SLOVENSKI STANDARD
SIST EN 60076-10:2002

01-oktober-2002

Nadomeġļa:
SIST EN 60551:1997
SIST EN 60551:1997/A1:1998

Power transformers - Part 10: Determination of sound levels (IEC 60076-10:2001)

Power transformers -- Part 10: Determination of sound levels

Leistungstransformatoren -- Teil 10: Bestimmung der Geräuschpegel

Transformateurs de puissance -- Partie 10: Détermination des niveaux de bruit

Ta slovenski standard je istoveten z: **EN 60076-10:2001**

ICS:

17.140.20	Emisija hrupa naprav in opreme	Noise emitted by machines and equipment
29.180	Transformatorji. Dušilke	Transformers. Reactors

SIST EN 60076-10:2002 **en**

EUROPEAN STANDARD **EN 60076-10**

NORME EUROPÉENNE

EUROPÄISCHE NORM July 2001

ICS 29.180 Supersedes EN 60551:1992 + A1:1997

English version

Power transformers
Part 10: Determination of sound levels
(IEC 60076-10:2001)

Transformateurs de puissance
Partie 10: Détermination des niveaux de bruit
(CEI 60076-10:2001)

Leistungstransformatoren
Teil 10: Bestimmung der Geräuschpegel
(IEC 60076-10:2001)

This European Standard was approved by CENELEC on 2001-06-01. 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.

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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 60076-10:2001 E

Foreword

The text of document 14/390/FDIS, future edition 1 of IEC 60076-10, prepared by IEC TC 14, Power transformers, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60076-10 on 2001-06-01.

This European Standard supersedes EN 60551:1992 + A1:1997.

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) 2002-03-01

– latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2004-06-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annex ZA is normative and annexes A and B are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60076-10:2001 was approved by CENELEC as a European Standard without any modification.

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.

Publication	Year	Title	EN/HD	Year
IEC 60076	Series	Power transformers	EN 60076	Series
IEC 60289 (mod)	1988	Reactors	EN 60289	1994
IEC 60651	1979	Sound level meters	EN 60651	1994
IEC 60726 (mod)	1982	Dry-type power transformers	HD 464 S1[1)] + A2 + A3 + A4	1988 1991 1992 1995
IEC 61043	1993	Electroacoustics - Instruments for the measurement of sound intensity - Measurement with pairs of pressure sensing microphones	EN 61043	1994
IEC 61378	Series	Convertor transformers	EN 61378	Series
ISO 3746	1995	Acoustics - Determination of sound power levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane	EN ISO 3746	1995
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	1995

[1)] HD 464 S1 includes A1:1986 to IEC 60726:1982.

NORME INTERNATIONALE

INTERNATIONAL STANDARD

CEI
IEC
60076-10

Première édition
First edition
2001-05

Transformateurs de puissance –

Partie 10:
Détermination des niveaux de bruit

Power transformers –

Part 10:
Determination of sound levels

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International Electrotechnical Commission
Международная Электротехническая Комиссия

CODE PRIX
PRICE CODE V

Pour prix, voir catalogue en vigueur
For price, see current catalogue

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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.
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International Standard IEC 60076-10 has been prepared by IEC technical committee 14: Power transformers.

This first edition of IEC 60076-10 cancels and replaces IEC 60551, published in 1987 and its amendment 1 (1995), and constitutes a technical revision.

This bilingual version (2005-07) replaces the English version.

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

FDIS	Report on voting
14/390/FDIS	14/394/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.

The French version of this standard has not been voted upon.

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
Part 7: Loading guide for oil-immersed power transformers
Part 8: Application guide
Part 10: Determination of sound levels
Part 11: Dry-type transformers
Part 13: Self protected liquid filled transformers
Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials

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.

INTRODUCTION

One of the many parameters to be considered when designing and siting transformers, reactors and their associated cooling equipment is the amount of sound that the equipment is likely to emit under normal operating conditions on site.

Sources of sound

The audible sound radiated by transformers is generated by a combination of magnetostrictive deformation of the core and electromagnetic forces in the windings, tank walls and magnetic shields. Historically, the sound generated by the magnetic field inducing longitudinal vibrations in the core laminations has been dominant. The amplitude of these vibrations depends on the flux density in the laminations and the magnetic properties of the core steel, and is therefore independent of the load current. Recent advances in core design, combined with the use of low induction levels, have reduced the amount of sound generated in the core such that the sound caused by the electromagnetic forces may become significant.

Current flowing in the winding conductors produces electromagnetic forces in the windings. In addition, stray magnetic fields may induce vibrations in structural components. The force (and therefore the amplitude of the vibrations) is proportional to the square of the current, and the radiated sound power is proportional to the square of the vibrational amplitude. Consequently, the radiated sound power is strongly dependent on the load current. Vibrations in core and winding assemblies can then induce sympathetic vibrations in tank walls, magnetic shields and air ducts (if present).

In the case of dry-type, air-cored shunt or series reactors, sound is generated by electromagnetic forces acting on the windings in a similar manner to that described above. These oscillatory forces cause the reactor to vibrate both axially and radially, and the axial and radial supports and manufacturing tolerances may result in the excitation of modes in addition to those of rotational symmetry. In the case of iron-cored reactors, further vibrations are induced by forces acting in the magnetic circuit.

For all electrical plants, the consequence of the presence of higher harmonics on the power supply should be understood. Normally, vibrations occur at even harmonics of the power frequency, with the first harmonic being dominant. If other frequencies are present in the power supply, other forces may be induced. For certain applications, this may be significant, particularly because the human ear is more sensitive to these higher frequencies.

Any associated cooling equipment will also generate noise when operating. Fans and pumps both tend to generate broad-band noise due to the forced flow of air or oil.

Measurement of sound

Sound level measurements have been developed to quantify pressure variations in air that a human ear can detect. The smallest pressure variation that a healthy human ear can detect is 20 μPa. This is the reference level (0 dB) to which all the other levels are compared. The perceived loudness of a signal is dependent upon the sensitivity of the human ear to its frequency spectrum. Modern measuring instruments process sound signals through electronic networks, the sensitivity of which varies with frequency in a manner similar to the human ear. This has resulted in a number of internationally standardized weightings of which the A-weighting network is the most common.

Sound intensity is defined as the rate of energy flow per unit area and is measured in watts per square metre. It is a vector quantity whereas, sound pressure is a scalar quantity and is defined only by its magnitude.

Sound power is the parameter which is used for rating and comparing sound sources. It is a basic descriptor of a source's acoustic output, and therefore an absolute physical property of the source alone which is independent of any external factors such as environment and distance to the receiver.

Sound power can be calculated from sound pressure or sound intensity determinations. Sound intensity measurements have the following advantages over sound pressure measurements:

- an intensity meter responds only to the propagating part of a sound field and ignores any non-propagating part, for example, standing waves and reflections;
- the intensity method reduces the influence of external sound sources, as long as their sound level is approximately constant.

The sound pressure method takes the above factors into account by correcting for background noise and reflections.

For a detailed discussion of these measuring techniques, see IEC 60076-10-1: Determination of sound levels – Application guide.

POWER TRANSFORMERS –

Part 10: Determination of sound levels

1 Scope

This part of IEC 60076 defines sound pressure and sound intensity measurement methods by which sound power levels of transformers, reactors and their associated cooling auxiliaries may be determined.

NOTE For the purpose of this standard, the term "transformer" means "transformer or reactor".

The methods are applicable to transformers and reactors covered by the IEC 60076 series, IEC 60289, IEC 60076-11 and the IEC 61378 series, without limitation as regards size or voltage and when fitted with their normal cooling auxiliaries.

This standard is primarily intended to apply to measurements made at the factory. Conditions on-site may be very different because of the proximity of objects, including other transformers. Nevertheless, the same general rules as are given in this standard may be followed when on-site measurements are made.

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 (all parts), *Power transformers*

IEC 60076-1:1993, *Power transformers – Part 1: General*

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

IEC 60289:1988, *Reactors*

IEC 61043:1993, *Electroacoustics – Instruments for the measurement of sound intensity – Measurement with pairs of pressure sensing microphones*

IEC 61378 (all parts), *Convertor transformers*

IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*

IEC 61672-2, *Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests*

ISO 3746:1995, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 9614-1:1993, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 1: Measurement at discrete points*