INTERNATIONAL STANDARD ISO 3741

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Acoustics — Determination of sound power levels of noise sources — Precision methods for broad-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 à large bande

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

International Standard ISO 3741 (originally ISO/DIS 2880) was drawn up by Technical Committee ISO/TC 43, *Acoustics*, and circulated to the Member Bodies in September 1972.

It has been approved by the Member Bodies of the following countries :

Australia	India	Romania
Austria	Ireland	South Africa, Rep. of
Belgium	Israel	Spain
Canada	Italy	Sweden
Czechoslovakia	Netherlands	Switzerland
Denmark	New Zealand	Thailand
France	Norway	United Kingdom
Germany	Poland	U.S.S.R.
Hungary	Portugal	

No Member Body expressed disapproval of the document.

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Annexes

Acoustics – Determination of sound power levels of noise sources – Precision methods for broad-band sources in reverberation rooms

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 must be in accordance with the general principles stated in the basic documents.

Guidelines for making these decisions are provided in ISO 3740. If no sound test code is specified for a particular machine, the mounting and operating conditions shall be fully described in the test report.

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	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	Special reverberation test room		Steady, broad-band narrow-band, discrete-frequency	A-weighted and in octave bands	Other weighted sound power levels
3744	Engineering	Outdoors or in large room	No restrictions : limited only by available test environment	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	Anechoic or semi-anechoic room	Preferably less than 0,5 % of test room volume	Any		
3746	Survey	No special test environment	No restrictions : limited only by available test environment	Steady, broad-band, narrow-band, discrete-frequency	A-weighted	Sound pressure levels as a function of time; other weighted sound power levels

* See clause 2.

0.2 SYNOPSIS OF ISO 3741

Applicability

Test environment

Reverberation room with prescribed volume and absorption or qualified according to a test procedure given in annex A. Guidelines for the design of reverberation rooms are given in annex D. The minimum test room volume depends on the lowest frequency band of interest ($V_{min} = 200\ m^3$ corresponds to 100 Hz for the lowest allowable one-third octave band).

Size of noise source

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

Character of noise radiated by the source

Steady (as defined in ISO 2204), broad-band.

Accuracy

Precision (standard deviation for determining sound power levels for 1 kHz octave band is less than or equal to 1,5 dB).

Quantities to be measured

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

Quantities to be determined

Sound power levels in frequency bands, A-weighted sound power level (optional).

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 radiated by a device, machine, component, or sub-assembly as a function of frequency, using a reverberation test room having prescribed acoustical characteristics. While other methods could be used to measure the noise emitted by machinery and equipment, the methods specified in this International Standard are particularly advantageous for rating the sound output of sources which produce steady noise and for which directivity information is not required. If the source emits non-steady noise or if directivity information is desired, one of the other methods specified in ISO 2204 shall be selected.

Among the reasons for obtaining data as described in this International Standard are :

1) rating apparatus according to its sound power output;

2) establishing sound control measures;

3) predicting the sound pressure levels produced by a device or machine in a given enclosure or environment.

In this International Standard, the computation of sound power from sound pressure measurements is based on the premise that the mean-square sound pressure averaged in space and time, $<\overline{p^2}>$, is

1) directly proportional to the sound power output of the source,

2) inversely proportional to the equivalent absorption area of the room, and

3) otherwise depends only on the physical constants of air density and velocity of sound.

This International Standard, together with the others in this series supersedes ISO/R 495.

1 SCOPE AND FIELD OF APPLICATION

1.1 General

This International Standard specifies a direct method and a comparison method for determining the sound power level produced by a source. It specifies test room requirements, source location and operating conditions, instrumentation and techniques for obtaining an estimate of mean-square sound pressure from which the sound power level of the source in octave or one-third octave bands is calculated.

1.2 Field of application

1.2.1 *Types of noise*

This International Standard applies primarily to sources which produce steady broad-band noise as defined in ISO 2204.

NOTE — When discrete frequencies or narrow bands of noise are present in the spectrum of a source, the mean-square sound pressure tends to be highly dependent on the positions of the source and the microphone within the room. The average value over a limited microphone path or array may differ significantly from the value averaged over all points in the room. Procedures for determining the sound power radiated by a source when discrete tones are present in the spectrum are described in ISO 3742.

1.2.2 *Size of source*

This International Standard applies only to small sound sources, i.e. sources with volumes which are preferably not greater than 1 % of the volume of the reverberation room used for the test.

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 of table 2 take into account the cumulative effects of all causes of measurement uncertainty.

TABLE 2 — **Uncertainty in determining sound power levels of broad-band sources in reverberation rooms**

Octave band centre frequencies	One-third octave band centre frequencies	Standard deviation
Hz	Hz	dB
125	100 to 160	3,0
250	200 to 315	2,0
500 to 4 000	400 to 5 000	1,5
8 000	6 300 to 10 000	3,0

2 REFERENCES

ISO/R 266, *Preferred frequencies for acoustical measurements.*

ISO/R 354, *Measurement of absorption coefficients in a reverberation room.*

ISO 2204, *Guide to the measurement of airborne acoustical noise and evaluation of its effects on man.*

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.* 1)

ISO 3742, *Acoustics — Determination of sound power levels of noise sources — Precision methods for discrete-frequency and narrow-band sources in reverberation rooms.*

ISO 3743, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for special reverberation test rooms.* 2)

ISO 3744, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for free field conditions over a reflecting plane.* 2)

ISO 3745, *Acoustics — Determination of sound power levels of noise sources — Precision methods for anechoic and semi-anechoic rooms.* 2)

ISO 3746, *Acoustics — Determination of sound power levels of noise sources — Survey method.* 1)

IEC Publication 50 (08), *International electrotechnical vocabulary — Electro-acoustics.*

IEC Publication 179, *Precision sound level meters.*

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

1) In preparation.

2) At present at the stage of draft.

3 DEFINITIONS

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

3.1 reverberation room : A test room meeting the requirements of this International Standard.

3.2 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.

3.3 mean-square sound pressure : The sound pressure averaged in space and time on a mean-square basis is denoted by $<\overline{p^2}>$. In practice, space/time-averaging over a finite path length or a fixed number of microphone positions, as well as deviations from the ideally reverberant sound field, lead only to an estimate of $<\overline{p^2}>$, called p_{av}^2 in this International Standard.

3.4 sound pressure level : Ten times the logarithm to the base 10 of the ratio of the mean-square sound pressure of a sound to the square of the reference sound pressure. This quantity is denoted by L_p. The width of a restricted frequency band shall be indicated; for example, octave band pressure level, one-third octave band pressure level, etc. The reference sound pressure is 20 µPa. Unit : decibel (dB).

3.5 sound power level : Ten times the logarithm to the base 10 of the ratio of a given sound power to the reference sound power. This quantity is denoted by L_W. The width of a restricted frequency band shall be indicated, for example, octave band power level, one-third octave band power level, etc. The reference sound power is 1 pW. Unit : decibel (dB).

3.6 frequency range of interest : For general purposes, the frequency range of interest includes the octave bands with centre frequencies between 125 and 8 000 Hz or the one-third octave bands with centre frequencies between 100 Hz and 10 000 Hz. Any band may be excluded in which the level is more than 40 dB below the highest band pressure level. For special purposes, other frequency ranges of interest may be defined depending upon the characteristics of the noise source, provided that the test room is satisfactory for use over the appropriate frequency range.

3.7 direct method : That method in which the sound power level is calculated from the measured sound pressure levels produced by the source in a reverberation room and from the volume and reverberation time of the room.

3.8 comparison method : That method in which the sound power level is calculated by comparing the measured sound pressure levels produced by the source in a reverberation room with the sound pressure levels produced in the same room by a reference sound source (RSS) of known sound power output.

4 TEST ROOM REQUIREMENTS

4.1 General

Annex D contains guidelines for the design of reverberation rooms to be utilized for determinations of sound power according to this International Standard.

The test room shall be large enough and have low enough total sound absorption to provide an adequate reverberant sound field for all frequency bands within the frequency range of interest.

4.2 Room volume

The minimum room volume shall be as prescribed in table 3. If frequencies above 3 000 Hz are included in the frequency range of interest, the volume of the test room shall not exceed 300 m^3. The ratio of the maximum dimension of the test room to its minimum dimension shall not exceed 3 : 1.

TABLE 3 – **Minimum room volume as a function of the *lowest frequency band of interest***

Lowest frequency band of interest	Minimum room volume m^3
125 Hz octave or 100 Hz third-octave	200
125 Hz third-octave	150
160 Hz third-octave	100
250 Hz octave or 200 Hz third-octave and higher	70

4.3 Criterion for room absorption

The equivalent absorption area of the test room primarily affects the minimum distance to be maintained between the sound source and the microphone positions. It also influences the sound radiation of the source. For these reasons, the absorption area shall be neither too large nor extremely small (see annex D).

The reverberation time, in seconds, shall be greater than V/S

where

V is the room volume, in cubic metres;

S is the total surface area of the test room, in square metres.

4.3.1 *Minimum distance*

The minimum distance between the sound source and the nearest microphone position shall not be less than

$$d_{min} = 0{,}08\sqrt{V/T}$$

where

V is the room volume, in cubic metres;

T is the reverberation time, in seconds.

4.3.2 *Surface treatment*

The surfaces of the test room closest to the source shall be designed to be reflective with an absorption coefficient less than 0,06. Except for this surface, none of the other surfaces shall have absorptive properties significantly deviating from each other. The other surfaces shall be so designed that for each one-third octave band within the frequency range of interest, the mean value of the absorption coefficient of each surface is between 0,5 and 1,5 times the mean value of the absorption coefficients of all surfaces.

4.4 Criterion for room adequacy

If the test room does not have an absorption as required by 4.3, the adequacy of the room shall be established by the procedure described in annex A.

4.5 Criterion for background noise level

The background noise level including any noise due to motion of the microphone shall be at least 6 dB, and preferably more than 12 dB, below the sound pressure level to be measured in each frequency band within the frequency range of interest.

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 RH (in percent) shall be controlled during the sound pressure level measurements. The product

$$RH \times (\theta + 5\ ^\circ C)$$

shall not differ by more than ± 10 % from the value of the product which prevailed during the measurements of clause 7.

5 INSTRUMENTATION

5.1 General

Instrumentation shall be designed to determine the mean-square value of the sound pressure in octave and/or one-third octave bands averaged over time and space.

Several alternative procedures for space-averaging are given in clause 7. Those involving automatic sampling require instrumentation with longer integration (averaging) times.

There are two alternative approaches to time-averaging the output voltage of the octave(or one-third octave) band filters :

1) Integration of the squared voltage over a fixed time interval, τ_D, by analogue or digital means.

2) Continuous analogue averaging of the squared voltage, using RC-smoothing network with a time constant, τ_A. This provides only an approximation of the true time average, and it places restrictions on the "settling" time and observation time (see 7.2.2).

NOTE — Filtering and RE-smoothing may require special attention to the "settling" time and the minimum observation time (see 7.2.2).

5.2 Indicating device

An estimate of p^2_{av} is obtained by determining the mean-square pressure corresponding to the mean-square value of the voltage at the output of the filter set, e_o (t). This mean-square pressure is denoted by p^2_{av}, and is determined for a given microphone path traverse (or array) and time (see 7.2.1).

5.2.1 *Integration over a fixed time interval*

If this method is used (see 5.1), the normalized variance of the estimates of the level of the mean-square voltage shall be less than 0,25 dB for a steady sine wave input over the frequency range of interest, and the average value of a series of ten estimates of the level of the mean-square voltage shall not differ from the value obtained by continuous integration by more than ± 0,25 dB.

The integration time, τ_D (see 5.1), shall be identical to the observation period used (for minimum values of observation periods, see 7.2.2; for relation between integrating time and microphone traversing or scanning period, if applicable, see 7.1.1).

5.2.2 *Continuous averaging*

The time constant, τ_A (see 5.1), shall be at least 0,7 s, and long enough to meet the criterion of 7.1.1.

5.3 The microphone and its associated cable

A condenser microphone, or the equivalent in accuracy, stability and frequency response, shall be used. The microphone shall have a flat frequency response for randomly incident sound over the frequency range of interest.

NOTE — This requirement is met by the 1 in microphone of a standardized sound level meter complying with IEC Publication 179 and calibrated for free-field measurements only if it has a linear random response.

The microphone and its associated cable shall be chosen so that their sensitivity does not change by more than 0,5 dB in the temperature range encountered in the measurement. If the microphone is moved, care shall be exercised to avoid introducing acoustical or electrical noise (for example, from gears, flexing cables, or sliding contacts) that could interfere with the measurements.

5.4 Frequency response of the instrumentation system

The frequency response of the instrumentation for randomly incident sound shall be determined according to the procedure of IEC Publication 179 with the tolerances given in table 4.

TABLE 4 — **Relative tolerances for the instrumentation system**
(adapted from IEC Publication 179)

Frequency	Tolerance limits	
Hz	dB	
50	1,5	− 1,5
63	1,5	− 1,5
80	1,5	− 1,5
100	1	− 1
125	1	− 1
160	1	− 1
200	1	− 1
250	1	− 1
315	1	− 1
400	1	− 1
500	1	− 1
630	1	− 1
800	1	− 1
1 000	1	− 1
1 250	1	− 1
1 600	1	− 1
2 000	1	− 1
2 500	1	− 1
3 150	1	− 1
4 000	1	− 1
5 000	1,5	− 1
6 300	1,5	− 2
8 000	1,5	− 3
10 000	2	− 4
12 500	3	− 6
16 000	3	− ∞
20 000	3	− ∞

1,5

5.5 Filter characteristics

An octave band or one-third octave band filter set meeting the requirements of IEC Publication 225 shall be used. The centre frequencies of the bands shall correspond to those of ISO/R 226.

5.6 Calibration

During each series of measurements, an acoustical calibrator with an accuracy of ± 0,2 dB shall be applied to the microphone for calibration of the complete measuring system at one or more frequencies within the frequency range of interest. The calibrator shall be recalibrated at least annually. In addition, an electrical calibration of the instrumentation system over the entire frequency range of interest shall be performed periodically.