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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Acoustics — Determination of sound power levels of noise sources — Precision methods for discrete-frequency and narrow-band sources in reverberation rooms

Acoustique — Détermination des niveaux de puissance acoustique émis par les sources de bruit — Méthodes de laboratoire en salles réverbérantes pour les sources émettant des bruits à composantes tonales et à bande étroite

Reference number
ISO 3742 : 1988 (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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 3742 was prepared by Technical Committee ISO/TC 43, *Acoustics.*

This second edition cancels and replaces the first edition (ISO 3742 : 1975), of which it constitutes a minor revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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0.1 Related International Standards

This International Standard is one of a series specifying various methods for determining the sound power levels of machines and equipment. These basic documents specify only the acoustical requirements for measurements appropriate for different test environments as shown in table 1.

When applying these basic documents, it is necessary to decide which one is most appropriate for the conditions and purposes of the test. The operating and mounting conditions of the machine or equipment to be tested are given as general principles stated in each of the basic documents. Guidelines for making these decisions are provided in ISO 3740. If no noise test code is specified for a particular machine, the mounting and operating conditions shall be fully described in the test report.

0.2 Synopsis of ISO 3742

0.2.1 Applicability

0.2.1.1 Test environment

Specified reverberation room which is to be qualified in accordance with a test procedure given in clause 3 of the main part of this International Standard and in the annex; additional test room requirements are given in ISO 3741.

0.2.1.2 Size of noise source

Volume of the source preferably less than 1 % of volume of the test room.

0.2.1.3 Character of noise radiated by the source

Steady (as defined in ISO 2204), discrete-frequency and/or narrow-band.

0.2.2 Precision

Measurements made in conformity with this International Standard will, with very few exceptions, result in standard deviations equal to or less than 1,5 dB from 400 to 5 000 Hz, 2 dB from 200 to 315 Hz, increasing to 3 dB below 200 Hz and above 5 000 Hz (see 1.3 and table 2).

0.2.3 Quantities to be measured

Sound pressure levels in frequency bands on a specified path or at several discrete microphone positions.

0.2.4 Quantities to be determined

Sound pressure levels in frequency bands; A-weighted sound power levels (optional).

0.2.5 Quantities which cannot be obtained

Directivity characteristics of the source; temporal pattern of radiated noise for sources emitting non-steady noise.

0.3 Introduction

This International Standard specifies in detail two laboratory methods for determining the sound power of small sources using a reverberation test room.

The procedure specified in ISO 3741 applies to sources which produce steady, broad-band noise. This International Standard gives additional precautions that have to be observed if discrete frequencies or narrow bands of noise are present in the spectrum of the noise radiated by the sound source.

If a source emits narrow-band or discrete-frequency sound, a precise determination of the radiated sound power requires greater effort. The accuracy objectives for characterizing broad-band sound sources (table 2 of ISO 3741) cannot be achieved with a microphone traverse of 3 m (or with only three microphones in a fixed array) and with only one source location in the reverberation room. The reasons are as follows:

a) the space/time-averaged sound pressure along the microphone path (see 7.1 in ISO 3741), or as determined with an array of three microphones, is not always a good estimate of the space/time-averaged mean-square pressure throughout the room;

b) the sound power radiated by the source is more strongly influenced by the normal modes of the room and by the position of the source within the room.

If narrow bands of noise or discrete frequencies are emitted by a source, a determination of its sound power level in a reverberation room requires the use of a greater number of source locations and microphone positions (or a greater path length for a moving microphone). The required numbers of locations and positions depend on the desired accuracy, the spectrum of the radiated noise, and the properties of the test

Table 1 — International Standards specifying various methods for determining the sound power levels of machines and equipment

International Standard No.*	Classification of method**	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	Engineering (grade 2)	Special reverberation test room		Steady, broad-band, narrow-band, or discrete-frequency	A-weighted and in octave bands	Other weighted sound power levels
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

* See clause 2.

** See ISO 2204.

room. These numbers can usually be reduced if one or more diffusers are rotating in the test room during the measurements. Guidelines for the design of suitable rotating diffusers are given in annex E in ISO 3741. The use of rotating diffusers considerably reduces the effort required to make measurements on sources that emit discrete-frequency components.

1 Scope and field of application

1.1 General

This International Standard specifies the special requirements that are necessary for accurate determinations of the sound power when discrete frequencies or narrow bands of noise are radiated by a source.

1.2 Field of application

This International Standard applies to sources which radiate discrete frequencies or narrow bands of noise. The spectrum of the source can include broad-band components upon which the prominent discrete frequencies or narrow bands of noise are superimposed. These methods are often complex and time-consuming for measurements on sources which primarily radiate discrete frequencies below 200 Hz. For such sources, measurements in a free field as described in ISO 3745 are likely to be more appropriate.

1.3 Measurement uncertainty

Measurements made in conformity with this International Standard tend to result in standard deviations which are equal to or less than those given in table 2. The standard deviations given in table 2 take into account the cumulative effects of all causes of measurement uncertainty.

NOTE — A more detailed description of the meaning of the standard deviations in table 2 is given in 1.3 in ISO 3741.

Table 2 — Uncertainty in determining sound power levels of discrete-frequency noise sources in reverberation rooms

Octave-band centre frequencies	One-third octave-band centre frequencies	Standard deviation
Hz	Hz	dB
125	100 to 160	3
250	200 to 315	2
500 to 4 000	400 to 5 000	1,5
8 000	6 300 to 10 000	3

1.4 Principal requirements

To meet the accuracy objectives of table 2, additional microphone positions and source locations are usually required as determined in clause 4. First, however, a determination may be made concerning the presence and significance of discrete-frequency components or narrow bands of noise in the spectrum of the sound emitted by the source (see clause 3).

Alternatively, it may be assumed that the spectrum of the sound emitted by the machine or equipment under test does contain significant discrete-frequency components. In this case either the precautions described in clause 4 should be followed or the test set-up should be qualified as described in the annex.

If the room qualifies according to the requirements of the annex, additional source locations are not required. Qualification of the test set-up according to the annex is usually possible only if a rotating diffuser and additional microphone positions are used in the room.

1.5 Other requirements

All other requirements for determining the sound power emitted by discrete-frequency and narrow-band sound sources are the same as for broad-band sources described in ISO 3741.

2 References

ISO 266, *Acoustics — Preferred frequencies for measurements.*

ISO 354, *Acoustics — Measurement of sound absorption in a reverberation room.*

ISO 1680, *Acoustics — Test code for the measurement of airborne noise emitted by rotating electrical machinery —*
Part 1: Engineering method for free-field conditions over a reflecting plane.
Part 2: Survey method.

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

ISO 3740, *Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards and for the preparation of noise test codes.*

ISO 3741, *Acoustics — Determination of sound power levels of noise sources — Precision methods for broad-band sources in reverberation rooms.*[1)]

ISO 3743, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for special reverberation test rooms.*

1) Cross-references to specific clauses, sub-clauses, etc. in ISO 3741 apply to the second edition published in 1988.

ISO 3744, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for free-field conditions over a reflecting plane.*

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

ISO 3746, *Acoustics — Determination of sound power levels of noise sources — Survey method.*

ISO 3747, *Acoustics — Determination of sound power levels of noise sources — Survey method using a reference sound source.*

IEC Publication 50(08), *International Electrotechnical Vocabulary — Electro-acoustics.*

IEC Publication 225, *Octave, half-octave and third-octave band filters intended for the analysis of sound and vibrations.*

IEC Publication 651, *Sound level meters.*

3 Determination of the significance of discrete-frequency components and narrow bands of noise

3.1 General

If a discrete-frequency component is present in the spectrum of a source, the spatial variations in the sound pressure level usually exhibit maxima separated by minima having an average spacing of approximately 0,8 λ, where λ is the wavelength corresponding to the frequency of the sound.

3.2 Qualitative procedure

The presence of a significant discrete-frequency component can often be detected by a simple listening test or by narrow-band analysis (e.g. by means of a fast Fourier transform analyser). If such a component is audible or if narrow-band analysis clearly indicates the presence of a discrete-frequency component, the measurements described in 3.3 may be omitted. In this case, either the provisions of the bottom row of table 3 shall be applied or, alternatively, the test set-up shall be qualified as described in the annex.

Discrete-frequency components may be present in the spectrum even if these components are not audible or if narrow-band analysis does not clearly indicate the presence of a discrete-frequency component. A conclusion that no discrete-frequency components are present can only be reached by performing the test described in 3.3.

3.3 Estimate of standard deviation

3.3.1 Obtain an estimate of the standard deviation of the sound pressure levels produced by the source under test in the room by following the procedure described in 3.3.2 and 3.3.3.

3.3.2 Select an array of six fixed microphones (or six microphone positions) spaced at least $\lambda/2$ apart, where λ is the wavelength of the sound corresponding to the lowest frequency of the frequency band of interest. Locate the source at a single position in the test room in accordance with ISO 3741.

Obtain the time-averaged sound pressure level, L_i, at each microphone position according to the techniques described in ISO 3741. Instead of a fixed array, a single microphone may be sequentially positioned at six points equally spaced along a path the length of which is calculated from equation (2) with $N_m = 6$.

Determine the time-averaged sound pressure level at each point.

Table 3 — Procedures to be followed in the measurement of discrete-frequency components or narrow bands of noise

Standard deviation, s dB	Procedure	Number of microphone positions, N_m (or microphone path length, l)	Number of source locations, N_s
$s < 1,5$	Assume broad-band source	$N_m = 3$ or l calculated from equation (2) for a continuous path	$N_s = 1$
$1,5 < s < 3$	Assume that a narrow band of noise is present	N_m determined from table 4 or l calculated from equation (2) for a continuous path	Use half the number of source locations calculated from equation (3)
$s > 3$	Assume that a discrete tone is present	N_m determined from table 4 or l calculated from equation (2) for a continuous path	Calculate N_s from equation (3)

3.3.3 For each one-third octave or octave band within the frequency range of interest, calculate the standard deviation, s, of the space/time-averaged sound pressure levels in the room, L_i, in decibels, from the following equation:

$$s = (n-1)^{-1/2} \left[\sum_{i=1}^{n} (L_i - L_m)^2 \right]^{1/2} \qquad \ldots (1)$$

where

L_m is the arithmetic mean value of the sound pressure levels L_1 to L_6, in decibels;

$n = 6$.

The magnitude of s depends upon the properties of the sound field in the test room. These properties are influenced by the characteristics of the room as well as the characteristics of the source (i.e. directivity and spectrum of emitted sound). In theory, a standard deviation of 5,56 dB corresponds to a spectral component of zero bandwidth, i.e. a discrete tone.

4 Number of microphone positions and source locations

4.1 General

Because equation (1) only gives an estimate of the true standard deviation, this International Standard uses three broad ranges of values for s to determine the number of microphone positions (or path length) and the number of source locations required to achieve the estimated accuracy. Detailed knowledge of the spectrum of the source is not necessary for carrying out the measurements. Irregularities in the sound field are taken into account in so far as they influence the estimate of the standard deviation, s.

4.2 Calculation

4.2.1 The value of s calculated according to 3.3.3 is used with tables 3 and 4 to determine the recommended microphone path length and the number of source locations. The number of microphone positions is determined from table 4. If a continuous microphone traverse is used, the length of the traverse, l, should be at least

$$l = N_m (\lambda/2) \qquad \ldots (2)$$

where

λ is as defined in 3.3.2;

N_m is the number of microphone positions.

4.2.2 The required number of source locations depends on the reverberation time and volume of the room, and on the frequency. For discrete-frequency tones, the recommended number of source locations, N_s, should be calculated from the following relation:

$$N_s \geqslant K \left[0{,}79 \left(\frac{T}{V} \right) \left(\frac{1\,000}{f} \right)^2 + \frac{1}{N_m} \right] \qquad \ldots (3)$$

where

T is the reverberation time of the room, in seconds;

V is the volume of the room, in cubic metres;

f is the frequency, in hertz, of the discrete tone or the centre frequency of the band in which a discrete-frequency or narrow-band noise component is found;

K is a constant given in table 4;

N_m is the number of microphone positions for the narrow-band or discrete-frequency tone (see table 4).

The value of N_s shall be rounded to the nearest higher integer.

Table 4 — Number of microphone positions required and constant K for determining number of source locations

Octave-band (and one-third octave-band) centre frequencies Hz	Number of microphone positions (N_m) if $1{,}5 < s < 3$ dB	Number of microphone positions (N_m) if $s > 3$ dB	Constant K determining number of source locations
125 (100, 125, 160)	3	6	5
250 (200, 250, 315)	6	12	10
500 (400, 500, 630)	12	24	20
1 000 (800, 1 000, 1 250) and above	15	30	25

The minimum distance between any two source locations shall be $\lambda/2$, where λ is as defined in 3.3.2. The source locations should not be symmetrical with respect to the axes of the test room.

4.2.3 After the minimum number of microphone positions (or appropriate microphone path length) and the recommended number of source locations have been selected, the procedures of 7.2 of ISO 3741 shall be followed to obtain values of L_p, the mean band pressure levels in the room in the one-third octave or octave bands of interest.

4.2.4 The sound power emitted by the source is then calculated using the procedures of clause 8 of ISO 3741.