INTERNATIONAL STANDARD ISO 3743

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION •МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Acoustics — Determination of sound power levels of noise sources — Engineering methods for special reverberation test rooms

Acoustique — Détermination des niveaux de puissance acoustique émis par les sources de bruit — Méthodes d'expertise pour les salles d'essai réverbérantes spéciales

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FOREWORD

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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 3743 was drawn up by Technical Committee ISO/TC 43, *Acoustics*, and was circulated to the Member Bodies in May 1975.

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

Australia
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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Acoustics — Determination of sound power levels of noise sources — Engineering methods for special reverberation test rooms

MODIFICATION TO FOREWORD *(Inside front cover)*

The following sentence is to be added at the end of the foreword :

"This International Standard cancels and replaces ISO Recommendation R 495-1966, of which it constitutes a technical revision."

Acoustics – Determination of sound power levels of noise sources – Engineering methods for special reverberation test 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 3743

Applicability

Test environment

Reverberation room with prescribed volume and absorption. Guidelines for the design of reverberation rooms are given in annex A.

Type of source

Device, machine, component, subassembly.

Size of noise source

Volume of the source not greater than 1 % of the volume of the test room.

Character of noise radiated by the source

Steady (as defined in ISO 2204).

Accuracy

Engineering (standard deviation for determining A-weighted and/or octave band sound power levels for 1 kHz is about 2,0 dB).

Quantities to be measured

Sound pressure levels with A-weighting and in octave bands on prescribed paths or at several fixed positions.

Quantities to be determined

Weighted sound power level with A or other weighting sound power levels in octave bands.

Quantities which cannot be obtained

Directivity characteristics of the source.

0.3 INTRODUCTION

This International Standard specifies relatively simple engineering methods for determining the weighted and octave band sound power levels of small noise sources. These methods are applicable to small machines, devices and components which are sources of steady noise and can be installed for the purposes of the measurements in a special test room with prescribed acoustical characteristics. These methods are particularly suitable when the cost and labour involved in carrying out the measurements should be minimized and high precision is not necessary.

These methods are based on the premise that the mean-square sound pressure averaged in space and time in the test room can be used to determine the sound power emitted by the source. The properties of the test room are chosen so that the room's influence on the sound power output of the source under test is reasonably small. A simple method is given to determine the number of microphone positions and source locations required in the test room.

This International Standard, together with the others in this series (see table 1), supersedes ISO/R 495.

1 SCOPE AND FIELD OF APPLICATION

1.1 General

This International Standard specifies relatively simple engineering methods for determining the approximate sound power levels of small noise sources. The measurements are carried out when the source is installed in a specially designed room having a prescribed reverberation time over the frequency range of interest. The results of the measurements are given in terms of the A-weighted and/or octave band power levels of the source.

NOTE — Precision methods for the determination of octave band and one-third octave-band power levels of small noise sources are specified in ISO 3741 and ISO 3742.

1.2 Field of application

1.2.1 *Types of noise*

The methods specified in this International Standard are not suitable for measurements of noise sources which emit impulsive noise consisting of single noise bursts. The results obtained for sources of quasi-steady impulsive noise may be of limited value. For sources of impulsive noise, the free-field methods specified in ISO 3744 and ISO 3745 should be used. A classification of different types of noise (steady, impulsive, etc.) is given in ISO 2204.

1.2.2 *Size of source*

This International Standard applies to small noise sources producing steady noise within a specified frequency range. 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 test room employed. The volume of the noise source shall not exceed 1 % of the volume of the test room. For the minimum test room volume of 70 m^3, the 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.

1.3 Measurement uncertainty

Measurements made in conformity with this International Standard result in standard deviations which are equal to or less than those given in table 2. The standard deviations of table 2 reflect the cumulative effects of all causes of measurement uncertainty excluding variations in the sound power of the source from test to test. For a source which emits noise with a relatively "flat" spectrum in the 100 to

10 000 Hz frequency range, the A-weighted sound power level is determined with a standard deviation of mean value of approximately 2,0 dB.

NOTE — The methods specified in ISO 3741 and ISO 3742 yield sound power levels with smaller standard deviations than those given in table 2.

TABLE 2 — **Uncertainty in determining sound power levels in special reverberation test rooms**

Octave band centre frequency	Standard deviation of mean value
Hz	dB
125	5,0
250	3,0
500 to 4 000	2,0
8 000	3,0

2 REFERENCES

ISO 266, *Preferred frequencies for acoustical measurements.*

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

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

ISO 3740, *Acoustics — Determination of sound power level of noise sources — Guidelines for the use of basic standards and for the preparation of noise test codes.*[1]

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

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

ISO 3744, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for free-field conditions over a reflecting plane.*[1]

ISO 3745, *Acoustics — Determination of sound power levels of noise sources — Precision methods for anechoic and semi-anechoic rooms.*[1]

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.*

3 DEFINITIONS

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

3.1 special reverberation test 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 pressure : The sound pressure averaged in space and time on a mean-square basis denoted by $<\overline{p^2}>$. In practice, space and 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^2_{av} in this International Standard.

3.4 sound pressure level, L_p, in decibels : 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. The weighting network or the width of the frequency band used shall be indicated at the quantity; for example, A-weighted sound pressure level, octave-band pressure level, etc. The reference sound pressure is 20 μPa.

3.5 sound power level, L_W, in decibels : Ten times the logarithm to the base 10 of the ratio of the given sound power to the reference sound power. The weighting network or the width of the frequency band used shall be indicated at the quantity; for example, A-weighted sound power level, octave band power level, etc. The reference sound power is 1 pW (= 10^{-12} W).

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. Any band may be excluded in which the level is more than 40 dB below the highest band pressure level. For special purposes, the frequency range of interest may be extended at either end, provided that the test environment and instrument accuracy are satisfactory for use over the extended frequency range. For sources which radiate predominantly high (or low) frequency sound, the frequency range of interest may be limited in order to optimize the test facility and procedures.

1) At present at the stage of draft.

3.7 direct method : That method in which the sound power level is calculated from the mean-square sound pressure level produced by the source in a special reverberation test room and the total absorption in the room.

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

3.9 volume of source under test : The volume of the whole object under test.

4 TEST ROOM REQUIREMENTS

4.1 General

Annex A contains guidelines for the design of a suitable test room and an example of the determination of the nominal reverberation time of the room. Reference should be made to ISO/R 354 for methods of measurement of reverberation time.

4.2 Room volume

The volume of the test room shall be at least 70 m³ 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 m³.

NOTE — 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 reverberation time T of the test room shall fall within the limiting curves defined by $T = 0{,}9\ RT_N$ and $1{,}1\ RT_N$ where $R = 1 + 257/(f\ V^{1/3})$ Y, f in hertz, V 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. T_N is the nominal reverberation time of the room determined by centring the measured values of T (normalized to the reverberation time at 1 000 Hz) within the limiting curves prescribed above, and shall be between 0,5 and 1,0 s (see annex A for an example). For a room volume V of 70 m³, R may be determined from figure 1.

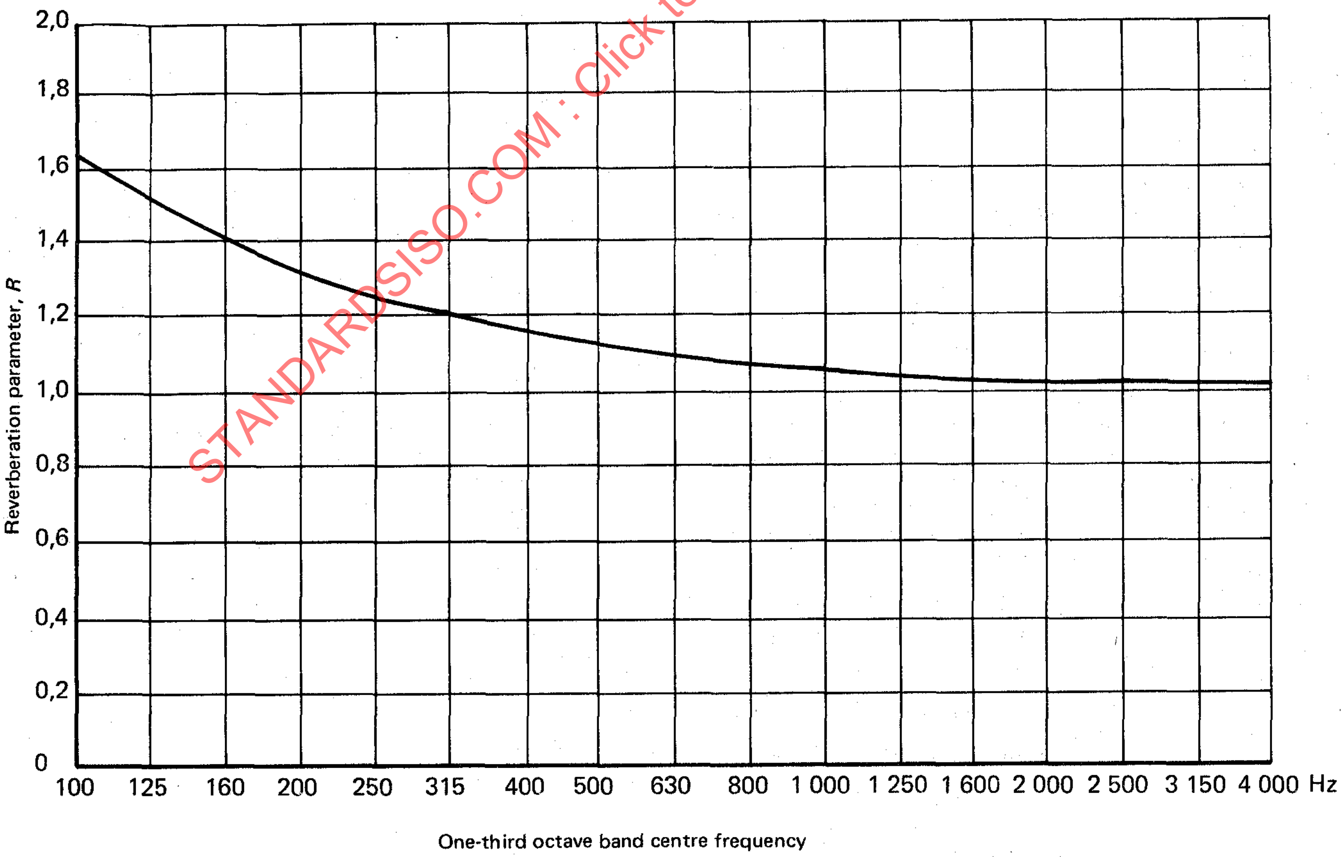

FIGURE 1 — **Values of *R* at the one-third octave band centre frequencies for $V = 70$ m³**

If, during the acoustical measurements, sound-absorptive structures support the source or if the source has absorptive surfaces, 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 those of the other surfaces. 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 the microphone positions, background sound pressure level shall be at least 4 dB and preferably more than 9 dB below the A-weighted sound pressure level or the band pressure levels produced by the source.

4.6 Criteria for temperature and humidity

To avoid excessive variations in air absorption (particularly at frequencies above 1 kHz) in the test room, no measurements shall be taken if the product RH X $(\theta + 5\,^\circ C)$ differs by more than ± 10 % from the value prevailing during the measurement of the reverberation time of the test room; RH is the relative humidity in percent, θ is the air temperature in degrees Celsius.

NOTE — 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 Test of room suitability

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

Step 1 : Make a precision determination of the octave band power levels of a small broad-band reference sound source according to one of the methods specified in ISO 3741. The reverberation room and the reference sound source shall also comply with the requirements of ISO 3741.

Step 2 : In the special reverberation test room, determine the octave band power levels of the same reference sound source under identical operating conditions according to the procedure given in this International Sandard.

Step 3 : For each octave band within the frequency range of interest; calculate the difference between the sound power levels so obtained.

Step 4 : Compare these differences with the values of table 3.

TABLE 3 — **Maximum differences between octave band power levels of broad-band noise sources measured according to ISO 3741 and according to this International Standard**

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

If the differences in octave band power levels do not exceed those specified in table 3, the room is suitable for sound power determinations of broad-band noise sources according to the procedures of this International Standard.

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, refer to IEC Publication 179.

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 B.

5.2 Microphone and 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.

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.

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

5.3 Amplifier and weighting network

The properties of the amplifier and the A-weighting network shall comply with the requirements of IEC Publication 179.

5.4 Octave band filters

The octave band filters shall comply with the requirements of IEC Publication 225.

5.5 Squaring and averaging circuits and indicating device

Squaring and averaging the microphone output voltage may be performed by analogue or digital equipment as described in annex B. In analogue systems, continuous averaging is generally performed by an RC-smoothing network with a time-constant τ_A. For these systems, the time-constant shall be at least 0,5 s and such that the indicated fluctuations are less than ± 5 dB.

In digital systems and in some analogue systems, true integration over a specified time-interval (integration time τ_D) is employed. The integration time shall be at least 1 s. The indication of the squaring and averaging (integrating) circuits and indicating device shall be within 3 % of the values.

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

Frequency	Tolerance limits
Hz	dB
100 to 4 000	± 1
5 000	± 1,5
6 300	+ 1,5 − 2
8 000	+ 1,5 − 3
10 000	+ 2 − 4

5.6 Frequency response of the instrumentation system

The frequency response of the instrumentation calibrated for randomly incident sound shall be determined according to the procedure of 8.2 of IEC Publication 179. The tolerances are given in table 4.

5.7 Calibration

During each series of measurements, an acoustical calibrator with an accuracy of ± 0,5 dB shall be applied to the microphone for calibration of the complete instrumentation system at one or more frequencies within the frequency range of interest. The calibrator shall be checked annually to verify that its output has not changed. In addition, an electrical calibration of the instrumentation system over the entire frequency range of interest shall be performed periodically.

6 INSTALLATION AND OPERATION OF SOURCE

6.1 General

The acoustical properties of the special reverberation test room and the manner in which the source is operated may have a significant influence on the sound power emitted by the source.

6.2 Source location

The source to be tested shall be placed in the test room in one or more locations that are typical of normal usage. If no such location(s) can be defined, the source shall be placed on the floor of the test room with a minimum distance of 1 m between any surface of the source and the nearest wall.

The location(s) of the source in the test room shall be described in the test report.

NOTE — The influence of the acoustical properties of the room on the sound power emitted by the source depends to some extent on the position of the source within the room. The requirements on the test room (see clause 4) tend to decrease this influence. However, in some cases it may be necessary or desirable to determine the sound power level of a source in several locations in the test room (see 7.4).

6.3 Source mounting

In many cases the sound power emitted will depend on the support or mounting conditions of the source, which must be carefully described in the test report. Whenever a typical condition of mounting or use exists for the equipment under test, this condition shall be used or simulated for the test, if feasible.

If a typical condition of mounting does not exist or cannot be utilized for the test, care shall be exercised to avoid changes in the sound output of the source due to the mounting system employed for the test. Steps shall be taken to reduce any sound radiation from the mounting of the equipment.

Sources normally mounted through a window, wall or ceiling shall be mounted through a wall or the ceiling of the test room.

The mounting conditions of the source and its associated equipment shall be described in the test report.

NOTE — The use of resilient supports and vibration-damping material on large surfaces employed to support the equipment under test may be appropriate.

6.4 Auxiliary equipment

Care shall be taken to ensure that any electrical conduits, piping or air ducts connected to the equipment do not radiate significant amounts of sound energy into the test room. If practicable, all auxiliary equipment necessary for the operation of the device under test shall be located outside the test room and the test room shall be cleared of all objects which may interfere with the measurements.

6.5 Operation of source during test

During the acoustical measurements, the source shall be operated in a specified manner typical of normal use. One or more of the following operational conditions may be appropriate :

a) device under normal load operating at normal speed;

b) device under full load (if different from a));

c) device under no load (idling);

d) device under operating condition corresponding to maximum sound generation.

The sound power levels of sources may be determined for any desired set of operating conditions (i.e., temperature, humidity, device speed, etc.). These test conditions shall be selected beforehand and shall be held constant during the test. The source shall be in a stable operating conditions before any noise measurements are made.

7 MEASUREMENT OF NOISE EMITTED BY SOURCE IN THE TEST ROOM

7.1 General

The calculation of the approximate sound power level of the source is based on measured mean-square values of the sound pressure averaged in time over an appropriate number of positions within the test room.

A single microphone moved from position to position, an array of fixed microphones or a microphone moving continuously over an appropriate path in the test room shall be used.

7.2 Period of observation

The period of observation shall be at least ten times the time-constant τ_A. During this period the indications shall be averaged and the mean value recorded as a result of the measurement.

For instrumentation with RC-smoothing, no observation shall be started after any filter switching or disturbance of the sound field (including transfer of the microphone to a new fixed position) until a "settling" time of at least 5 times the time-constant of the instrumentation has elapsed.

If a fixed integration time is used, the measurement at each fixed microphone position shall be of at least 5 s duration (for example if $\tau_D = 1$ s, five readings shall be averaged on a mean-square basis). If $\tau_D = 5$ s, the reading at the end of the 5 s interval shall be taken. If the microphone is moved over a path, the total period of observation shall be at least 30 s for frequency bands centred on 160 Hz and below (and for A-weighting), and at least 10 s for frequency bands centred on 200 Hz or above.

7.3 Microphone positions

No microphone position shall be closer to the surface of the room than $\lambda/4$, where λ is the wavelength of sound corresponding to the centre frequency of the lowest octave band in which measurements are made. The minimum distance (r_{min}) in metres between any microphone position and the surface of the source under test shall be

$$r_{min} = 0{,}3\, V^{1/3}$$

where V is the volume of the test room, in cubic metres.

The distance between any two microphones positions shall be at least $\lambda/2$, where λ is the wavelength of the sound wave corresponding to the centre frequency of lowest octave band in which measurements are made.

For measurements with A-weighting, assume $\lambda = 3{,}5$ m.

7.4 Number of microphone and source positions

The number of microphone positions and source locations necessary to obtain a specified precision of the sound power levels depend upon the properties of the source and the test room. For each source, the minimum number of positions necessary to obtain standard deviations which are equal to or less than the values given in table 2 shall be determined by the following procedure. This procedure shall be followed for each octave band of interest and for A-weighting.

Step 1 : For a particular source location, measure the sound pressure levels at six microphone positions.

Step 2 : Calculate the estimated standard deviation s_M, in decibels, of the measured sound pressure levels from the following relationship :

$$s_M = (n-1)^{-1/2} \left[\sum_{i=1}^{n} (L_{pi} - L_{pm})^2 \right]^{1/2}$$

where

L_{pi} is the ith value of the sound pressure level in decibels, reference : 20 μPa;

L_{pm} is the mean value of $L_{p1}, L_{p2}, \ldots, L_{p6}$, in decibels, reference : 20 μPa;

$n = 6$.

When the range of values of $L_{p1}, L_{p2}, \ldots, L_{p6}$ is not greater than 5 dB, a simple arithmetic average may be used for L_{pm}. When the range is greater than 5 dB, the following expression shall be used :

$$L_{pm} = 10 \log_{10}\left[1/6\left(10^{L_{p1}/10} + 10^{L_{p2}/10} + \ldots + 10^{L_{p6}/10}\right)\right]$$

NOTE — The magnitude of s_M will depend on the properties of the sound field in the test room. These properties are influenced by the characteristics of the test room and the source (i.e. its directivity and the spectrum of the emitted sound).

Step 3 : Enter in table 5 the value of s_M, in decibels, determined from step 2 and select from the table a suitable combination of the minimum number of microphone positions, N_m, and source locations, N_s, for each octave band and for A-weighting. These minimum numbers of positions must be used in order to obtain the accuracy specified in table 2.

As s_M has been determined from six measurements in each octave band and for A-weighting, the minimum value of N_m will generally be 6. If several samples of the same type of sound source are measured one after another in the same test room, smaller values of N_m may be chosen for all but the first sample when appropriate. In these circumstances, the sources shall, however, be identical not only in geometry but also as far as the spectrum of the emitted sound is concerned.

TABLE 5 — **Minimum number of source locations, N_s, for given numbers of microphone positions, N_m, values of s_M and octave band centre frequencies**

s_M	Octave band centre frequency	$N_m =$	3	6	12
dB	Hz				
< 2,3	125 to 8 000 and A-weighting	$N_s =$	1	1	1
2,3 to 4,0	125	$N_s =$	1	1	1
	250, 500 and A-weighting	$N_s =$	2	2	1
	1 000 to 8 000	$N_s =$	2	1	1
> 4,0	125	$N_s =$	3	2	2
	250 and A-weighting	$N_s =$	4	3	2
	500	$N_s =$	4	2	2
	1 000 to 8 000	$N_s =$	3	2	1

NOTE — For each source position the mean-square pressure shall be determined.

7.5 Criteria for the presence of spectral irregularities

The presence of irregularities in the spectrum of the emitted sound can be determined from the values of s_M. Because s_M is only an estimate of the true standard deviation σ, three broad ranges have been selected to define the presence of discrete frequencies or narrow bands of noise.

a) If $s_M > 4$ dB, a discrete tone may be present in the band in question.

b) If 2,3 dB $< s_M <$ 4 dB, narrow band noise components may be present in the frequency band in question.

c) If $s_M <$ 2,3 dB, the spectrum is probably broad-band in character.

The suspected presence of any narrow-band components or discrete frequencies in the spectrum of the emitted sound shall be reported.

7.6 Averaging technique with moving microphone

The use of a moving microphone traversing a path in the test room at constant speed will often be more convenient than the use of a number of fixed microphone positions. The path may be a line, an arc, a circle or some other geometric figure.

7.6.1 *Path length for continuous averaging*

For continuous averaging, the minimum path length l may be determined from the formula

$$l = \frac{\lambda}{2} N_m \text{ if the path is a line or arc.}$$

If the averaging is made over a rectangular or circular area, the minimum area A may be determined from the formula

$$A = \left(\frac{\lambda}{2}\right)^2 N_m$$

In these formulae, λ is the wavelength of the sound corresponding to the centre frequency of the octave band in which the measurement is made. The values of s_M in table 5 may be determined by measuring the mean-square pressure at six points spaced at least $\lambda/2$ apart along the path.

For measurements with A-weighting, assume $\lambda = 3{,}5$ m.

7.6.2 *Location of path within test room*

The path shall contain microphone positions that meet the requirements of 7.3.

If the path or a portion of the path can be included within a plane, this plane shall not lie within 10° of a parallel to any room surface.

7.6.3 *Speed of traverse*

The path shall be traversed by the microphone at a constant speed. The repetition rate of the microphone traverse (or the scanning rate for an array of fixed microphones) shall be related to the integrating time or time-constant of the instrumentation system. From RC-smoothing, the traverse or scanning period shall be less than twice the time-constant. If an integrator is used, a single period of the microphone traverse (or the period of scanning the entire microphone array) shall be equal to the integrating time. The total period of observation is specified in 7.2.

7.7 Array of fixed microphones

If an array of fixed microphones is used for the measurements, all microphones and cables shall comply with the requirements of 5.2.

The number of microphones to be used shall be determined as specified in 7.4 and the microphone positions shall be located as specified in 7.3.

If the array or a portion of the array can be included within a plane, this plane shall not lie within 10° of a parallel to any room surface.

During the sampling of the output of the microphones, the precautions of 7.2 shall be observed.

7.8 Correction for background sound pressure levels

The measured band pressure levels shall be corrected for the influence of background noise according to table 6. When the background sound pressure level is less than 4 dB below the sound pressure level with either the reference sound source or the equipment operating, the accuracy of the measurements will be reduced and no data shall be reported.

TABLE 6 – **Corrections for background sound pressure levels**

Difference between sound pressure level measured with sound source operating and background sound pressure level alone	Correction to be subtracted from sound pressure level measured with sound source operating to obtain sound pressure level due to sound source alone
dB	dB
4	2
5	2
6	1
7	1
8	1
9	0,5
10	0,5
> 10	0

8 CALCULATION OF SOUND POWER LEVELS

8.1 Calculation procedure for the mean band pressure levels

From the measured band pressure levels for each octave band of interest and from the measured A-weighted sound pressure levels, the mean octave band level and the A-weighted sound pressure level shall be calculated from the following expression :

$$L_{pm} = 10 \log_{10} \left[\frac{1}{n} \left(10^{L_{p1}/10} + 10^{L_{p2}/10} + \ldots + 10^{L_{pn}/10} \right) \right]$$

where

L_{pm} is the mean octave band level or a mean A-weighted level, in decibels;

L_{p1} is the octave band level or A-weighted level for the first measurement, in decibels;

L_{pn} is the octave band level or A-weighted level for the nth measurement, in decibels;

n is the total number of measurements for a particular octave band or with the A-weighting network inserted.

8.2 Direct method for determination of sound power levels

The approximate band power levels or A-weighted sound power level of the source shall be calculated from the following expression :

$$L_W = L_{pm} - 10 \log_{10} \frac{T_N}{T_0} + 10 \log_{10} \frac{V}{V_0} - 13$$

where

L_W is the band power level or A-weighted sound power level, in decibels, of the source under test, reference 1 pW;

T_N is the nominal reverberation time of the test room (see 4.3);

$T_0 = 1$ s;

V is the volume of the test room.

$V_0 = 1$ m³.

NOTE – The constant 13 dB instead of 14 dB (which appears in other ISO documents) and the variation of the reverberation time with frequency account approximately for the increase in sound energy density near the surfaces of the special reverberation test room and near the source.

8.3 Comparison method for determination of band power levels

A reference source meeting the requirements of ISO 3741 (annex B) shall be placed on the floor of the room at least 1,5 m from any wall. The minimum distance between the source and any microphones shall fulfill the requirements of 7.3.

The mean sound pressure level of the reference source in each octave band, L_{pr}, shall then be determined using the numbers of microphone and source positions given in table 5 with $s_M < 2,3$, background noise corrections (if necessary) and the calculation procedure of 8.1.

The sound power level produced by the source in each octave band within the frequency range of interest is then calculated as follows. Subtract the band pressure level produced by the reference sound source (corrected for background noise according to 7.8) from the known sound power level produced by the reference sound source. Add the difference to the band pressure level of the source under test (corrected for background noise according to 7.8). That is :

$$L_{we} = L_{pe} + (L_{wr} - L_{pr})$$

where

L_{we} is the band power level, in decibels, of the source under test, reference 1 pW;

L_{pe} is the band mean pressure level, in decibels, of the source under test, reference 20 µPa;

L_{wr} is the band power level, in decibels, of the reference sound source, reference 1 pW;

L_{pr} is the band pressure level, in decibels, of the reference sound source, reference 20 µPa.

9 INFORMATION TO BE RECORDED

The following information, when applicable, shall be compiled and recorded for all measurements made according to the requirements of this International Standard.

9.1 Sound source under test

a) Description of the sound source under test (including dimensions).

b) Operating conditions.

c) Mounting conditions.

d) Location(s) of sound source in test room.

e) If the test object has multiple noise sources, description of source(s) in operation during measurements.

9.2 Acoustic environment

a) Dimensions of test room; description of physical treatment of walls, ceiling, and floor; sketch showing the location of source and room contents.

b) Acoustical qualification of test room (see 4.7).

c) Air temperature in degrees Celsius, relative humidity in per cent and barometric pressure in millibars or pascals.

9.3 Instrumentation

a) Equipment used for the measurements, including name, type, serial number and manufacturer.

b) Bandwidth of frequency analyser.

c) Frequency response of instrumentation system.

d) Method used to calibrate the microphone(s) and the date and place of calibration.

e) Calibration of reference sound source (see 4.7).

9.4 Acoustical data

a) The locations and orientation of the microphone path or array (a sketch shall be included if necessary).

b) The corrections in decibels, if any, applied in each frequency band for the frequency response of the microphone, frequency response of the filter in the pass band, background noise, etc.

c) The sound power levels, in decibels, calculated for all frequency bands used, with reference to 1 pW (= 10^{-12} W), and the A-weighted sound power level, in decibels, with reference to 1 pW.

d) The corrected sound power levels tabulated or plotted to the nearest half decibel.

e) The date and time when the measurements were performed.

f) Remarks on subjective impression of noise (audible discrete tones, impulsive character, spectral content, temporal characteristics, etc.).

10 INFORMATION TO BE REPORTED

The report shall contain the statement that the sound power levels have been obtained in full conformity with the procedures of this International Standard. The report shall state that these sound power levels are in decibels, reference 1 pW.

Only those data (see clause 9) shall be reported which are required for the purposes of the measurements.

ANNEX A

GUIDELINES FOR THE DESIGN OF SPECIAL REVERBERATION TEST ROOMS

A.1 GENERAL

For the measurements specified in this International Standard, the noise source (machine, device, or component) should be operated in a test room which has the required acoustical properties specified in clause 4. These characteristics may be obtained in different ways, some of which are described in this annex.

A.2 SIZE AND SHAPE OF TEST ROOM

The minimum volume of the test room should be 70 m^3. The test room should provide an adequate reverberant sound field for all frequency bands within the frequency range of interest. This requires that the frequencies of the normal modes of the room be well distributed within the frequency range of interest. Some recommended ratios of dimensions for rectangular rooms are given in table 7. Other ratios may be used, but ratios equal to or closely approximating integers of simple fractions should be avoided.

TABLE 7 – **Recommended room dimension ratios for rectangular rooms** (L_x, L_y, L_z)

L_y/L_x	L_z/L_x
0,83	0,47
0,83	0,65
0,79	0,63

If the dimension ratios approximate those of table 7, rooms with volumes larger than 70 m^3 will generally give an improved accuracy for measurements at low frequencies.

A.3 ABSORPTION OF TEST ROOM

In many cases it is necessary to adapt a room with hard surfaces (for example concrete walls) as a test room. The reverberation time of such a room is usually high at low and middle frequencies, but approximates the prescribed value at the upper limit of the frequency range of interest. The reverberation time of the room at low and middle frequencies can be reduced to the recommended values by the installation of sound-absorptive materials on the walls and ceiling.

To correct the middle and high frequencies, perforated panels with mineral wool interiors will often be suitable. Information concerning the absorptive properties of such materials is generally available from manufacturers and test laboratories.

Suitable absorbers of low-frequency sound can be constructed as membrane absorbers; for example, a wooden frame covered with hardboard and filled with mineral wool. For such an absorber, the approximate value of the frequency f, in hertz, at which maximum absorption is obtained is given by the formula

$$f \approx 60\ (d\ M)^{-1/2}$$

where

d is the distance of the hardboard from the wall, in metres;

M is the surface density of the hardboard, in kilograms per square metre.

Example : An absorber consisting of a $0{,}95 \times 0{,}65 \times 0{,}05\ m^3$ wooden frame covered with a 4 mm thick hardboard as shown in figure 2 has a sound absorption charactersitic as shown in figure 3.

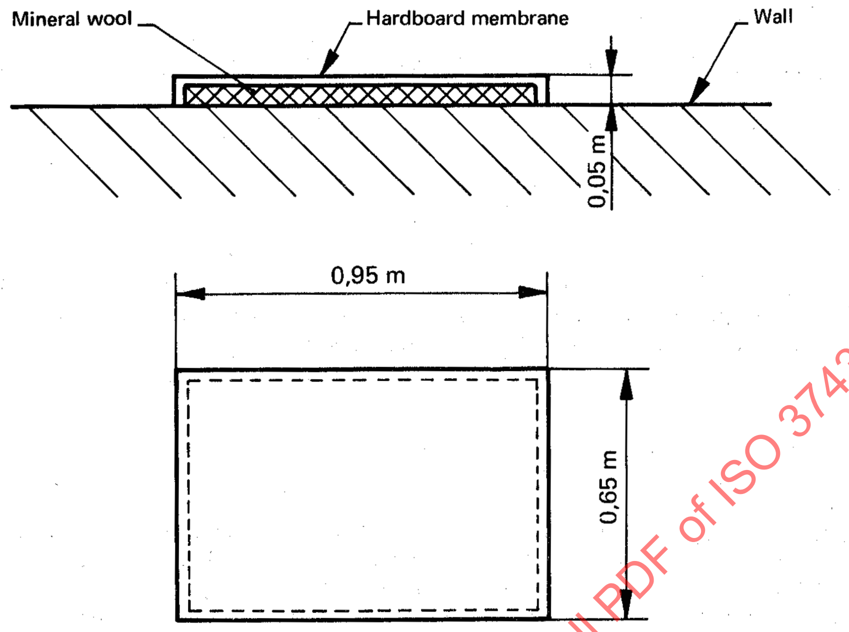

FIGURE 2 – **Hardboard membrane-absorber**

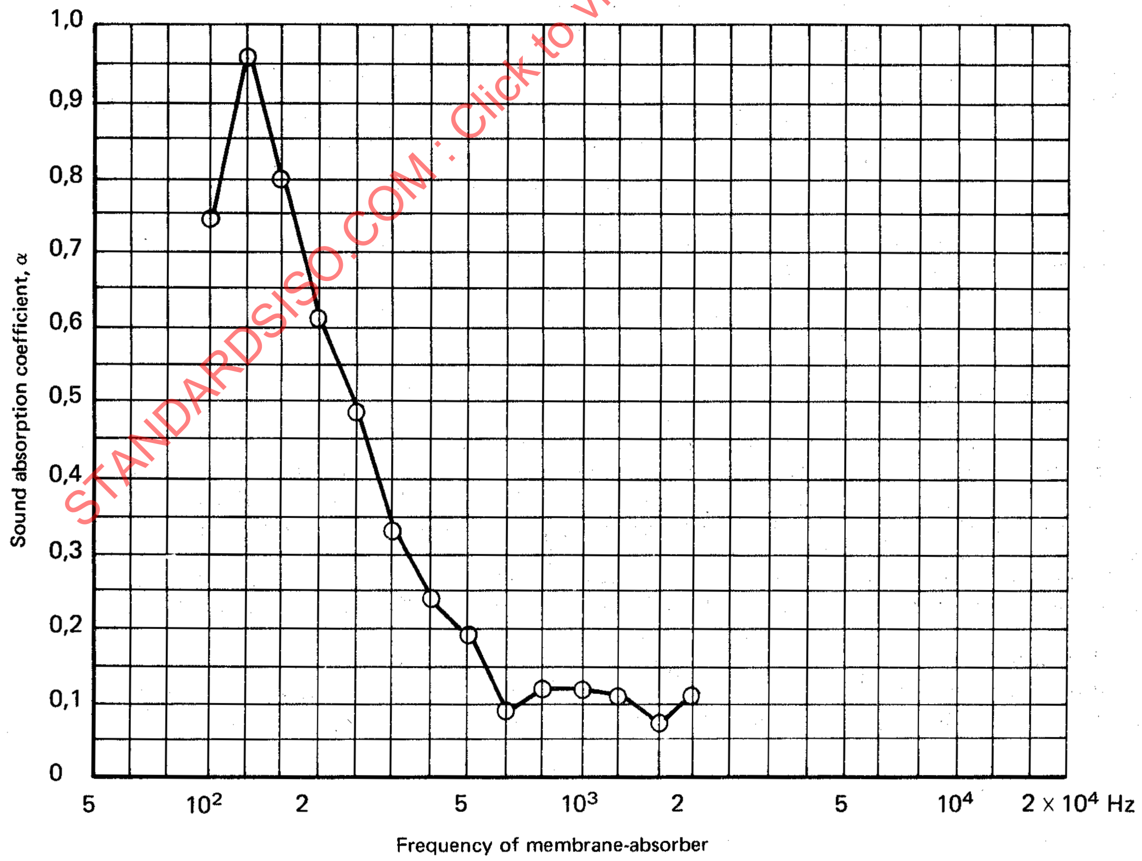

FIGURE 3 – **Sound absorption coefficient α for the membrane-absorber measured in a 200 m^3 reverberation room**