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Acoustics — Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels

Acoustique — Prescriptions relatives aux performances et à l'étalonnage des sources sonores de référence pour la détermination des niveaux de puissance acoustique

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Foreword

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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 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

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

This third edition cancels and replaces the second edition (ISO 6926:1999), which has been technically revised with the following changes:

— the clause on measurement uncertainty has been updated with stricter reference to ISO/IEC Guide 98-3 and moved backwards in the standard to be more in line with ISO 3745;

— the corrections for meteorological conditions have been brought in line with ISO 3745 and a new Annex A on the acoustic radiation impedance correction has been introduced;

— an alternative method using sound intensity for low frequency calibration in hemi-anechoic rooms not fully qualified for low frequencies has been introduced in a new Annex B.

Introduction

Reference sound sources are used extensively in “comparison methods” for determining the noise emissions of physically stationary sound sources. A reference sound source, of known sound power output, is used to establish the numerical relationship between the sound power level of a source, in a given location in a given acoustic environment and the space- and time-averaged sound pressure level at a set of microphone positions. Once that relationship is established, it is straightforward to measure the average sound pressure level produced by an “unknown source” and to determine the sound power level produced by that source.

This International Standard defines the important physical and performance characteristics of reference sound sources and specifies procedures for their calibration, primarily to determine the sound power level of other sound sources.

This International Standard supplements a group or family of International Standards, the ISO 3740 group, which describes various methods for determining the sound power levels of machines and equipment. This group of International Standards specifies the acoustical requirements for measurements that are appropriate for different test environments.

Five International Standards in the ISO 3740 group include procedures in which a reference sound source is used: ISO 3741, ISO 3743-1, ISO 3744, ISO 3746 and ISO 3747. ISO 3740 gives guidelines for the use of all the International Standards in the group.

Note that the sound power output of reference sound sources will vary, in particular at low frequencies, with the distance from the source to nearby reflecting planes. Sound power data of reference sound sources are thus valid only for the position used during the calibration.

In addition to being useful for determining sound power levels by the comparison method, reference sound sources can be used for qualification tests on an acoustic environment and to estimate the influence of an acoustic environment on the sound pressure levels produced by one or more sound sources located in that environment. Examples of International Standards referring to reference sound sources with these applications are ISO/TR 11690-3 and ISO 14257. Requirements other than those of this International Standard can be applicable in these cases.

Acoustics — Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels

1 Scope

This International Standard specifies the acoustical performance requirements for reference sound sources:

— temporal steadiness (stability) of the sound power output;

— spectral characteristics;

— directivity.

Temporal steadiness is defined in terms of the standard deviation of repeatability (see 5.2). The spectral characteristics can be verified in either a hemi-anechoic room or a reverberation test room from measurements of the frequency band sound power levels in accordance with this International Standard (see 5.4). The performance requirements on directivity index can only be verified in a hemi-anechoic room (see 5.5.)

This International Standard also specifies procedures for providing level calibration data and uncertainty on a sound source intended for use as a reference sound source in terms of its sound power level under reference meteorological conditions as defined in Clause 4 in octave and in one-third-octave bands, and with frequency weighting A.

This International Standard is titled as a calibration standard even though the method is conducted in a testing laboratory and the level calibration results are not directly traceable to national standards of measure in a strict metrological sense. Testing laboratories performing this method are not expected to meet all requirements normally associated with a calibration laboratory.

NOTE ISO/IEC 17025[15] specifies different requirements for the competence of testing laboratories and calibration laboratories respectively. Laboratories testing reference sound sources in accordance with this International Standard would typically comply with the requirements for testing laboratories but not necessarily with those for calibration laboratories.

This International Standard specifies methods to calibrate reference sound sources not only in a free field over a reflecting plane but also in reverberation test rooms at different distances from the boundary surfaces. For the position of the reference sound source on one reflecting plane, the two different test environments mentioned above are considered equivalent for frequency bands above or equal to 200 Hz. At 160 Hz and below, some systematic differences can occur (see 11.2). For frequencies below 100 Hz, an alternative calibration method using sound intensity is given.

The sound source can either be placed directly on the floor or mounted on a stand to be used at a certain elevation above the floor. According to this International Standard, stand-mounted sources are calibrated in reverberation test rooms. Floor-mounted sources are either calibrated in hemi-anechoic or in reverberation test rooms. For floor-mounted sources in hemi-anechoic rooms, this International Standard is valid only for sources whose maximum vertical dimension is less than 0,5 m and whose maximum horizontal dimension is less than 0,8 m. According to this International Standard, only floor-mounted reference sound sources can be used when carrying out measurements on a measurement surface. For reference sound sources to be used or calibrated under reverberant conditions, no such restrictions on maximum dimensions apply.

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 3741:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for 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 9613-1:1993, *Acoustics — Attenuation of sound during propagation outdoors — Part 1: Calculation of the absorption of sound by the atmosphere*

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

IEC 60942:2003, *Electroacoustics — Sound calibrators*

IEC 61094-1, Measurement microphones — Part 1: Specifications for laboratory standard microphones

IEC 61094-4, Measurement microphones — Part 4: Specifications for working standard microphones

IEC 61183, *Electroacoustics — Random-incidence and diffuse-field calibration of sound level meters*

IEC 61260-1, Electroacoustics — Octave-band and fractional-octave-band filters — Part 1: Specifications

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

IEC 61672-3:2013, Electroacoustics — Sound level meters — Part 3: Periodic tests

IEC 62585, Electroacoustics — Methods to determine corrections to obtain the free-field response of a sound level meter

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

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

3.1
reference sound source
RSS
portable, generally electroacoustical or aerodynamic sound source or other noise-generating device, and associated control circuitry giving a broadband stable output complying with the requirements of this International Standard

3.2
free sound field over a reflecting plane
sound field in a homogeneous, isotropic medium in the half-space above an infinite, reflecting plane in the absence of other reflecting obstacles

3.3
hemi-anechoic room
test room in which a free sound field over a reflecting plane is obtained

3.4
reverberation test room
test room meeting the requirements of ISO 3741

3.5
measurement surface
hypothetical surface of area, S, on which the microphone positions are located at which the sound pressure levels are measured, enveloping the source under test and, in the case of a hemi-anechoic room, terminating on the reflecting plane on which the source is located

Note 1 to entry: The measurement surface area is expressed in metres squared.

3.6
surface sound pressure level
$\overline{L_p}$
energy-average of the time-averaged sound pressure levels at all the microphone positions, or traverses, on the measurement surface, with the background noise corrections, K_1, applied at each microphone position or traverse

Note 1 to entry: Surface sound pressure level is expressed in decibels.

Note 2 to entry: For definition and calculation of K_1, see ISO 3745.

3.7
sound power level
L_W

ten times the logarithm to the base 10 of the ratio of the sound power of a source, 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_{WA} denotes the A-weighted sound power level.

Note 2 to entry: This definition is technically in accordance with ISO 80000-8:2007,[17] 8-23.

[SOURCE: ISO/TR 25417:2007, 2.9]

3.8
measurement radius
r
radius of a hemi-spherical measurement surface

3.9
directivity index
$D_{\mathrm{I}i}$
measure of the extent to which a source radiates sound in a particular direction, relative to the mean sound radiation over the measurement surface, where for fixed microphones, the direction is from the source to the position of the microphone, and for traverses, the direction is from the source to the position along the microphone path at which the highest sound pressure level is recorded

Note 1 to entry: The directivity index of direction, i, is calculated from measurements in a hemi-anechoic room by the following formula:

$$D_{\mathrm{I}i} = L_{pi} - \overline{L_p}$$

where

L_{pi} <for fixed microphones> is the sound pressure level for each one-third-octave band at the ith microphone position on the measurement surface, in decibels;

L_{pi} <for microphone traverses> is the maximum sound pressure level for each one-third-octave band that is recorded during the ith microphone traverse (see 8.2) on the measurement surface, in decibels;

$\overline{L_p}$ is the surface sound pressure level averaged over the same measurement surface, in decibels.

Note 2 to entry: With the above "operational" definition, the directivity index is a measure of the uniformity of sound radiation from the source over the particular measurement surface being employed and as it is installed in the test environment. Definitions for the "theoretical" directivity index appearing in textbooks and the literature usually represent the uniformity of sound radiation by comparing the source under test in its test environment to a point source of the same sound power radiating into a full sphere in a totally free field. When such definitions are applied to sources located in a free field above a reflecting plane, they include a constant "+3 dB" to account for the hemispherical radiation. Care should be taken when comparing or using different definitions of directivity index.

3.10
frequency range of interest
frequency range of one-third-octave bands with nominal mid-band frequencies from 100 Hz to 10 000 Hz

Note 1 to entry: The frequency range of interest in one-third-octave bands may be extended up to as much as 20 000 Hz or down to as low as 50 Hz, provided the requirements of this International Standard are still met.

3.11
comparison method
method in which the sound power level is calculated by comparing the measured sound pressure levels produced by the source under test in an environment with the sound pressure levels produced by a reference sound source of known sound power output in the same environment

3.12
direct method
method in reverberation test rooms where the sound power level is calculated using the equivalent sound absorption area determined from measurements of the reverberation time

3.13
reverberation time
T
time that is required for the sound pressure level to decrease by 60 dB after the sound source has stopped

Note 1 to entry: If the reverberation time is evaluated from the decay of the first 10 dB or 15 dB, it is denoted T_{10} or T_{15}, respectively.

Note 2 to entry: It is expressed in seconds.

3.14
repeatability condition
condition where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time

4 Reference meteorological conditions

Reference meteorological conditions for the purpose of calculating the sound power level, corresponding to a reference characteristic acoustic impedance of air ρc = 411,5 Nsm^{-3} (where ρ is the density of air and c is the speed of sound) are the following:

air temperature: 23,0 °C;

static pressure: 1,013 25 × 10^5 Pa;

relative humidity: 50 %.

5 Performance requirements

5.1 General

A manufacturer may only state that its RSS is in compliance with this International Standard if all of the requirements laid out in this Clause are met.

5.2 Temporal steadiness (stability) of sound power output

The sound power level of the reference sound source shall be stable over time such that the measured standard deviations under repeatability conditions, σ_r (see 8.3.3 and 9.3.2), do not exceed those given in Table 1.

Table 1 — Maximum value of the standard deviation of the sound power level under repeatability conditions for a reference sound source in accordance with this International Standard

One-third-octave midband frequency Hz	Standard deviation under repeatability conditions, σ_r dB
50 to 80	0,8
100 to 160	0,4
200 to 20 000	0,2

NOTE 1 For special purposes, a reference sound source may have a more limited frequency range.

A reference sound source meeting the requirements of this International Standard shall include information on the range of variation of the source of electrical or mechanical power (e.g. the line voltage) within which the sound power level in any one-third-octave band within the frequency range of interest shall not vary by more than ±0,3 dB.

NOTE 2 The sound power level of a reference sound source depends on the static pressure and the air temperature. For the RSS to be used at different temperatures or altitudes, it is expected that information concerning appropriate corrections, and their uncertainties, for the influence of air temperature and static pressure on sound power emitted by the RSS, is included. For an aerodynamic fan RSS, the rotational speed and variations due to changing meteorological conditions during the qualification test are found according to 8.4 and 9.4.

5.3 Total broadband sound power level

There are no specific requirements placed on the total broadband sound power level produced by the RSS. However, if the total broadband sound power level is reported, either as an unweighted or frequency-weighted quantity, the corresponding frequency range shall also be reported.

5.4 Spectral characteristics

The RSS shall produce broadband steady sound over the frequency range in which it is intended for use, but at least for one-third-octave midband frequencies between 100 Hz and 10 000 Hz. Over this frequency range, all of the one-third-octave-band sound power levels, when measured in conformity with the requirements of Clause 8 and Clause 9, as applicable, shall be within a range of 12 dB. Under these same measuring conditions, and over this same frequency range, the sound power level in each one-third-octave band shall not deviate by more than 3 dB from the sound power level in the adjacent higher or lower one-third-octave bands (the higher band only in the case of the 100 Hz band, and the lower band only in the case of the 10 000 Hz band). If the frequency range is extended beyond 100 Hz to 10 000 Hz, then the requirements for the extended range are 16 dB and 4 dB, respectively.