

# Australian/New Zealand Standard™

## Power transformers

### Part 10: Determination of sound levels (IEC 60076-10, Ed.1 (2001) MOD)



**AS/NZS 60076.10:2009**

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee EL-008, Power Transformers. It was approved on behalf of the Council of Standards Australia on 16 March 2009 and on behalf of the Council of Standards New Zealand on 20 March 2009.

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The following are represented on Committee EL-008:

Australian Chamber of Commerce and Industry  
Australian Industry Group  
Australian Institute of Petroleum  
Department of Environment, Water, Heritage and the Arts  
Electricity Engineers Association, New Zealand  
Energy Efficiency & Conservation Authority of New Zealand  
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## PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-008, Power Transformers to supersede AS 2374.6—1994 on publication.

The objective of this Standard is to specify methods of measuring sound pressure and sound intensity so that the sound power levels emitted by power transformers and associated auxiliaries may be determined.

This Standard is an adoption with national modifications and has been reproduced from IEC 60076-10, Ed.1 (2001), *Power Transformers—Part 10: Determination of sound levels*, and has been varied as indicated to take account of Australian/New Zealand conditions.

Annex ZA contains the specified sound levels for transformers in Australia and New Zealand.

AS/NZS 60076.10.1, *Power Transformers—Part 10.1: Determination of sound levels—Application guide*, provides requirements and information for the application of this Standard.

Variations to IEC 60076-10, Ed.1 (2001) are indicated at the appropriate places throughout this standard. Strikethrough (~~example~~) identifies IEC text, tables and figures which, for the purposes of this Australian/New Zealand Standard, are deleted. Where text, tables or figures are added, each is set in its proper place and identified by shading (example). Added figures are not themselves shaded, but are identified by a shaded border.

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- (b) In the source text ‘this part of IEC 60076’ should read ‘this Australian/New Zealand Standard’.
- (c) A full point should be substituted for a comma when referring to a decimal marker.

The form in Annex B, ‘Typical report of sound level determination’, may be reproduced freely for the purpose of reporting the results from the tests in this Standard.

The terms ‘normative’ and ‘informative’ are used to define the application of the annex to which they apply. A normative annex is an integral part of a standard, whereas an informative annex is only for information and guidance.

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## 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  $\mu\text{Pa}$ . 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.

## STANDARDS AUSTRALIA

## Australian/New Zealand Standard

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Any table, figure or text of the international standard that is struck through is not part of this standard. Any Australian/New Zealand table, figure or text that is added is part of this standard and is identified by shading.

**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.

Annex ZA contains the specified sound levels for transformers for use in Australia and New Zealand.

**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.

References to international standards that are struck through in this clause are replaced by references to Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is identified as such.

IEC 60076 (all parts), *Power transformers*

~~IEC 60076-1:1993, Power transformers — Part 1: General~~

AS 60076.1, *Power transformers, Part 1: General*

~~IEC 60076-11, Power transformers — Part 11: Dry-type transformers~~

AS 60076.11, *Power transformers, Part 11: Dry-type transformers*

~~IEC 60289:1988, Reactors~~

AS 1028, *Power reactors and earthing transformers* (identical to IEC 60289:1988)

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