INTERNATIONAL STANDARD

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Acoustics — Test code for the measurement of airborne noise emitted by rotating electrical machines

Acoustique — Code d'essai pour le mesurage du bruit aérien émis par les machines électriques tournantes

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2, www.iso.org/directives.

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This second edition cancels and replaces the first edition (ISO 1680:1999), which has been technically revised.

Acoustics — Test code for the measurement of airborne noise emitted by rotating electrical machines

1 Scope

This International Standard specifies all the information necessary to carry out efficiently and under standardized conditions the determination, declaration, and verification of the noise emission characteristics of rotating electrical machines. It specifies noise measurement methods that can be used, and specifies the operating and mounting conditions required for the test.

Noise emission characteristics include the sound power level and emission sound pressure level. The determination of these quantities is necessary:

— for comparing the noise emitted by machines;

— to enable manufacturers to declare the noise emitted; and

— for the purposes of noise control.

The use of this International Standard as a noise test code ensures the reproducibility of the determination of the noise emission characteristics within specified limits determined by the grade of accuracy of the basic noise measurement method used. Noise measurement methods allowed by this International Standard are precision methods (grade 1), engineering methods (grade 2) and survey methods (grade 3). Methods of engineering grade (grade 2) are to be preferred.

This International Standard is applicable to rotating electrical machines of any length, width or height.

2 Normative references

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.

ISO 3741, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for reverberation test rooms*

ISO 3743-1, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for small movable sources in reverberant fields — Part 1: Comparison method for a hard-walled test room*

ISO 3743-2, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering methods for small, movable sources in reverberant fields — Part 2: Methods for special reverberation test rooms*

ISO 3744:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

ISO 3745:2012, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic rooms and hemi-anechoic rooms*

ISO 3746, *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*

ISO 3747, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering/survey methods for use in situ in a reverberant environment*

ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 7574-4, *Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 4: Methods for stated values for batches of machines*

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

ISO 9614-2, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning*

ISO 9614-3, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 3: Precision method for measurement by scanning*

ISO 11203, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level*

IEC 60034-1, *Rotating electrical machines — Part 1: Rating and performance*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
time averaged sound pressure level
$L_{p,T}$

ten times the logarithm to the base 10 of the ratio of the time average of the square of the sound pressure, p, during a stated time interval of duration, T (starting at t_1 and ending at t_2), to the square of a reference value, p_0, expressed in decibels

$$L_{p,T} = L_{p,\mathrm{eq}T} = 10 \lg \left[\frac{\frac{1}{T}\int_{t_1}^{t_2} p^2(t)\,\mathrm{d}t}{p_0^2} \right] \ \mathrm{dB}$$

where the reference value, p_0, is 20 µPa

Note 1 to entry: Because of practical limitations of the measuring instruments, p^2 is always understood to denote the square of a frequency-weighted and frequency-band-limited sound pressure. If a specific frequency weighting as specified in IEC 61672-1 and/or specific frequency bands are applied, this should be indicated by appropriate subscripts; e.g. $L_{p,\mathrm{A},10\ \mathrm{s}}$ denotes the A-weighted time-averaged sound pressure level over 10 s.

3.2
measurement surface
hypothetical surface of area S, enveloping the source on which the measurement points are located

Note 1 to entry: The measurement surface terminates on one or more reflecting planes.

3.3
surface sound pressure level
$\overline{L_p}$
energy average of the time-averaged sound pressure levels at all the microphone positions on the measurement surface, with the background noise correction K_1 and the environmental correction K_2 applied

Note 1 to entry: It is expressed in decibels.

3.4
sound intensity
$\vec{I}$
time-averaged value of the product of the instantaneous sound pressure and the associated sound velocity at a point in a temporally stationary sound field

3.5
normal sound intensity level
L_{I_n}
ten times the logarithm to the base 10 of the ratio of the unsigned value of the normal component of the sound intensity (which is radiated by the sound source under test and determined in a direction perpendicular to the measurement surface) to the reference sound intensity

Note 1 to entry: It is expressed in decibels.

Note 2 to entry: The reference sound intensity is 10^{-12} Wm^{-2}.

3.6
sound power level
L_W
ten times the logarithm to the base 10 of the ratio of the sound power, P, to a reference value, P_0, expressed in decibels

$$L_W = 10 \lg \frac{P}{P_0} \text{ dB}$$

where the reference value, P_0, is 1 pW

Note 1 to entry: If a specific frequency weighting as specified in IEC 61672-1 and/or specific frequency bands are applied, this should be indicated by appropriate subscripts; e.g. $L_{W,A}$ denotes the A-weighted sound power level.

Note 2 to entry: This definition is technically in accordance with ISO 80000-8:2007, 8-23[15].

3.7
emission sound pressure
p
time-averaged sound pressure, at a specified position near a noise source, when the source is in operation under specified operating and mounting conditions on a reflecting plane surface, excluding the effects of background noise as well as the effects of reflections from room surfaces other than the plane or planes permitted for the purpose of the test

Note 1 to entry: It is expressed in pascals.

3.8
emission sound pressure level
L_p
ten times the logarithm to the base 10 of the ratio of the square of the emission sound pressure, $p^2(t)$, to the square of the reference sound pressure, p_0^2, measured with a particular time weighting and a particular frequency weighting, selected from those defined in IEC 61672-1

Note 1 to entry: It is expressed in decibels. The reference sound pressure is 20 μPa.

EXAMPLE The A-weighted emission sound pressure level with time weighting F is denoted L_{pAF}. The C-weighted peak emission sound pressure level is denoted $L_{pC,peak}$.

3.9
noise emission declaration
information on the noise emitted by the machine, given by the manufacturer or supplier in technical documents or other literature concerning noise emission values

Note 1 to entry: The noise emission declaration may take the form of either the declared single-number noise emission value or the declared dual-number noise emission value.

3.10
measured noise emission value
L
A-weighted sound power level, or the A-weighted time-averaged emission sound pressure level, or the C-weighted peak emission sound pressure level, as determined from measurements

Note 1 to entry: Measured values may be determined either from a single machine or from the average of a number of machines, and are not rounded.

3.11
declared single-number noise emission value
L_d
sum, rounded to the nearest whole decibel, of the measured noise emission value, L, and the associated uncertainty, U:

$$L_d = L + U$$

3.12
declared dual-number noise emission value
L **and** U
measured noise emission value L, and its associated uncertainty U, both rounded to the nearest decibel

4 Description of machinery family

This International Standard is applicable to self-standing rotating electrical machines, i.e. motors and generators (d.c. and a.c machines), without any limitation on the output or voltage, and with any linear dimensions.

Families of devices covered by this International Standard include rotating electrical machines to be fed by the following possibilities:

— a network (sinusoidal supply) whenever specially designed for that purpose;

— an associated converter.

In the case of supply by a converter, the noise radiated by the converter is excluded from the scope of this International Standard; only the effect of non-sinusoidal voltage and current within the machine is to be taken into account.

Auxiliary components required for the operation of the machine (e.g. oil pumps or cooling ventilators) should be included when integrated with the machine. When these components are separately mounted, they shall not be included as part of the machine under test.

5 Sound power determination

5.1 General

The sound power radiated by rotating electrical machines shall be determined on the basis of one of the following basic standards:

— accuracy grade 1: ISO 3741, ISO 3745, ISO 9614-1, ISO 9614-3;

— accuracy grade 2: ISO 3743-1, ISO 3743-2, ISO 3744, ISO 3747, ISO 9614-1, ISO 9614-2.

Methods of engineering grade (grade 2) are to be preferred.

Furthermore, survey methods may also be used if it has been proved that no method with better accuracy is practical:

— accuracy grade 3: ISO 3746, ISO 9614-1, ISO 9614-2.

5.2 Guidelines for the selection of the most appropriate basic standard

The usable basic standards are mainly distinguished by the following:

— different environmental conditions;

— different requirements with respect to the background noise levels related to the noise level of the machine under test;

— different grades of accuracy;

— different quantities to be measured: sound pressure or sound intensity.

NOTE 1 Detailed guidelines for the selection of the most appropriate basic standards are given in ISO 3740.

The sound intensity measurement method has the following advantages as compared to the sound pressure measurement method.

a) Determination of the correct sound power is possible regardless of whether the measurement surface lies within or outside the near field.

b) Determination of the correct sound power is possible in the presence of noise fields where the sound pressure method gives results which are so wrong that they would no longer conform to sound pressure measurement standards.

c) It allows a better grade of accuracy for the sound power determination especially under the worst environmental conditions (and therefore allows determination of the sound power level of machines in the presence of noisy loading machines).

NOTE 2 Methods described in ISO/TS 7849[4] allow that part of the radiated airborne sound power caused by the vibrating outer surface of the machine to be determined separately.

A description of the fields of application of the main basic standards is given in Table 1, supplemented by Figure 1. A more precise distinction of these standards is shown in Annex A.

5.3 Additional requirements

Each of the basic standards gives detailed and precise requirements for all acoustical aspects of the relevant measurement procedure, such as definition of the measurement surface, if any, microphone array, environmental adequacy, determination of environmental and background noise corrections, if relevant, together with requirements for instrumentation. These standards leave open precise definitions of mounting and operating conditions which shall be stated in the machinery-specific noise test code. These requirements are given in Clause 6.

When applying ISO 3744 or ISO 3746 which use sound pressure measurements under more or less free-field conditions, a parallelepiped measurement surface shall be used to facilitate the location of the microphone positions.

Supplementing the general rules for rotating electrical machines, the following simplifications may be used.

a) The arrangement of the measurement positions may, especially for large machines, be simplified if, for a specific type of machine, it can be shown, with the help of preliminary investigations on machines of that specific type, that the sound field is adequately uniform and that measurements lead to values of sound power level deviating by no more than 0,5 dB for grade 2 methods and 1 dB (A-weighted) for grade 3 methods from those determined with a complete arrangement of measurement positions.

b) For sources that produce a symmetrical radiation pattern, it may be sufficient to distribute the measurement positions over only a portion of the measurement surface. This is acceptable only if, for a specific type of machine, it can be shown, with the help of preliminary investigations on machines of that specific type, that the measurements lead to values of sound power level deviating by no more than 0,5 dB for grade 2 methods and 1 dB (A-weighted) for grade 3 methods from those determined with a complete arrangement of measurement positions.

c) If required to check the presence of prominent discrete tone(s), the so called “magnetic noise”, being typical of rotating electrical machines, should be taken into consideration with preference. Under no-load operating conditions, this noise component is weak and do not disturb in general, but may increase significantly under loading conditions.

Consequently the following alternative tonality tests are useful for rotating electrical machines:

1) measuring the A-weighted sound power level, $L_{W,\mathrm{A}}$, caused by changing the operating conditions from no-load to rated load to determine the relevant difference $\Delta L_{W,\mathrm{A}}$, in decibels; or

NOTE This test is used by IEC 60034-9[9] where limit values for $\Delta L_{W,\mathrm{A}}$ are given.

2) measuring the one-third-octave band pressure spectrum under rated load conditions at the measurement position with the highest value of $L_{p,\mathrm{A},T}$, and calculation of the difference between each protruding level and its two adjacent band levels.

Differences larger than 6 dB can be characterized as prominent for the frequency range from 500 Hz to 10 000 Hz; or

3) determining the tonality under rated load conditions according to ISO 7779:2010,[3] Annex D.

Table 1 — Sound power determination procedures and relations to their fields of application

International Standard	Environment	Background noise levels	Grade of accuracy	Quantity to be measured
ISO 3741	Special measurement room, "reverberant room"	Very low background noise levels	Grade 1	Sound pressure
ISO 3743-1	High reverberant ordinary room	Low background noise level	Grade 2	Sound pressure
ISO 3743-2	Special measurement room	Low background noise level	Grade 2	Sound pressure
ISO 3744	*In situ*, but with limited environmental reflections	Low background noise levels	Grade 2	Sound pressure
ISO 3745	Special measurement room, "anechoic, hemi-anechoic room"	Very low back-ground noise levels	Grade 1	Sound pressure
ISO 3746	*In situ*, less limited environ-mental reflections	Less limited back-ground noise levels	Grade 3	Sound pressure
ISO 3747	*In situ*, approximately reverberant conditions	Low background noise levels	Grade 2	Sound pressure
ISO 9614-1	*In situ*, practically no limi-tations	Practically no limitation for stationary background noise levels	Grades 1, 2, and 3	Normal component of sound intensity
ISO 9614-2	*In situ*, practically no limi-tations	Practically no limitation for stationary background noise levels	Grade 2 and 3	Normal component of sound intensity
ISO 9614-3	*In situ,* practically no limi-tations	Practically no limitation for stationary background noise levels	Grade 1	Normal component of sound intensity