformers[1]

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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.

1 Under consideration.

POWER TRANSFORMERS –

Part 5: Ability to withstand short circuit

1 Scope

This part of IEC 60076 identifies the requirements for power transformers to sustain without damage the effects of overcurrents originated by external short circuits. It describes the calculation procedures used to demonstrate the thermal ability of a power transformer to withstand such overcurrents and both the special test and the theoretical evaluation method used to demonstrate the ability to withstand the relevant dynamic effects. The requirements apply to transformers as defined in the scope of IEC 60076-1.

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 60076-1:1993, *Power transformers – Part 1: General*
Amendment 1 (1999)[2]

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

IEC 60076-8:1997, *Power transformers – Part 8: Application guide*

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

3 Requirements with regard to ability to withstand short circuit

3.1 General

Transformers together with all equipment and accessories shall be designed and constructed to withstand without damage the thermal and dynamic effects of external short circuits under the conditions specified in 3.2.

External short circuits are not restricted to three-phase short circuits; they include line-to-line, double-earth and line-to-earth faults. The currents resulting from these conditions in the windings are designated as overcurrents in this part of IEC 60076.

---

2 There exists a consolidated edition 2.1 (2000) that includes edition 2.0 and its amendment.