

**Jõutrafad. Osa 1: Üldist**

**Power transformers - Part 1: General**

This document is a preview generated by EVS

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

See Eesti standard EVS-EN 60076-1:2012 sisaldab Euroopa standardi EN 60076-1:2011 ingliskeelset teksti.	This Estonian standard EVS-EN 60076-1:2012 consists of the English text of the European standard EN 60076-1:2011.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 04.11.2011.	Date of Availability of the European standard is 04.11.2011.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile [standardiosakond@evs.ee](mailto:standardiosakond@evs.ee).

ICS 29.180

Võtmesõnad: definitions, general, power transformers, rating plates, service conditions, tests, tolerances,

### **Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele**

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:  
Aru 10, 10317 Tallinn, Eesti; [www.evs.ee](http://www.evs.ee); telefon 605 5050; e-post [info@evs.ee](mailto:info@evs.ee)

### **The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation**

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:  
Aru 10, 10317 Tallinn, Estonia; [www.evs.ee](http://www.evs.ee); phone 605 5050; e-mail [info@evs.ee](mailto:info@evs.ee)

English version

**Power transformers -  
Part 1: General  
(IEC 60076-1:2011)**

Transformateurs de puissance -  
Partie 1: Généralités  
(CEI 60076-1:2011)

Leistungstransformatoren -  
Teil 1: Allgemeines  
(IEC 60076-1:2011)

This European Standard was approved by CENELEC on 2011-05-25. 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 CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

**CENELEC**

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

**Management Centre: Avenue Marnix 17, B - 1000 Brussels**

## Foreword

The text of document 14/675/FDIS, future edition 2 of IEC 60076-1, prepared by IEC TC 14, Power transformers, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60076-1 on 2011-05-25.

This European Standard supersedes EN 60076-1:1997 + A1:2000 + A12:2002.

EN 60076-1:2011 includes the following significant technical changes with respect to EN 60076-1:1997:

- 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

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) 2012-05-04
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2014-05-25

Annex ZA has been added by CENELEC.

---

## Endorsement notice

The text of the International Standard IEC 60076-1:2011 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60060 series	NOTE	Harmonized in EN 60060 series (not modified).
IEC 60068-3-3	NOTE	Harmonized as EN 60068-3-3.
IEC 60076-4	NOTE	Harmonized as EN 60076-4.
IEC 60076-6	NOTE	Harmonized as EN 60076-6.
IEC 60076-13	NOTE	Harmonized as EN 60076-13.
IEC 60270	NOTE	Harmonized as EN 60270.
IEC 60310	NOTE	Harmonized as EN 60310.
IEC 60529:1989	NOTE	Harmonized as EN 60529:1991 (not modified).
IEC 61378 series	NOTE	Harmonized in EN 61378 series (not modified).
IEC 61378-1	NOTE	Harmonized as EN 61378-1.
IEC 61378-2	NOTE	Harmonized as EN 61378-2.

---

This document is a preview generated by EVS

## 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.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60076-2	-	Power transformers - Part 2: Temperature rise for liquid-immersed transformers	EN 60076-2	-
IEC 60076-3	2000	Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air	EN 60076-3	2001
IEC 60076-5	2006	Power transformers - Part 5: Ability to withstand short circuit	EN 60076-5	2006
IEC 60076-10	2001	Power transformers - Part 10: Determination of sound levels	EN 60076-10	2001
IEC 60076-11	2004	Power transformers - Part 11: Dry-type transformers	EN 60076-11	2004
IEC 60137	2008	Insulated bushings for alternating voltages above 1 000 V	EN 60137	2008
IEC 60214-1	2003	Tap-changers - Part 1: Performance requirements and test methods	EN 60214-1	2003
IEC 60296	2003	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear	EN 60296 + corr. September	2004 2004
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	EN 60721-3-4	1995
ISO 9001	2008	Quality management systems - Requirements	EN ISO 9001	2008

## CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references .....	8
3 Terms and definitions .....	8
3.1 General .....	8
3.2 Terminals and neutral point .....	9
3.3 Windings .....	10
3.4 Rating .....	11
3.5 Tappings .....	13
3.6 Losses and no-load current .....	15
3.7 Short-circuit impedance and voltage drop .....	16
3.8 Temperature rise .....	17
3.9 Insulation .....	17
3.10 Connections .....	17
3.11 Test classification.....	18
3.12 Meteorological data with respect to cooling .....	19
3.13 Other definitions .....	19
4 Service conditions .....	20
4.1 General .....	20
4.2 Normal service conditions .....	20
5 Rating and general requirements.....	22
5.1 Rated power.....	22
5.1.1 General .....	22
5.1.2 Preferred values of rated power.....	22
5.1.3 Minimum power under alternative cooling modes .....	22
5.1.4 Loading beyond rated power.....	23
5.2 Cooling mode .....	23
5.3 Load rejection on transformers directly connected to a generator .....	23
5.4 Rated voltage and rated frequency .....	23
5.4.1 Rated voltage .....	23
5.4.2 Rated frequency .....	23
5.4.3 Operation at higher than rated voltage and/or at other than rated frequency .....	24
5.5 Provision for unusual service conditions .....	24
5.6 Highest voltage for equipment $U_m$ and dielectric tests levels.....	25
5.7 Additional information required for enquiry .....	25
5.7.1 Transformer classification.....	25
5.7.2 Winding connection and number of phases .....	25
5.7.3 Sound level .....	26
5.7.4 Transport.....	26
5.8 Components and materials .....	26
6 Requirements for transformers having a tapped winding.....	27
6.1 General – Notation of tapping range.....	27
6.2 Tapping voltage – tapping current. Standard categories of tapping voltage variation. Maximum voltage tapping.....	27
6.3 Tapping power. Full-power tappings – reduced-power tappings .....	30

6.4	Specification of tappings in enquiry and order .....	31
6.4.1	General .....	31
6.4.2	Constructional specification .....	31
6.4.3	Functional specification .....	32
6.5	Specification of short-circuit impedance .....	32
6.6	Load loss and temperature rise .....	33
7	Connection phase displacement symbols .....	34
7.1	Connection and phase displacement symbols for three-phase transformers and for single phase transformers connected in a three phase bank .....	34
7.1.1	Connection symbol .....	34
7.1.2	Phase displacement in clock number notation.....	34
7.1.3	Windings not intended to be loaded .....	35
7.1.4	Reconnectable windings .....	35
7.1.5	Examples .....	35
7.2	Connection and phase displacement symbols for single phase transformers not in three phase bank .....	37
7.2.1	Connection symbol .....	37
7.2.2	Phase displacement in clock number notation.....	38
7.2.3	Windings not intended to be loaded .....	38
7.2.4	Reconnectable windings .....	38
8	Rating plates .....	39
8.1	General .....	39
8.2	Information to be given in all cases .....	39
8.3	Additional information to be given when applicable.....	40
9	Safety, environmental and other requirements.....	41
9.1	Safety and environmental requirements.....	41
9.1.1	Liquid leaks .....	41
9.1.2	Safety considerations .....	41
9.2	Dimensioning of neutral connection .....	42
9.3	Liquid preservation system .....	42
9.4	DC currents in neutral circuits .....	43
9.5	Centre of gravity marking .....	43
10	Tolerances .....	43
11	Tests .....	44
11.1	General requirements for routine, type and special tests .....	44
11.1.1	General .....	44
11.1.2	Routine tests .....	46
11.1.3	Type tests .....	46
11.1.4	Special tests.....	47
11.2	Measurement of winding resistance.....	47
11.2.1	General .....	47
11.2.2	Dry-type transformers.....	47
11.2.3	Liquid-immersed type transformers.....	48
11.3	Measurement of voltage ratio and check of phase displacement.....	48
11.4	Measurement of short-circuit impedance and load loss.....	48
11.5	Measurement of no-load loss and current.....	49
11.6	Measurement of zero-sequence impedance(s) on three-phase transformers.....	50
11.7	Tests on on-load tap-changers – Operation test.....	51



11.8 Leak testing with pressure for liquid immersed transformers (tightness test).....	51
11.9 Vacuum deflection test for liquid immersed transformers .....	51
11.10 Pressure deflection test for liquid immersed transformers.....	52
11.11 Vacuum tightness test on site for liquid immersed transformers.....	53
11.12 Check of core and frame insulation .....	53
12 Electromagnetic compatibility (EMC) .....	53
13 High frequency switching transients.....	54
Annex A (informative) Check list of information to be provided with enquiry and order .....	55
Annex B (informative) Examples of specifications for transformers with tappings .....	59
Annex C (informative) Specification of short-circuit impedance by boundaries .....	63
Annex D (informative) Examples of three-phase transformer connections .....	64
Annex E (normative) Temperature correction of load loss .....	67
Annex F (informative) Facilities for future fitting of condition monitoring systems to transformers .....	68
Annex G (informative) Environmental and safety considerations .....	69
Bibliography.....	70
Figure 1 – Different types of voltage variation .....	30
Figure 2 – Illustration of 'clock number' notation .....	35
Figure 3 – Illustration of 'clock number' notation for transformers with open windings .....	37
Figure 4 – Illustration of 'clock number' notation .....	39
Figure C.1 – Example of specification of short-circuit impedance by boundaries .....	63
Figure D.1 – Common connections .....	64
Figure D.2 – Additional connections.....	65
Figure D.3 – Designation of connections of three-phase auto-transformers by connection symbols (auto-transformer Ya0) .....	66
Figure D.4 – Example of three single-phase transformers connected to form a three-phase bank (connection symbol Yd5).....	66
Table 1 – Tolerances .....	44
Table B.1 – Example of combined voltage variation .....	60
Table B.2 – Example of functional specification with HV voltage variation.....	61
Table B.3 – Example of functional specification with LV voltage variation .....	62
Table F.1 – Facilities for condition monitoring .....	68

## 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).