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Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering method for small, movable sources in reverberant fields —

Part 1:
Comparison method for a hard-walled test room

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

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

[Revision of first edition (ISO 3743-1:1994)]

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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 method 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

0.1 This International Standard is one of the series ISO 3740 to ISO 3747, 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 will depend 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)]. The series of standards of which this International Standard is a part gives 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 on mounting, loading and operating conditions under which the sound power levels or sound energy levels are to be obtained.

0.2 The method given in this International Standard 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.

0.3 The methods specified in this International Standard permit the determination of the sound power level and the sound energy level in frequency bands and/or with frequency weighting A applied.

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

1) Under revision

Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering method for small, movable sources in reverberant fields —

Part 1:
Comparison method for a hard-walled test room

1 Scope

1.1 General

This International Standard 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 frequency weighting A applied is calculated using the octave-band levels.

1.2 Types of noise and noise sources

The method specified in this International Standard 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 International Standard 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 International Standard, for measurements made in octave bands of frequency and for calculations from those measurements with frequency weighting A applied. The uncertainty conforms with that of the engineering grade of accuracy (grade 2) defined in ISO 12001.

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

ISO 7574-1, *Acoustics – Statistical methods for determining and verifying stated noise emission values of machinery and equipment – Part 1: General considerations and definitions*

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

IEC 60942, *Electroacoustics – Sound calibrators*

IEC 61260, *Electroacoustics – Octave-band and fractional-octave-band filters*

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

Guide to the expression of uncertainty in measurement (GUM). International Organization for Standardization, Geneva, Switzerland. ISBN 92-67-10188-9, First Edition 1993, corrected and reprinted 1995

3 Terms and Definitions

For the purposes of this International Standard, the following definitions apply.

3.1
sound pressure
p
fluctuating pressure superimposed on the static pressure by the presence of sound, 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

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

The reference value, p_0, is 20 μPa (2×10^{-5} Pa).

NOTE 2 The frequency weighting or the width of the frequency band should be indicated in the symbol.

3.3
time-averaged sound pressure level
$L_{p,T}$
level of the time-averaged square of the sound pressure over the measurement time interval $T = t_2 - t_1$, expressed in decibels:

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

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 $L_{p\mathrm{A}}$.

3.4
single-event sound pressure level
L_E
level of the time-integrated square of the sound pressure of an isolated single sound event (burst of sound or transient sound) of specified duration T (or specified measurement time interval $T = t_2 - t_1$, covering the single event) normalized to reference time interval T_0 = 1 s, expressed in decibels

$$L_E = 10 \lg \left[\frac{1}{T_0} \int_{t_1}^{t_2} \frac{p^2(t)}{p_0^2} \mathrm{d}t \right] \mathrm{dB} = L_{p,T} + 10 \lg \left[\frac{T}{T_0} \right] \mathrm{dB} \tag{3}$$

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, 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 the requirements of ISO 6926

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

NOTE For special purposes, the range may be extended or reduced, provided that the test environment, reference sound source and instrument specifications are satisfactory for use over the modified range.

3.12
reference box
hypothetical rectangular 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 (see 6.3)

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

NOTE Background noise may include contributions from airborne sound, 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, expressed in decibels

NOTE 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 midband frequency.

3.15
sound power
W
rate per unit time at which airborne sound energy is radiated by a source, expressed in watts

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, W, to a reference value, W_0, expressed in decibels

$$L_W = 10 \lg \frac{W}{W_0} \text{ dB} \tag{4}$$

The reference value, W_0, is 1 pW (10^{-12} W).

NOTE 2 The frequency weighting, or the width of the frequency band used, is indicated in the symbol. For example, the A-weighted sound power level is L_{WA}.

3.17
sound energy
J
energy of a single burst of sound or transient sound emitted by a source, expressed in joules

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

$$L_J = 10 \lg \frac{J}{J_0} \text{ dB} \tag{5}$$

The reference value, J_0, is 1 pJ (10^{-12} J).

NOTE 2 The frequency weighting, or the width of the frequency band used, is indicated in the symbol. For example, the A-weighted sound energy level is L_{JA}.

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. 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) will comply with this requirement. Table 1 may be used for guidance.

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 (for example, 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, rectangular 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 below shall be followed.

A highly directional, broad-band sound source, having a directivity index 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 according to 7.3 and the mean time-averaged octave-band sound pressure levels, L_{p1}, are determined (see $\overline{L_{p(ST)}}$ in 8.2). The sound source is then turned 45° to 135° in compliance with the requirement of 6.3 and the corresponding octave-band sound pressure level, L_{p2}, is determined. This procedure is repeated twice more to determine L_{p3} and 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 time-averaged octave-band sound pressure levels are determined. The test room is considered to be suitable for the purposes of this International Standard if the maximum difference between the octave-band sound pressure levels of any two source positions for the frequency bands with midband 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 may be used. However, if this alternative procedure is used, the suitability of the room may be taken as proven only for testing this type of noise source.

4.5 Criterion for background noise

At each microphone position or for each microphone traverse, the mean octave-band sound pressure levels due to background noise shall be at least 6 dB and preferably more than 15 dB below the mean octave-band sound pressure levels from the noise source under test (see 8.2 and 8.4) 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 or ISO 9614-2 may be used.

4.6 Ambient temperature and humidity

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

5 Instrumentation and measurement equipment

5.1 General

The instrumentation system, including the microphones and cables, shall meet the requirements for a Class 1 instrument given in IEC 61672-1, and the filters shall meet the requirements for a Class 1 instrument given in IEC 61260. 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 Class 1 requirements given in IEC 60942 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 at each end of the series of measurements shall be less than or equal to 0,5 dB. If the difference exceeds 0,5 dB, the results of the series of measurements shall be discarded.

The calibration of the sound calibrator, the compliance of the instrumentation system with the requirements of IEC 61672-1, and the compliance of the reference sound source with the requirements of ISO 6926, shall be verified, at intervals in a laboratory making calibrations traceable to appropriate standards.

NOTE Unless national regulations dictate otherwise, it is recommended that the sound calibrator should be calibrated at intervals not exceeding 2 years, the reference sound source should be calibrated at intervals not exceeding 3 years, and the compliance of the instrumentation system with the requirements of IEC 61672-1 should be verified at intervals not exceeding 2 years.

6 Definition, location, installation and operation of noise source under test

6.1 General

It is important to decide which components, sub-assemblies, auxiliary equipment, power sources, etc., constitute integral parts of the noise source under test and are defined as part of the source, the sound power level or sound energy level of which is to be determined. It is important also to define the manner in which the noise source is installed and operated for the test, since both these factors can have a significant influence on the sound power or sound energy emitted. This clause describes the approach to be adopted in setting up the noise source for testing and in defining the conditions, so as to achieve an arrangement which is reproducible and which can be related clearly to the results obtained.