

JÕUTRAFOD. OSA 10: MÜRATASEMETE MÄÄRAMINE

Power transformers - Part 10: Determination of sound levels

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN 60076-10:2016 sisaldab Euroopa standardi EN 60076-10:2016 ingliskeelset teksti.	This Estonian standard EVS-EN 60076-10:2016 consists of the English text of the European standard EN 60076-10:2016.
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 11.11.2016.	Date of Availability of the European standard is 11.11.2016.
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.

ICS 29.180

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:

Koduleht www.evs.ee; telefon 605 5050; e-post 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:

Homepage www.evs.ee; phone +372 605 5050; e-mail info@evs.ee

English Version

**Power transformers -
Part 10: Determination of sound levels
(IEC 60076-10:2016)**

Transformateurs de puissance -
Partie 10: Détermination des niveaux de bruit
(IEC 60076-10:2016)

Leistungstransformatoren -
Teil 10: Bestimmung der Geräuschpegel
(IEC 60076-10:2016)

This European Standard was approved by CENELEC on 2016-10-17. 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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

This document (EN 60076-10:2016) consists of the text of IEC 60076-10:2016 prepared by IEC/TC 14 "Power transformers".

The following dates are fixed:

- latest date by which the document has to be implemented (dop) 2017-10-17
at national level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2019-10-17

This document supersedes EN 60076-10:2001.

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

Endorsement notice

The text of the International Standard IEC 60076-10:2016 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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60076-1	2011	Power transformers - Part 1: General	EN 60076-1	2011
IEC 60076-8	1997	Power transformers - Part 8: Application guide	-	-
IEC 61043	1993	Electroacoustics - Instruments for the measurement of sound intensity - Measurement with pairs of pressure sensing microphones	EN 61043	1994
IEC 61672-1	-	Electroacoustics - Sound level meters - Part 1: Specifications	EN 61672-1	-
IEC 61672-2	-	Electroacoustics - Sound level meters - Part 2: Pattern evaluation tests	EN 61672-2	-
ISO 3382-2	2008	Acoustics - Measurement of room acoustic parameters - Part-2: Reverberation time in ordinary rooms	EN ISO 3382-2	2008
ISO 3746	2010	Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane	EN ISO 3746	2010
ISO 9614-1	1993	Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 1: Measurement at discrete points	EN ISO 9614-1	2009
ISO 9614-2	1996	Acoustics - Determination of sound power levels of noise sources using sound intensity - Part-2: Measurement by scanning	EN ISO 9614-2	1996

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	8
2 Normative references.....	8
3 Terms and definitions	9
4 Sound power for different loading conditions	11
4.1 General.....	11
4.2 Sound power at no-load excitation	12
4.3 Sound power of the cooling device(s)	12
4.4 Sound power due to load current	12
5 Sound level measurement specification.....	14
6 Instrumentation, calibration and accuracy.....	15
7 Principal radiating surface.....	16
7.1 General.....	16
7.2 Transformers with or without cooling device.....	16
7.3 Transformers in enclosures with cooling devices inside the enclosure	16
7.4 Transformers in enclosures with cooling devices outside the enclosure	17
7.5 Cooling devices mounted on a separate structure where the distance between the two principal radiating surfaces is ≥ 3 m	17
7.6 Dry-type transformers.....	17
7.7 Dry-type air-core reactors.....	17
8 Prescribed contour	18
9 Microphone positions	19
10 Calculation of the measurement surface area	19
10.1 Measurement surface area for measuring distances up to 30 m.....	19
10.2 Measurement surface area for measuring distances larger than 30 m.....	19
11 Sound measurement.....	20
11.1 Test conditions.....	20
11.1.1 Placement of test object	20
11.1.2 Test energisation options	20
11.1.3 Test application details	21
11.1.4 Prevailing ambient conditions	21
11.2 Sound pressure method	21
11.2.1 General	21
11.2.2 Test procedure.....	21
11.2.3 Calculation of the spatially averaged sound pressure level.....	22
11.2.4 Validation of test measurements with respect to background noise.....	23
11.2.5 Calculation of environmental correction K	23
11.2.6 Final correction for steady-state background noise and test environment.....	25
11.3 Sound intensity method	26
11.3.1 General	26
11.3.2 Test procedure.....	26
11.3.3 Calculation of average normal sound intensity and sound pressure level	27
11.3.4 Measurement validation	28
11.3.5 Final correction based on P-I index and direction flag	28

12	Determination of sound power level by calculation	29
13	Logarithmic addition and subtraction of individual sound levels	29
14	Far-field calculations for distances larger than 30 m	30
15	Presentation of results	31
Annex A (informative) Narrow-band and time-synchronous measurements		40
A.1	General considerations	40
A.2	Narrow-band measurement	40
A.2.1	General	40
A.2.2	Post processing of narrow-band measurements to exclude background noise	41
A.3	Time-synchronous averaging technique	41
Annex B (informative) Typical report of sound level determination		42
B.1	Sound pressure method	42
B.2	Sound pressure method – Appendix for the point-by-point procedure	50
B.3	Sound intensity method	51
B.4	Sound intensity method – Appendix for the point-by-point procedure	59
Bibliography		60
Figure 1 – Typical microphone path / positions for sound measurement on transformers excluding cooling devices		33
Figure 2 – Typical microphone path / positions for sound measurement on transformers having cooling devices mounted either directly on the tank or on a separate structure spaced < 3 m away from the principal radiating surface of the main tank		34
Figure 3 – Typical microphone path / positions for sound measurement on transformers having separate cooling devices spaced < 3 m away from the principal radiating surface of the main tank		35
Figure 4 – Typical microphone path / positions for sound measurement on cooling devices mounted on a separate structure spaced ≥ 3 m away from the principal radiating surface of the transformer		36
Figure 5 – Typical microphone positions for sound measurement on dry-type transformers without enclosures		37
Figure 6 – Principle radiating surface and prescribed contour of dry-type air-core reactors		38
Figure 7 – Environmental correction, K		39
Table 1 – Test acceptance criteria		23
Table 2 – Approximate values of the average acoustic absorption coefficient		25

INTERNATIONAL ELECTROTECHNICAL COMMISSION

POWER TRANSFORMERS –**Part 10: Determination of sound levels****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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 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 60076-10 has been prepared by IEC technical committee 14: Power transformers

This second edition cancels and replaces the first edition published in 2001 and constitutes a technical revision.

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

- additional useful definitions introduced;
- definition of distribution type transformers introduced for the purpose this standard;
- new clause for sound level measurement specification introduced;
- requirement for 1/3 octave band measurements introduced for transformers other than distribution type transformers;

- standard measurement distance changed from 0,3 m to 1 m for transformers other than distribution type transformers;
- height of measurement surface is now clearly defined to count from the reflecting plane;
- measurement surface formula unified;
- correction criteria for intensity method introduced;
- rules for sound measurements on dry-type reactors introduced;
- figures revised;
- new informative test report templates introduced (Annex B);
- IEC 60076-10-1 (application guide) revised in parallel providing worthwhile information for the use of this standard.

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

FDIS	Report on voting
14/846/FDIS	14/849/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 in the IEC 60076 series, published under the general title *Power transformers*, can be found 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

One of many parameters considered when specifying, designing and placing transformers, reactors and their associated cooling devices is the sound level that the equipment is likely to emit under defined in-service conditions. This part of IEC 60076 provides the basis for the specification and test of sound levels.

This standard describes in a logical sequence the loading conditions, how to specify and to test as well as how to evaluate and report sound levels for the equipment under test. A new section for the specification of sound levels has been introduced as Clause 5.

For the purpose of this standard, the definition “distribution type transformers” was introduced. This reflects industry’s need to maintain simpler and faster sound measurements for this category of transformers.

The new requirement for reporting 1/3-octave band spectra for all sound levels (including the background noise) on units for installation in substations reflects the more onerous conditions imposed by planning authorities on the purchaser and also the improved functionality of modern instrumentation.

When the sound intensity method was introduced in this standard limited experience was available. During subsequent years of operating this standard levels of experience have significantly increased and necessary changes have become evident. The equivalence of the pressure and the intensity methods has been demonstrated within certain test limitations.

The introduction of new validation criteria for the intensity method recognises these limitations. The permissible pressure – intensity index ΔL remains 8 dB however the difference between measured sound pressure level and reported sound intensity level is limited to 4 dB.

For the pressure method the correction procedure for reflections has been enhanced by recommending the application of frequency dependent K values derived by measurement of the reverberation time of the test facility. Where K is derived from absorption coefficients the table for the average absorption coefficients has been rationalised to represent surfaces likely to be found in the working environment.

Walk-around procedure and point-by-point procedure are equally applicable. The walk-around procedure reflects the evolution of working practice allowing more time efficient measurements mainly on large units. For distribution type transformers and in special situations (health and safety) the point-by-point procedure is more appropriate.

In order to mitigate near-field effects the preferred measurement distance is set to 1 m with exceptions for distribution type transformers, small test facilities, situations with low signal-to-noise ratio and for health and safety where the distance is maintained at 0,3 m.

One single formula for the calculation of the measurement surface area S has been introduced because the former complexity could only result in differences always smaller than 1 dB.

All figures describing the measurement surface area have been revised to be in accordance with the enveloping method for sound power determination. The height h is always measured from the test facility floor regardless of the height of the supports beneath the test object unless the test object is mounted on a support with a sufficiently large surface acting as reflecting plane.

Additional figures explain the procedure for the determination of the measurement surface area and the prescribed contour for a number of configurations of dry-type reactors.

When using this standard, it is recommended to frequently refer to the corresponding application guide IEC 60076-10-1:2016 as it promotes understanding with important background information and helpful details. IEC 60076-10 and IEC 60076-10-1 were revised in parallel by the same maintenance team resulting in fully aligned documents.

This document is a preview generated by EVS