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Acoustics — Determination of sound power levels of noise sources — Engineering methods for small, movable sources in reverberant fields —

Part 1: Comparison method for hard-walled test rooms

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Acoustique — Détermination des niveaux de puissance acoustique émis par les sources de bruit — Méthodes d'expertise en champ réverbéré applicables aux petites sources transportables —

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

Reference number
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Contents

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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.

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.

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

ISO 3743 consists of the following parts, under the general title *Acoustics — Determination of sound power levels of noise sources — Engineering methods for small, movable sources in reverberant fields*:

— *Part 1: Comparison method for hard-walled test rooms*

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

Part 2 is a revision of ISO 3743:1988.

Annex A of this part of ISO 3743 is for information only.

Introduction

0.1 ISO 3743 is one of the ISO 3740 series, which specifies various methods for determining the sound power levels of machines, equipment and their sub-assemblies. These basic standards specify the acoustical requirements for measurements appropriate for different test environments as shown in table 0.1. When selecting one of the methods of the ISO 3740 series, it is necessary to select the most appropriate for the conditions and purposes of the noise test. General guidelines to assist in the selection are provided in ISO 3740. The ISO 3740 series gives only general principles regarding the operating and mounting conditions of the machine or equipment under test. Reference should be made to the noise test code for a specific type of machine or equipment, if available, for specifications on mounting and operating conditions.

0.2 The method given in this part of ISO 3743 enables measurement of sound pressure levels in octave bands at prescribed fixed microphone positions or along prescribed paths. A comparison method is used which allows determination of sound power levels in octave bands; A-weighted sound power levels may be calculated from the octave-band sound power levels. Quantities which cannot be determined are the directivity characteristics of the source and the temporal pattern of noise radiated by sources emitting non-steady noise.

0.3 Parts 1 and 2 of ISO 3743 specify engineering methods for determining the A-weighted and octave-band sound power levels of small noise sources. The methods are applicable to small machines, devices, components and sub-assemblies which can be installed in a hard-walled test room with prescribed acoustical characteristics or in a special reverberation test room. The methods are particularly suitable for small items of portable equipment; they are not intended for larger pieces of stationary equipment which, due to their manner of operation or installation, cannot readily be moved into the test room and operated as in normal usage. The procedures are intended to be used when an engineering grade of accuracy is desired without requiring the use of laboratory facilities.

Table 0.1 — International Standards specifying various methods for determining the sound power levels of machines and equipment

International Standard	Classification of method[1]	Test environment	Volume of source	Character of noise	Sound power levels obtainable	Optional information available
3741	Precision (grade 1)	Reverberation room meeting specified requirements	Preferably less than 1 % of test room volume	Steady, broad-band	In one-third-octave or octave bands	A-weighted sound power level
3742				Steady, discrete frequency or narrow-band		
3743-1	Engineering (grade 2)	Hard-walled test room		Steady, broad-band, narrow-band, or discrete frequency	A-weighted and in octave bands	Other weighted sound power levels
3743-2		Special reverberation test room				
3744	Engineering (grade 2)	Outdoors or in large room	Greatest dimension less than 15 m	Any	A-weighted and in one-third-octave or octave bands	Directivity information and sound pressure levels as a function of time; other weighted sound power levels
3745	Precision (grade 1)	Anechoic or semi-anechoic room	Preferably less than 0,5 % of test room volume	Any		
3746	Survey (grade 3)	No special test environment	No restrictions; limited only by available test environment	Any	A-weighted	Sound pressure levels as a function of time; other weighted sound power levels
3747	Survey (grade 3)	No special test environment; source under test not movable	No restrictions	Steady, broad-band, narrow-band, or discrete frequency	A-weighted	Sound power levels in octave bands

1) See ISO 2204.

0.4 In ISO 3743-2, the comparison method can also be used, but an alternative method permits the determination of the A-weighted sound power level of the source under test from a single A-weighted sound pressure level measurement at each microphone position, rather than from a summation of octave-band levels. This direct method eliminates the need for a reference sound source, but requires the use of a special reverberation test room. The direct method is based on the premise that the sound pressure level, averaged in space and time in the test room, can be used to determine the sound power level emitted by the source. The properties of the special reverberation test room are chosen so that the room's influence on the sound power output of the equipment under test is small. The number of microphone positions and source locations required in the test room are specified.

The requirements to be fulfilled by the special reverberation test room for measurements in accordance with the method given in ISO 3743-2 are significantly more restrictive than those placed on the hard-walled test room by the comparison method given in this part of ISO 3743.

Acoustics — Determination of sound power levels of noise sources — Engineering methods for small, movable sources in reverberant fields —

Part 1:
Comparison method for hard-walled test rooms

1 Scope

1.1 General

This part of ISO 3743 specifies a relatively simple engineering method for determining the sound power levels of small, movable noise sources. The measurements are carried out when the source is installed in a hard-walled test room. A comparison method is used to determine to the octave-band sound power levels of the source. The spatial average (octave-band) sound pressure levels produced by the source under test are compared to the spatial average (octave-band) sound pressure levels produced by a reference sound source of known sound power output. The difference in sound pressure levels is equal to the difference in sound power levels if conditions are the same for both sets of measurements. The A-weighted sound power level is then calculated from the octave-band sound power levels.

NOTE 1 Precision methods for the determination of sound power levels of small noise sources are specified in ISO 3741 and ISO 3745.

1.2 Types of noise

The method specified in this part of ISO 3743 is suitable for measurements of all types of noise within a specified frequency range, except intermittent noise consisting of isolated bursts of sound energy.

NOTES

2 A classification of different types of noise is given in ISO 2204.

3 For sources of intermittent noise consisting of short-duration noise bursts, the free-field methods specified in ISO 3744 and ISO 3745 should be used.

1.3 Noise source

The noise source may be a device, machine, component or sub-assembly.

The maximum size of the source under test depends upon the size of the room used for the acoustical measurements. (See also 4.1).

1.4 Measurement uncertainty

Determinations made in accordance with this part of ISO 3743 result, with few exceptions, in standard deviations of reproducibility of the A-weighted sound power level equal to or less than 1,5 dB (see table 1).

A single value of the sound power level of a noise source determined according to the procedures of this part of ISO 3743 is likely to differ from the true value by an amount within the range of the measurement uncertainty. The uncertainty in determinations of the sound power level arises from several factors which affect the results, some associated with environmental conditions in the measurement laboratory and others with experimental techniques.

If a particular noise source were to be transported to each of a number of different laboratories, and if, at each laboratory, the sound power level of that source were to be determined in accordance with this part of ISO 3743, the results would show a scatter. The standard deviation of the measured levels could be calculated (see examples in ISO 7574-4:1985, annex B) and would vary with frequency. With few exceptions, these standard deviations would not exceed those listed in table 1. The values given in table 1 are standard deviations of reproducibility, σ_R, as defined in ISO 7574-1. The values of table 1 take into account the cumulative effects of measurement uncertainty in applying the procedures of this part of ISO 3743, but exclude variations in the sound power output caused

by changes in operating conditions (e.g. rotational speed, line voltage) or mounting conditions.

The measurement uncertainty depends on the standard deviation of reproducibility tabulated in table 1 and on the degree of confidence that is desired. As examples, for a normal distribution of sound power levels, there is a 90 % confidence that the true value of the sound power level of a source lies within the range $\pm$ 1,645 σ_R of the measured value and a 95 % confidence that it lies within the range $\pm$ 1,96 σ_R of the measured value. For further examples, reference should be made to the ISO 7574 and ISO 9296 series.

Table 1 — Estimated values of the standard deviation of reproducibility of sound power levels determined in accordance with this part of ISO 3743

Octave-band centre frequency Hz	Standard deviation of reproducibility, σ_R dB
125	3,0
250	2,0
500 to 4 000	1,5
8 000	2,5
A-weighted	1,5*)

*) Applicable to a source which emits noise with a relatively "flat" spectrum in the frequency range 100 Hz to 10 000 Hz.

NOTES

4 The standard deviations listed in table 1 are associated with the test conditions and procedures defined in this part of ISO 3743, and not with the noise source itself. They arise partly from variations between measurement laboratories in the geometry of the test room, the acoustical properties of the test room boundaries, background noise, the type and calibration of instrumentation, and the reference sound source. They are also due to variations in experimental measurement techniques, including microphone placement and spatial averaging, location of source under test, integration times, and measurement of reverberation time.

5 If several laboratories use similar facilities and instrumentation, the results of sound power determinations on a given source in those laboratories may be in better agreement than would be implied by the standard deviations given in table 1.

6 For a particular family of sound sources, of similar size with similar sound power spectra and similar operating conditions, the standard deviations of reproducibility may be smaller than the values given in table 1. Hence, a noise test code for a particular type of machinery or equipment making reference to this part of ISO 3743 may state standard deviations smaller than those listed in table 1 if substantiation is available from the results of suitable interlaboratory tests.

7 The standard deviation of reproducibility, as tabulated in table 1, includes the uncertainty associated with repeated measurements on the same noise source under the same conditions (for standard deviation of repeatability, see ISO 7574-1). This uncertainty is usually much smaller than the uncertainty associated with interlaboratory variability. However, if it is difficult to maintain stable operating or mounting conditions for a particular source, the standard deviation of repeatability may not be small compared with the values given in table 1. In such cases, the fact that it was difficult to obtain repeatable sound power level data on the source should be recorded and stated in the test report.

8 The procedures of this part of ISO 3743 and the standard deviations given in table 1 are applicable to measurements on an individual machine. Characterization of the sound power levels of batches of machines of the same family or type involves the use of random sampling techniques in which confidence intervals are specified, and the results are expressed in terms of statistical upper limits. In applying these techniques, the total standard deviation must be known or estimated, including the standard deviation of production, as defined in ISO 7574-1, which is a measure of the variation in sound power output between individual machines within the batch. Statistical methods for the characterization of batches of machines are described in ISO 7574-4.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 3743. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 3743 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2204:1979, *Acoustics — Guide to International Standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings.*

ISO 3744:1994, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane.*

ISO 3745:1977, *Acoustics — Determination of sound power levels of noise sources — Precision methods for anechoic and semi-anechoic rooms.*

ISO 6926:1990, *Acoustics — Determination of sound power levels of noise sources — Requirements for the performance and calibration of reference sound sources.*

ISO 7574-1:1985, *Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 1: General considerations and definitions.*

ISO 7574-4:1985, *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.*

IEC 225:1966, *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations.*

IEC 651:1979, *Sound level meters.*

IEC 804:1985, *Integrating-averaging sound level meters.*

IEC 942:1988, *Sound calibrators.*

3 Definitions

For the purposes of this part of ISO 3743, the following definitions apply.

3.1 sound pressure, p: A fluctuating pressure superimposed on the static pressure by the presence of sound. It is expressed in pascals.

NOTE 9 The magnitude of the sound pressure can be expressed in several ways, such as instantaneous sound pressure or maximum sound pressure, but, in this part of ISO 3743 the term defines the sound pressure averaged on a mean-square basis (square root of the time average of the squared value) in time, and in space (i.e. over all microphone positions).

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 to the square of the reference sound pressure. Sound pressure levels are expressed in decibels. The reference sound pressure is 20 μPa ($2 \times \mu 10^{-5}$ Pa).

The frequency weighting or the width of the frequency band used and the time weighting (S, F or I, see IEC 651) shall be indicated.

NOTE 10 For example, the A-weighted sound pressure level with time weighting S is L_{pAS}.

3.3 time-averaged sound pressure level, $L_{peq,T}$: Sound pressure level of a continuous steady sound that, within a measurement time interval, T, has the same mean square sound pressure as a sound under consideration which varies with time.

$$L_{peq,T} = 10 \lg \left[\frac{1}{T} \int_0^T 10^{0,1 L_p(t)} \, dt \right] \text{ dB}$$

$$= 10 \lg \left[\frac{1}{T} \int_0^T \frac{p^2(t)}{p_0^2} \, dt \right] \text{ dB} \qquad \ldots (1)$$

Time-averaged sound pressure levels are expressed in decibels and shall be measured with an instrument which complies with the requirements of IEC 804.

NOTES

11 Time-averaged sound pressure levels are usually A-weighted and denoted by $L_{pAeq,T}$ which is usually abbreviated to L_{pA}.

12 In general, the subscripts "eq" and "T" are omitted since time-averaged sound pressure levels are necessarily determined over a certain measurement time interval.

3.4 sound power, W: The rate per unit time at which sound energy is radiated by a source. It is expressed in watts.

3.5 sound power level, L_W: Ten times the logarithm to the base 10 of the ratio of the sound power radiated by the source under test to the reference sound power. It is expressed in decibels. The reference sound power is 1 pW (10^{-12} W).

The frequency weighting or the width of the frequency band used shall be indicated.

NOTE 13 For example, the A-weighted sound power level is L_{WA}.

3.6 reverberant sound field: That portion of the sound field in the test room over which the contribution of the sound received directly from the source is negligible compared to the sound reflected from the boundaries of the room and from objects within the room.

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

3.8 frequency range of interest: For general purposes, the frequency range of interest includes the octave bands with midband frequencies from 125 Hz to 8 000 Hz, i.e. from the lower cut-off of the 125 Hz band (90 Hz) to the upper cut-off of the 8 000 Hz band (11 200 Hz).

NOTE 14 For special purposes, the frequency range of interest may be extended or reduced, but this places additional requirements on the characteristics of the test room which are not described in this part of ISO 3743.

3.9 reference sound source (RSS): Stable sound source emitting steady, broad-band noise with adequate sound power over a wide frequency range, calibrated in accordance with ISO 6926. The sound power levels of the reference sound source are known over the frequency range of interest.

3.10 reference box: Hypothetical surface which is the smallest rectangular parallelepiped that just encloses the source under test and terminates on the floor of the test room.

NOTE 15 Small individual components of the source which do not contribute to its sound radiation may lie outside the reference box.

3.11 comparison method: That method in which the sound power level of a source under test is determined by comparing the averaged value (on a mean-square basis) of the sound pressure levels produced by the source in the test room to the averaged value of the sound pressure levels produced in the same room by a reference sound source of known sound power output. The difference in sound pressure levels is equal to the difference in sound power levels when conditions are the same for both sets of measurements.

3.12 direct method: That method in which the sound power level of a source under test is determined from the averaged value (on a mean-square basis) of the sound pressure levels produced by the source in the test room, the reverberation time, and the volume of the test room.

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

NOTE 16 Background noise may include contributions from airborne sound, structure-borne vibration, and electrical noise in instrumentation.

3.14 background noise level: Sound pressure level measured in the test room when the source under test is not operating. It is expressed in decibels.

3.15 sound absorption coefficient: In a specified frequency band, a measure of the absorptive property of a material or surface. Ideally, the sound absorption coefficient is the fraction of the randomly incident sound power absorbed or otherwise not reflected.

3.16 highly directional sound source: Sound source with a maximum directivity index measured in accordance with ISO 3745 which exceeds 15 dB.

4 Requirements for hard-walled test room

4.1 Volume of test room

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 source shall not exceed 1,0 m. In rooms with volumes greater than 100 m^3, the largest dimension of the source shall not exceed 2,0 m.

4.2 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 2 may be used for guidance.

Table 2 — 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	

4.3 Test of room suitability

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

A highly directional, broad-band sound source is located in the test room as given in 7.2. Microphone positions are chosen according to 7.4 and the average (energy basis) octave-band sound pressure level, L_{p1}, is determined (see $L_{p(ST)}$ in clause 8). The sound source is then turned 45° to 135° in compliance with the requirement of 7.5 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. 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