INTERNATIONAL STANDARD

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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

Acoustique — Détermination des niveaux de puissance et d'énergie acoustiques émis par les sources de bruit à partir de la pression acoustique — Méthodes d'expertise en champ réverbéré applicables aux petites sources transportables

Partie 1: Méthode par comparaison en salle d'essai à parois dures

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 3743-1 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This second edition cancels and replaces the first edition (ISO 3743-1:1994), which has been technically revised.

ISO 3743 consists of the following parts, under the general title *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*

— *Part 2: Methods for special reverberation test rooms*

Introduction

This part of ISO 3743 is an element of the series ISO 3740[1] to ISO 3747[7], which specify various methods for determining the sound power levels and sound energy levels of noise sources including machinery, equipment and their sub-assemblies. The selection of one of the methods from the series for use in a particular application depends on the purpose of the test to determine the sound power level or sound energy level and on the facilities available. General guidelines to assist in the selection are provided in ISO 3740[1]. ISO 3740[1] to ISO 3747[7] give only general principles regarding the operating and mounting conditions of the machinery or equipment for the purposes of the test. It is important that test codes be established for individual kinds of noise source, in order to give detailed requirements for mounting, loading, and operating conditions under which the sound power levels or sound energy levels are to be obtained.

The method given in this part of ISO 3743 is based on a comparison of the sound pressure levels in octave frequency bands of a noise source under test with those of a calibrated reference sound source; A-weighted sound power levels or sound energy levels may be calculated from the octave-band levels. The method is applied in a hard-walled test room with prescribed acoustical characteristics, where it can be used for small items of portable equipment. Such a room allows either the sound power levels or the sound energy levels of the noise source under test to be determined, depending on the character of the noise emitted by the source. However, this kind of test room is not suitable for larger pieces of stationary equipment which, due to their manner of operation or installation, cannot readily be moved. The application of the method for use where the equipment or machinery is found *in situ* is described in ISO 3747[7].

The methods specified in this part of ISO 3743 permit the determination of the sound power level and the sound energy level in frequency bands and/or with frequency A-weighting applied.

This part of ISO 3743 describes a method of accuracy grade 2 (engineering grade) as defined in ISO 12001. For applications where greater accuracy is required, reference can be made to ISO 3741[2] or an appropriate part of ISO 9614[15][17]. If the relevant criteria for the measurement environment specified in this part of ISO 3743 are not met, it might be possible to refer to another standard from this series, or to an appropriate part of ISO 9614[15][17].

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

1 Scope

1.1 General

This part of ISO 3743 specifies methods for determining the sound power level or sound energy level of a noise source by comparing measured sound pressure levels emitted by this source (machinery or equipment) mounted in a hard-walled test room, the characteristics of which are specified, with those from a calibrated reference sound source. The sound power level (or, in the case of noise bursts or transient noise emission, the sound energy level) produced by the noise source, in frequency bands of width one octave, is calculated using those measurements. The sound power level or sound energy level with A-weighting applied is calculated using the octave-band levels.

1.2 Types of noise and noise sources

The method specified in this part of ISO 3743 is suitable for all types of noise (steady, non-steady, fluctuating, isolated bursts of sound energy, etc.) defined in ISO 12001.

The noise source under test may be a device, machine, component or sub-assembly. The maximum size of the source depends upon the size of the room used for the acoustical measurements (see 4.2).

1.3 Test environment

The test environment that is applicable for measurements made in accordance with this part of ISO 3743 is a hard-walled test room with prescribed acoustical characteristics.

1.4 Measurement uncertainty

Information is given on the uncertainty of the sound power levels and sound energy levels determined in accordance with this part of ISO 3743, for measurements made in frequency octave bands and for A-weighted frequency calculations performed on them. The uncertainty conforms to ISO 12001:1996, accuracy grade 2 (engineering grade).

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.

ISO 5725 (all parts), *Accuracy (trueness and precision) of measurement methods and results*

ISO 6926, *Acoustics — Requirements for the performance and calibration of reference sound sources for the determination of sound power levels*

ISO 12001:1996, *Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code*

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

IEC 60942:2003, *Electroacoustics — Sound calibrators*

IEC 61260:1995, *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 61672-1:2002, *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
sound pressure
p
difference between instantaneous pressure and static pressure

NOTE 1 Adapted from ISO 80000-8:2007[19], 8-9.2.

NOTE 2 Sound pressure is expressed in pascals.

3.2
sound pressure level
L_p
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure, p, to the square of a reference value, p_0, expressed in decibels

$$L_p = 10 \lg \frac{p^2}{p_0^2} \text{ dB} \quad (1)$$

where the reference value, p_0, is 20 μPa

[ISO/TR 25417:2007[18], 2.2]

NOTE 1 If specific frequency and time weightings as specified in IEC 61672-1 and/or specific frequency bands are applied, this is indicated by appropriate subscripts; e.g. L_{pA} denotes the A-weighted sound pressure level.

NOTE 2 This definition is technically in accordance with ISO 80000-8:2007[19], 8-22.

3.3
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

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

where the reference value, p_0, is 20 µPa

NOTE 1 In general, the subscript "T" is omitted since time-averaged sound pressure levels are necessarily determined over a certain measurement time interval.

NOTE 2 Time-averaged sound pressure levels are often A-weighted, in which case they are denoted by $L_{p\mathrm{A},T}$, which is usually abbreviated to $L_{p\mathrm{A}}$.

NOTE 3 Adapted from ISO/TR 25417:2007[18], 2.3.

3.4
single event time-integrated sound pressure level
L_E
ten times the logarithm to the base 10 of the ratio of the integral of the square of the sound pressure, p, of an isolated single sound event (burst of sound or transient sound) over a stated time interval T (starting at t_1 and ending at t_2) to a reference value, E_0, expressed in decibels

$$L_E = 10 \lg \left[\frac{\int_{t_1}^{t_2} p^2(t) \, \mathrm{d}t}{E_0} \right] \text{ dB} \quad (3)$$

where the reference value, E_0, is $(20\ \mu\mathrm{Pa})^2\ \mathrm{s} = 4 \times 10^{-10}\ \mathrm{Pa}^2\ \mathrm{s}$

NOTE 1 This quantity can be obtained by $L_{p,T} + 10 \lg \frac{T}{T_0}$ dB , where T_0 = 1 s

NOTE 2 When used to measure sound immission, this quantity is usually called "sound exposure level" (see ISO/TR 25417:2007[18]).

3.5
measurement time interval
T
portion or a multiple of an operational period or operational cycle of the noise source under test for which the time-averaged sound pressure level is determined

NOTE Measurement time interval is expressed in seconds.

3.6
comparison method
method by which the sound power level or sound energy level of a noise source under test is determined from a comparison of the sound pressure levels produced by the source under test with those of a reference sound source of known sound power output, when both sources are operated in the same environment

3.7
hard-walled test room
room in which the acoustical reflectivity of all room surfaces (including the floor and ceiling) is high over the frequency range of interest

3.8
reverberant sound field
that portion of the sound field in the test room over which the influence of sound received directly from the source is negligible

3.9
sound absorption coefficient
α
at a given frequency and for specified conditions, the relative fraction of sound power incident upon a surface which is not reflected

3.10
reference sound source
sound source meeting specified requirements

NOTE For the purposes of this International Standard, the requirements are those specified in ISO 6926:1999, Clause 5.

3.11
frequency range of interest
for general purposes, the frequency range of octave bands with nominal mid-band frequencies from 125 Hz to 8 000 Hz

NOTE For special purposes, the frequency range can be reduced, provided that the test environment, reference sound source, and instrument specifications are satisfactory for use over the modified frequency range. The frequency range can be extended downwards as far as the 63 Hz octave band, but cannot be extended upwards beyond the 8 000 Hz band. Any reduced or extended frequency range is clearly indicated as such in the report.

3.12
reference box
hypothetical right parallelepiped terminating on the floor of the test room on which the noise source under test is located, that just encloses the source including all the significant sound radiating components and any test table on which the source is mounted

NOTE If required, the smallest possible test table can be used for compatibility with emission sound pressure measurements at bystander positions in accordance with the ISO 11200 to ISO 11204 series.

3.13
background noise
noise from all sources other than the noise source under test

NOTE Background noise includes contributions from airborne sound, noise from structure-borne vibration, and electrical noise in the instrumentation.

3.14
background noise correction
K_1
correction applied to the measured sound pressure levels to account for the influence of background noise

NOTE 1 Background noise correction is expressed in decibels.

NOTE 2 The background noise correction is frequency dependent; the correction in the case of a frequency band is denoted K_{1f}, where f denotes the relevant mid-band frequency, and that in the case of A-weighting is denoted K_{1A}.

3.15
sound power
P
through a surface, product of the sound pressure, p, and the component of the particle velocity, u_n, at a point on the surface in the direction normal to the surface, integrated over that surface

[ISO 80000-8:2007[19], 8-16]

NOTE 1 Sound power is expressed in watts.

NOTE 2 The quantity relates to the rate per time at which airborne sound energy is radiated by a source.

3.16
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

$$L_W = 10 \lg \frac{P}{P_0} \text{ dB} \tag{4}$$

where the reference value, P_0, is 1 pW

NOTE 1 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 This definition is technically in accordance with ISO 80000-8:2007[19], 8-23.

[ISO/TR 25417:2007[18], 2.9]

3.17
sound energy
J
integral of the sound power, P, over a stated time interval of duration T (starting at t_1 and ending at t_2)

$$J = \int_{t_1}^{t_2} P(t)\, \mathrm{d}t \tag{5}$$

NOTE 1 Sound energy is expressed in joules.

NOTE 2 The quantity is particularly relevant for non-stationary, intermittent sound events.

[ISO/TR 25417:2007[18], 2.10]

3.18
sound energy level
L_J
ten times the logarithm to the base 10 of the ratio of the sound energy, J, to a reference value, J_0, expressed in decibels

$$L_J = 10 \lg \frac{J}{J_0} \text{ dB} \tag{6}$$

where the reference value, J_0, is 1 pJ

NOTE 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_{JA} denotes the A-weighted sound energy level.

[ISO/TR 25417:2007[18], 2.11]

4 Test room and size of noise source under test

4.1 Reference box

In order to assist in specification of the size of the test room, the reference box shall first be delineated. The reference box is a hypothetical surface defined by the smallest right parallelepiped that just encloses the noise source under test. The noise source under test shall be taken to include all significant sources of sound emission, including auxiliary equipment which cannot either be removed or adequately quietened, and the reference box shall be extended appropriately. When defining the dimensions of the reference box, elements protruding from the source which are not significant radiators of sound may be disregarded.

4.2 Volume of test room and size of noise source under test

The volume of the test room shall be at least 40 m^3, and at least 40 times the volume of the reference box.

In rooms with volumes between 40 m^3 and 100 m^3, the largest dimension of the reference box shall not exceed 1,0 m. In rooms with volumes greater than 100 m^3, the largest dimension of the reference box shall not exceed 2,0 m.

4.3 Acoustical properties of test room

A hard-walled room shall be used. This means that the sound absorption coefficient of any portion of any boundary surface shall not exceed 0,20 at all frequencies within the frequency range of interest. Most ordinary, unfurnished rooms without special acoustical treatment (e.g. acoustical ceilings and/or absorptive wall coverings) comply with this requirement. Table 1 gives guidelines.

Table 1 — Acceptable and unacceptable rooms

Acceptable rooms	Unacceptable rooms
Nearly empty rooms with smooth hard walls and ceiling made of concrete, brick, plaster or tile	Rooms with upholstered furniture, machinery or industrial rooms with a small amount of sound absorptive material on ceiling or walls (e.g. partially absorptive ceiling)
Partly empty rooms, rooms with smooth hard walls	Rooms with some sound absorptive materials on both ceiling and walls
Rooms without upholstered furniture, right cuboid machinery rooms or industrial rooms, no sound absorptive materials on surfaces	Rooms with large amounts of sound absorptive materials on either ceiling or walls
Irregularly shaped rooms without upholstered furniture, irregularly shaped machinery rooms or industrial rooms, no sound absorptive materials on surfaces	

4.4 Criterion for acoustic adequacy of test room

The suitability of a test room can differ from one noise source under test to another. The requirements for the room are most critical when a highly directional sound source is to be evaluated. When testing the general suitability of a test room, the procedure described hereafter shall be followed.

A highly directional, broad-band sound source, having a directivity index (see ISO 3744[4] or ISO 3745[5]) of at least 5 dB at all frequencies of interest above 500 Hz, is located in the test room as given in 6.3, so that the strongest component of sound energy is within 45° of the horizontal plane and is reflected at least once from a boundary with a minimum of loss before reaching any of the microphone positions. Microphone positions are chosen in accordance with 7.3 and the mean background noise corrected octave band time-averaged sound pressure level, $\overline{L_{p1}}$, is determined [see Equation (14) omitting RSS terms, i.e.

$$L_{W(\text{RSS})} \equiv \overline{L'_{p(\text{RSS})}} \equiv K_{1(\text{RSS})} \equiv 0$$

and substituting $\overline{L_{p1}}$ for L_W]. The sound source is then turned 45° to 135° in compliance with the requirement of 6.3 and the corresponding octave-band time-averaged sound pressure level, $\overline{L_{p2}}$, is determined. This procedure is repeated twice more to determine $\overline{L_{p3}}$ and $\overline{L_{p4}}$. The fourth position shall be within 45° to 90° of the first position. This whole procedure is then repeated four more times with the sound source turned upwards so that the strongest component of sound energy is within 45° of the vertical, and four more mean octave band time-averaged sound pressure levels are determined. The test room is considered to be suitable for the purposes of this part of ISO 3743 if the maximum difference between the octave band sound pressure levels of any two source positions for the frequency bands with mid-band frequencies between 125 Hz and 8 000 Hz does not exceed the standard deviations of reproducibility of Table 3.

NOTE As an alternative to the highly directional sound source, a sound source of the same type as the noise source to be tested can be used. However, if this alternative procedure is used, the suitability of the room can be taken as proven only for testing this type of noise source.

4.5 Criterion for background noise

The mean octave-band time-averaged sound pressure level of the background noise measured and averaged over the microphone positions or traverses (see 8.1.2), shall be at least 6 dB, and preferably more than 15 dB, below the corresponding mean uncorrected octave-band sound pressure levels (time averaged or single event) from the noise source under test (see 8.1.2 and 8.2.2) and from the reference sound source.

NOTE If it is necessary to make measurements where the difference between the sound pressure levels of the background noise and the sources is less than 6 dB, ISO 9614-1[15] or ISO 9614-2[16] can be used.

4.6 Ambient temperature and humidity

The ambient temperature and relative humidity in the test room shall be monitored and maintained at as nearly constant values as practicable during measurements.

5 Instrumentation and measurement equipment

5.1 General

The instrumentation system, including the microphones and cables, shall meet the requirements of IEC 61672-1:2002, class 1, and the filters shall meet the requirements of IEC 61260:1995, class 1. The reference sound source shall meet the requirements given in ISO 6926.

5.2 Calibration

Before and after each series of measurements, a sound calibrator meeting the requirements of IEC 60942:2003, class 1 shall be applied to each microphone to verify the calibration of the entire measuring system at one or more frequencies within the frequency range of interest. Without any further adjustment, the difference between the readings made before and after each series of measurements shall be less than or equal to 0,5 dB. If this value is exceeded, the results of the series of measurements shall be discarded.