INTERNATIONAL STANDARD

ISO 3743-2

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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

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

Partie 2: Méthodes en salle d'essai réverbérante spéciale

Reference number
ISO 3743-2:1994(E)

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 3743-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This first edition cancels and replaces the ISO 3743:1988, of which it constitutes a minor revision.

ISO 3743 consists of the following parts, under the general title *Acoustics — Determination of sound power levels of noise sources using sound pressure — 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*

Annex A forms an integral part of this part of ISO 3743. Annexes B, C and D are for information only.

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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 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 with A-weighting and in octave bands at prescribed fixed microphone positions or along prescribed paths. It allows determination of A-weighted sound power levels or sound power levels with other weighting and 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 special reverberation test room or in a hard-walled test room with prescribed acoustical characteristics. 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.

0.4 In ISO 3743-1, a comparison method is used to determine 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.

The requirements to be fulfilled by the special reverberation test room for measurements in accordance with this part of ISO 3743 are significantly more restrictive than those placed on the hard-walled test room by the comparison method of ISO 3743-1.

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.

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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

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 specially designed room having a specified reverberation time over the frequency range of interest. The A-weighted sound power level of the source under test is determined 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. Guidelines for the design of special reverberation rooms are given in annex B.

In addition to the direct method, a comparison method is also described (see 8.3). However, since the requirements on the test room for the comparison method of ISO 3743-1 are considerably less restrictive, it is recommended that the comparison method of ISO 3743-1 be used if a special reverberation test room is not available.

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

1.2 Types of noise

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

NOTES

2 A classification of different types of noise is given in ISO 12001.

3 For sources of impulsive 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 and the lower limit of the frequency range for which the methods are applicable depend upon the size of the room used for the acoustical measurements. The volume of the noise sources should not exceed 1 % of the volume of the special reverberation test room. For the minimum test room volume of 70 m^3, the recommended maximum size of the source is 0,7 m^3. Measurements on sources emitting discrete-frequency components below 200 Hz are frequently difficult to make in such small rooms.

1.4 Measurement uncertainty

Determinations made in accordance with this part of ISO 3743 result, with few exceptions, in standard deviations of reproducibility equal to or less than 2,0 dB from 500 Hz to 4 000 Hz, 3,0 dB for 250 Hz and 8 000 Hz, and 5,0 dB for 125 Hz (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 $\pm$ 1,645σ_R of the measured value and a 95 % confidence that it lies within the range $\pm$ 1,96σ_R of the measured value. For further examples, reference may be made to the ISO 9296 and ISO 7574 series.

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 deviations of reproducibility, as tabulated in table 1, include 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.

Table 1 — Estimated values of the standard deviation of reproducibility of sound power levels determined according to this part of ISO 3743

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

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

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 3741:1988, *Acoustics — Determination of sound power levels of noise sources — Precision methods for broad-band sources in reverberation rooms.*

ISO 3743-1:1994, *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.*

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 definitions given in ISO 3743-1 and the following definition apply.

3.1 special reverberation test room: A test room meeting the requirements of this part of ISO 3743.

4 Requirements for special reverberation test room

4.1 General

Guidelines for the design of a suitable test room and an example of the determination of the nominal reverberation time of the room are given in annex B. Methods of measurement of reverberation time are given in ISO 354.

4.2 Volume of test room

The volume of the test room shall be at least 70 m^3 and preferably greater if the 125 Hz octave band is within the frequency range of interest. If the 4 kHz and 8 kHz octave bands are within the frequency range of interest, the volume shall not exceed 300 m^3.

NOTE 9 When using the comparison method, the use of larger room volumes is acceptable.

4.3 Reverberation time of test room

The calculation of sound power levels from measured values of the sound pressure levels requires a compensation for the frequency-dependent concentration of sound energy near the walls of the test room. To facilitate this compensation, the reverberation time should be slightly higher at low frequencies. The re-

verberation time T of the test room shall fall within the limiting curves defined by $T = 0{,}9\ R\ T_{nom}$ and $1{,}1\ R\ T_{nom}$, where the reverberation parameter, R, is given by

$$R = 1 + 257/\left(f\ V^{1/3}\right)$$

where

f is the frequency, in hertz;

V is the volume, in cubic metres.

For frequencies above 6,3 kHz, constants 0,9 and 1,1 shall be replaced by 0,8 and 1,2, respectively. The nominal reverberation time of the room, T_{nom}, is determined by centring the measured values of T (normalized to the reverberation time at 1 000 Hz) within the limiting curves specified above, and shall be between 0,5 s and 1,0 s (see annex B for an example). For a room volume V of 70 m^3, the value of R is determined from figure 1.

If, during the acoustical measurements, sound-absorptive structures support the source or if the source has absorptive surfaces, the reverberation time T shall be measured with these items present.

4.4 Surface treatment

The floor of the test room shall be reflective with an absorption coefficient less than 0,06. Except for the floor, none of the surfaces shall have absorptive properties significantly deviating from each other. For each octave band within the frequency range of interest, the mean value of the absorption coefficient of each wall and of the ceiling shall be within 0,5 and 1,5 times the mean value of the absorption coefficient of the walls and ceiling.

4.5 Criterion for background noise

At each microphone position, the sound pressure levels due to background noise shall be at least 4 dB and preferably more than 10 dB below the A-weighted sound pressure level or the band pressure levels produced by the source.

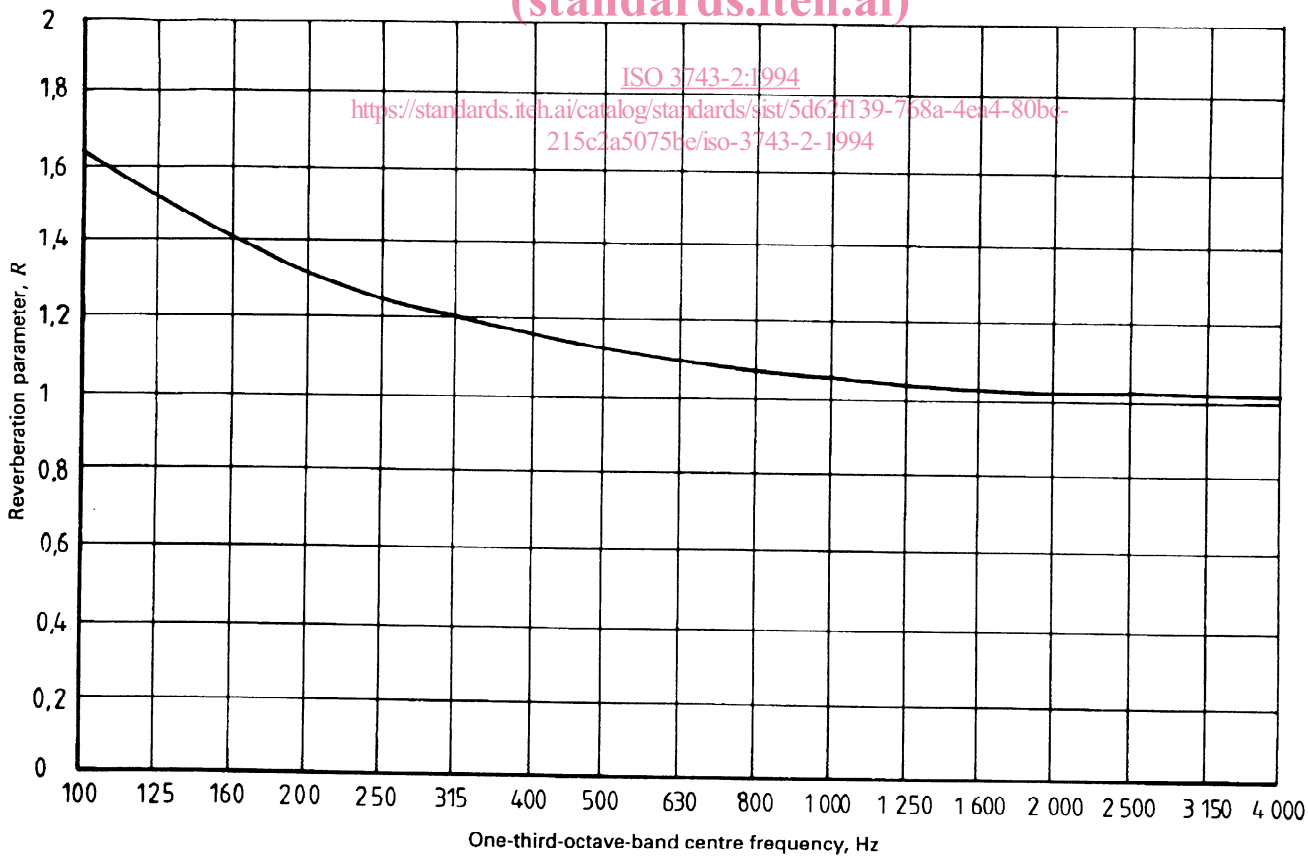

Figure 1 — Values of R at the one-third-octave-band centre frequencies for $V = 70\ m^3$

4.6 Criteria for temperature and humidity

The air absorption in the reverberation room varies with temperature and humidity, particularly at frequencies above 1 000 Hz. The temperature θ, in degrees Celsius, and the relative humidity (r.h.), expressed as a percentage, shall be controlled during the sound pressure level measurements. The product

$$\text{r.h.} \times (\theta + 5\ ^\circ\text{C})$$

shall not differ by more than $\pm$ 10 % from the value of the product which prevailed during the measurement of the reverberation time of the test room.

NOTE 10 To keep the reverberation time within the specified limits at the highest frequencies, a reduction of the air absorption is sometimes necessary. An increase in the humidity (for example by using a small humidifier) may be beneficial.

4.7 Evaluation of suitability of test room

Before a test room is used for sound power level determinations, its suitability shall be evaluated using the following procedure.

a) **Step 1**

Obtain a small broad-band reference sound source which has been calibrated in accordance with ISO 3741, or by following the procedures described in ISO 6926 and ISO 3745.

b) **Step 2**

In the special reverberation test room, determine the octave-band power levels of the same reference sound source under identical operating conditions in accordance with the procedure given in this part of ISO 3743.

c) **Step 3**

For each octave band within the frequency range of interest, calculate the difference between the sound power levels obtained in this way.

d) **Step 4**

Compare these differences with the values given in table 2.

If the differences in octave-band power levels do not exceed those specified in table 2, the room is suitable for sound power determinations of broad-band noise sources in accordance with the procedures of this part of ISO 3743.

Table 2 — Maximum permitted differences between octave-band power levels of broad-band noise sources measured in accordance with 4.7 a)

Octave-band centre frequency Hz	Difference in band power levels dB
125	± 5
250 to 4 000	± 3
8 000	± 4

5 Instrumentation

5.1 General

The basic instrumentation consists of a microphone, an amplifier with A-weighting network, a squaring and averaging circuit and an indicating device. A set of octave-band filters is also required. These elements may be separate instruments or they may be integrated into a complete unit, for example, a suitable sound level meter. For requirements on sound level meters, see IEC 651 and IEC 804.

The microphone shall, whenever possible, be physically separated from the rest of the instrumentation with which it is connected by means of a cable. Examples of suitable instrumentation systems are given in annex C.

5.2 Microphone and its associated cable

The microphone shall have a flat frequency response for randomly incident sound over the frequency range of interest, as determined by the procedure given in 5.6.

NOTES

11 This requirement is not normally met by the microphone of a sound level meter which is calibrated for free-field measurements.

12 If several microphones are used, it is desirable to avoid the axis of each microphone being oriented in the same direction in space.

The frequency response and stability of the microphone system shall not be adversely affected by the cable connecting the microphone to the rest of the instrumentation system. If the microphone is moved, care shall be exercised to avoid introducing acoustical or electrical noise that could interfere with the measurements.