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Acoustics — Determination of sound insulation performances of enclosures —

Part 2:
Measurements *in situ* (for acceptance and verification purposes)

Acoustique — Détermination de l'isolement acoustique des encoffrements —

Partie 2: Mesurages sur site (aux fins d'acceptation et de vérification)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11546-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

ISO 11546 consists of the following parts, under the general title *Acoustics — Determination of sound insulation performances of enclosures*:

— *Part 1: Measurements under laboratory conditions (for declaration purposes)*

— *Part 2: Measurements in situ (for acceptance and verification purposes)*

Annex A forms an integral part of this part of ISO 11546. Annexes B, C, D and E are for information only.

Acoustics — Determination of sound insulation performances of enclosures —

Part 2:
Measurements *in situ* (for acceptance and verification purposes)

1 Scope

This part of ISO 11546 specifies *in situ* methods for the determination of the sound insulation performance (insertion loss) of machine enclosures.

It applies to a total enclosure only and not to the individual panels from which the enclosure is made.

NOTES

1 Sound insulation for enclosure panels such as wall elements, doors, windows, silencers, etc. should be measured in accordance with other relevant standards.

2 Related standards concern noise-attenuation measurements of enclosures under laboratory conditions (ISO 11546-1) and cabins (ISO 11957).

The measurement methods specified in this part of ISO 11546 are based on International Standards in the series ISO 3740, ISO 9614 and ISO 11200 (see table 1). Depending on the method chosen, the sound insulation performance (insertion loss) of the enclosure is determined in terms of the reduction of sound power level or sound pressure level. Methods are given for measurements where the enclosure surrounds the actual sound source (machine). When these methods are not practicable, alternative measurements can be performed with an artificial sound source. Such methods are also described in this part of ISO 11546.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 11546. 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 11546 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 140-6:1978, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 6: Laboratory measurements of impact sound insulation of floors.*

ISO 717-1:—[1], *Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation.*

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

1) To be published. (Revision of ISO 717-1:1982 and ISO 717-3:1982)

ISO 3746:1995, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane.*

ISO 3747:1987, *Acoustics — Determination of sound power levels of noise sources — Survey method using a reference sound source.*

ISO 4871:—[2], *Acoustics — Declaration and verification of noise emission values of machinery and equipment.*

ISO 9614-1:1993, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points.*

ISO 9614-2:—[3], *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning.*

ISO 11201:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Engineering method in an essentially free field over a reflecting plane.*

ISO 11202:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Survey method in situ.*

ISO 11204:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Method requiring environmental corrections.*

IEC 651:1979, *Sound level meters.*

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

IEC 942:1988, *Sound calibrators.*

IEC 1260:—[4], *Electroacoustics — Octave-band and fractional-octave-band filters.*

3 Definitions

For the purposes of this part of ISO 11546, the following definitions apply.

3.1 A-weighting: Frequency weighting as defined in IEC 651.

3.2 enclosure: A structure enveloping a noise source (machine), designed to protect the environment from this noise source (machine).

NOTE 3 An enclosure can be, for example, a freestanding structure terminated on the floor or a structure more or less fixed to the machine. (Concerning enclosures fixed to the machine, see clause 4.)

3.3 sound pressure level, L_p: Ten times the logarithm to the base 10 of the ratio of the square of the sound pressure of a sound to the square of the reference sound pressure. Sound pressure levels are expressed in decibels. The reference sound pressure is 20 μPa (2×10^{-5} Pa).

3.4 average sound pressure level, $\bar{L}_p$: Mean-square of the sound pressure levels:

$$\bar{L}_p = 10 \lg \left(\frac{10^{0,1L_{p1}} + 10^{0,1L_{p2}} + \ldots + 10^{0,1L_{pn}}}{n} \right) \text{ dB}$$

where L_{p1}, L_{p2}, ..., L_{pn} are the sound pressure levels, in decibels, to be averaged.

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

3.6 average sound power level, $\bar{L}_W$: Mean-square of the sound power levels:

$$\bar{L}_W = 10 \lg \left(\frac{10^{0,1L_{W1}} + 10^{0,1L_{W2}} + \ldots + 10^{0,1L_{Wn}}}{n} \right) \text{ dB}$$

where L_{W1}, L_{W2}, ..., L_{Wn} are the sound power levels, in decibels, to be averaged.

3.7 sound power insulation, D_W: Reduction in sound power level obtained due to the enclosure (octave bands or one-third-octave bands). It is expressed in decibels.

3.8 A-weighted sound power insulation, D_{WA}: Reduction in the A-weighted sound power level obtained due to the enclosure for the actual sound source spectrum. It is expressed in decibels.

3.9 sound pressure insulation, D_p: Reduction in the sound pressure level at a specified position due to the

2) To be published. (Revision of ISO 4871:1984)

3) To be published.

4) To be published. (Revision of IEC 225:1966)

enclosure (octave bands or one-third-octave bands). It is expressed in decibels.

3.10 A-weighted sound pressure insulation, D_{pA}: Reduction in A-weighted sound pressure level at a specified position due to the enclosure for the actual sound source spectrum. It is expressed in decibels.

3.11 estimated noise insulation due to the enclosure, $D_{WA,e}$ or $D_{pA,e}$: Calculated reduction in A-weighted sound power or sound pressure level obtained from D_W or D_p, measured in accordance with this part of ISO 11546, and a specific noise spectrum. (See annex C.) It is expressed in decibels.

3.12 weighted sound power insulation, $D_{W,w}$: Single-number value determined in accordance with the method stated in ISO 717-1 except that the sound reduction index is replaced by the sound power insulation, D_W. It is expressed in decibels.

3.13 fill ratio, ϕ: Ratio of the volume of the source in an enclosure to the interior volume of that enclosure.

In cases where the shape of the source complicates calculation of the source volume, the volume of a reference box determined in accordance with ISO 3744 or ISO 3746 can be used.

3.14 leak ratio, θ: Ratio between the area of all openings of the enclosure and the total interior surface area of the enclosure (including openings).

NOTES

4 Openings provided with sufficiently efficient sound-attenuating silencers are not regarded as openings with respect to the leak ratio.

5 The reciprocal value of the leak ratio is designated the seal ratio, Ψ ($\Psi = 1/\theta$).

4 Choice of measurement method

Accurate values of the sound insulation performance of an enclosure can only be obtained when the measurements take place with the actual sound source for which the enclosure is designed. Thus, whenever practicable, methods using the real source shall be used. If the enclosure is fixed or otherwise connected to the sound source, the sound insulation performance can only be determined with the actual sound source.

NOTE 6 The result of an *in situ* measurement depends on the enclosure construction and the workmanship when installed.

In some specific cases, an artificial sound source can be used instead of the sound source, for which the enclosure is intended. This method may, for example, be used in cases where the actual sound source (machine) cannot work without auxiliary equipment with a high noise level. Furthermore, an artificial sound source may be used in cases where it is impossible to achieve identical operating conditions for the machine during measurements with and without an enclosure, respectively.

The leak ratio of an enclosure measured in accordance with this part of ISO 11546 with an artificial sound source should be small (θ preferably less than 2 %) and the interior surfaces of the enclosure should be sound absorbing.

NOTE 7 The more the enclosure deviates from these ideal conditions regarding leak ratio and absorption, the more there is a need to take measurements using the actual sound source.

In cases where a single-number value is wanted based on measurements carried out with the artificial sound source method, the weighted sound power insulation, $D_{W,w}$, is the preferred quantity (see definition 3.12). The weighted sound power insulation is a practicable single-number value to be used for a rough comparison of different enclosures. However, this quantity must not be taken as a general measure of the sound insulation performance of the enclosure, as the performance in actual situations strongly depends on the spectrum of the actual noise.

This part of ISO 11546 is intended for use together with a relevant International Standard for the determination of sound power level or measurement of sound pressure level. The applicability of the different methods described is summarized in table 1 and in annex C.

The requirement concerning the maximum volume of the enclosure, as given by the relevant International Standard selected from table 1, shall be fulfilled.

If the actual noise spectrum is known or can be assumed, the reduction in A-weighted noise level due to the enclosure can be estimated according to the method given in annex D.

NOTE 8 Measurement data obtained using the actual sound source are not necessarily comparable with data obtained using an artificial sound source. In cases where the actual sound source is connected to the enclosure, structure-borne sound may influence the measurement result.

Table 1 — Applicability of the different test methods

Test method	Test environment	International Standard	Symbol[1)]	Sub-clause
Actual sound source	Hard-walled test room	ISO 3743-1	D_W, D_{WA}	6.1 6.2
	Outdoors or in large room	ISO 3744	D_W, D_{WA}	
	No special test environment	ISO 3746	D_{WA}	
	No special test environment	ISO 3747	D_W, D_{WA}	
	No special test environment	ISO 9614-1 ISO 9614-2	D_W, D_{WA}	
	Free-field over a reflecting plane; indoor or outdoor	ISO 11201	D_p, D_{pA}	6.1 6.3
	No special test environment	ISO 11202	D_{pA}	
	Outdoors or in large room	ISO 11204	D_p, D_{pA}	
Artificial sound source	Hard-walled test room	ISO 3743-1	D_W, $D_{W,w}$	7.1 7.2 7.3
	Outdoors or in large room	ISO 3744	D_W, $D_{W,w}$	
	No special test environment	ISO 3747	D_W, $D_{W,w}$	
	No special test environment	ISO 9614-1 ISO 9614-2	D_W, $D_{W,w}$	
	Free field over reflecting plane; indoor or outdoor	ISO 11201	D_p	
	Outdoors or in large room	ISO 11204	D_p	

1) Notation according to clause 3.

5 Instrumentation

The instrumentation system, including the microphones and cables, shall meet the requirements for a type 1 instrument as specified in IEC 651 or, in the case of integrating-averaging sound level meters, the requirements for a type 1 instrument as specified in IEC 804.

NOTE 9 Generally, an integrating-averaging sound level meter is preferred.

For measurements in octave or one-third-octave bands, the instrumentation system shall meet the requirements for a type 1 filter as specified in IEC 1260.

Before and after each series of measurements, the calibration of the entire measuring system shall be verified using an acoustical calibrator with an accuracy of ± 0,3 dB (type 1 in accordance with IEC 942).

NOTES

10 An equivalent verification method which has been proved to be capable of checking the stability of the measurement system may be used.

11 For measurements carried out in accordance with ISO 3746, ISO 11202 and ISO 11204 (survey), type 2 instruments are acceptable.

6 Test methods applicable to enclosures with the actual sound source

6.1 General

6.1.1 When applying the actual sound source method, the maximum permissible volume of the enclosure is given by the relevant International Standard, selected from table 1.

6.1.2 The operating conditions of the actual sound source shall be representative of normal use and shall not change between the measurements made with and without the enclosure. If a special test code exists for the actual sound source, the operating conditions specified in such a test code shall be used.

6.1.3 If the enclosure includes active elements (e.g. fans), these elements shall be in operation during the measurements. If the active elements are not intended for continuous operation, measurement shall be carried out both with the active elements switched on and switched off.

6.1.4 If practicable, choose the microphone positions to give the same environmental corrections both with and without the enclosure. When measuring with the enclosure, the test object is defined to be the machine with the enclosure. The microphone positions used for measurements on the enclosed source shall, if practicable, be the same as those used for the unenclosed source.

NOTE 12 When measurements are carried out on enclosures with high sound insulation, care should be taken to ensure that structure-borne sound/vibration in the floor of the test room does not influence the measurement result.

6.2 Determination of sound power insulation

One of the International Standards ISO 3743-1, ISO 3744, ISO 3746, ISO 3747, ISO 9614-1 or ISO 9614-2 shall be chosen depending on the test environment.

Determine the time-averaged sound power level during a typical operational cycle of the machine.

Make the measurements with and without the enclosure. The sound power insulation in octave or one-third-octave bands (D_W) and A-weighted (D_{WA}) are given by:

$$D_W = L_W(\text{without enclosure}) - L_W(\text{with enclosure}) \quad \ldots (1)$$

$$D_{WA} = L_{WA}(\text{without enclosure}) - L_{WA}(\text{with enclosure}) \quad \ldots (2)$$

where

L_W is the sound power level, in decibels, in octave or one-third-octave bands measured in accordance with the relevant International Standard;

L_{WA} is the A-weighted sound power level, in decibels, measured or calculated in accordance with the relevant International Standard.

The frequency range shall at least cover the range 100 Hz to 5 000 Hz for one-third-octave bands and 125 Hz to 4 000 Hz for octave bands.

NOTE 13 Frequency ranges of 50 Hz to 10 000 Hz for one-third-octave bands and 63 Hz to 8 000 Hz for octave bands are preferred.

The A-weighted levels are calculated from the band pressure levels when ISO 3743-1, ISO 3747, ISO 9614-1 and ISO 9614-2 are used. According to ISO 3744, the A-weighted levels can be calculated or measured directly. According to ISO 3746, only the A-weighted sound power level can be determined.

NOTE 14 In order to ensure consistency between frequency band data and the A-weighted value, use of the calculated A-weighted value is preferred.

Provided that the test environments and microphone positions are identical for measurements with and without the enclosure, the sound power level difference is equal to the sound pressure level difference averaged according to the chosen International Standard. This means that under identical test conditions (i.e. identical environmental corrections) it is not necessary to convert the measured sound pressure levels into sound power levels before calculating the level difference. If the measurements with and without the enclosure cannot be carried out within a very short period of time under fully controlled and identical test conditions, the sound power levels shall be determined.

NOTE 15 In cases where the sound is radiated from a limited part of the enclosure (e.g. from an opening) and measurements are impeded by a high background noise level, it is possible to determine the radiated sound power from the enclosure on a limited area in front of the radiating part. It is necessary to ensure that sound radiation from the area of the enclosure not covered by the limited measurement surface is negligible.

6.3 Determination of sound pressure insulation at a specified position

Make the measurements as specified in ISO 11201, ISO 11202 or ISO 11204. The sound pressure insu-

lation in one-third-octave or octave bands (D_p) and A-weighted (D_{pA}) are given by:

$$D_p = L_p(\text{without enclosure}) - L_p(\text{with enclosure}) \quad \ldots (3)$$

$$D_{pA} = L_{pA}(\text{without enclosure}) - L_{pA}(\text{with enclosure}) \quad \ldots (4)$$

where

L_p is the sound pressure level, in decibels, in one-third-octave or octave bands at a specified position measured in accordance with the relevant International Standard;

L_{pA} is the A-weighted sound pressure level, in decibels, at a specified position measured or calculated in accordance with the relevant International Standard.

Use the frequency range as given in 6.2. According to ISO 11201 and ISO 11204, A-weighted values can be measured directly or calculated from frequency band data. According to ISO 11202, only the A-weighted sound pressure level can be measured.

NOTES

16 For *in situ* measurements, it will often be impossible to fulfil the requirements given in ISO 11201 concerning test environments. If the requirements are not fulfilled, the measurement results can be influenced by reflected sound. In such cases, ISO 11202 or ISO 11204 should be applied.

17 In order to ensure consistency between frequency band data and the A-weighted value, use of the calculated A-weighted value is preferred.

7 Test methods applicable to enclosures without the actual sound source

7.1 General

Measurements carried out by use of an artificial sound source are possible in specific cases where the actual sound source cannot be used (see clause 4). When an artificial sound source is used, only one-third-octave or octave band insulation can be determined directly. The A-weighted sound insulation can be estimated according to the method stated in annex D, provided that the frequency spectrum of the actual noise source is known.

The volume of the enclosure shall not exceed the maximum allowable volume stated in the relevant International Standard.

If the enclosure includes active elements (e.g. fans), an artificial sound source shall not be used.

NOTE 18 Enclosures with a small leak ratio ($\theta < 2$ %) and with sound-absorbing interior surfaces are particularly suitable for measurements with the artificial sound source method.

7.2 Artificial sound source method

For measurements with precision and engineering grades of accuracy, the artificial sound source shall be constructed as shown in annex A. The fill ratio (3.13) shall not exceed 25 %. The sound power output shall be sufficient to give a sound pressure level outside the enclosure so that requirements regarding background noise in that International Standard used are fulfilled. Background noise corrections shall be made as indicated in that International Standard.

For measurements with the survey grade of accuracy, other types of artificial sound sources may be applied, for example loudspeakers or reference sound sources (e.g. fan type). It must, however, be realised that the environment may influence the sound power output of sound sources with low radiation impedance and thus cause incorrect measurement results in connection with insertion-loss measurements. Low-impedance sound sources used for measurements on small enclosures should be avoided.

Note that differences can occur between results obtained from measurements carried out with different types of artificial sound sources.

NOTES

19 An artificial sound source should be as omnidirectional as possible. In the case of a loudspeaker, a polyhedron-type (preferably a dodecahedron) gives an adequate approximation of uniform omnidirectional radiation.

20 The artificial sound source shown in annex A has an essentially downwards sound radiation which implies that the surface supporting the sound source will be excited strongly. This should be kept in mind especially in cases where a lightweight wooden floor is an integrated part of the enclosure. The near-field influence from the sound source may lead to an increased sound radiation from the other surfaces of the enclosure due to contribution of structure-borne sound from the floor.

For measurements on enclosures without an integrated floor, there might be a risk of flanking transmission in the floor of the test room. Attention should especially be drawn to this if the floor of the test room is a lightweight wooden or concrete type.

The degree of near-field influence can be estimated by comparing results from measurements with the sound source placed on the floor and raised from the floor, re-

spectively. (See annex A.) If a significant difference between these test results is observed, the near-field influence is essential, and the placement of the sound source must be considered very carefully regarding the position of the actual sound source.

Make measurements with an artificial sound source in one-third-octave or octave bands and as specified in 6.1, 6.2 and 6.3.

In the case of a cubic or quasicubic enclosure, the artificial sound source shall be placed on the floor near the centre of the enclosure or at the position planned for the actual sound source.

In the case of an enclosure with a rectangular base, the artificial sound source shall be placed on the floor in at least two positions corresponding to positions planned for the actual sound source.

In any case, the source shall not be closer than $0{,}2d$ to any wall of the enclosure, where d is the shortest inner dimension of the enclosure.

Use two orientations of the source with an angle between them of 90° if the dimensions of the enclosure allow this.

NOTE 21 The positions and orientations of the artificial sound source should be agreed between the parties involved in cases where the placement is not obvious.

Express the final result as the arithmetic mean value of the results for the different source positions.

The frequency range shall at least cover the range 100 Hz to 5 000 Hz for one-third-octave bands and 125 Hz to 4 000 Hz for octave bands.

NOTE 22 Frequency ranges of 50 Hz to 10 000 Hz for one-third-octave bands and 63 Hz to 8 000 Hz for octave bands are preferred.

Calculate the sound power insulation, D_W, from equation (1) (see 6.2).

Calculate the sound pressure insulation, D_p, from equation (3) (see 6.3).

7.3 Weighted sound power insulation

The weighted sound power insulation, $D_{W,w}$ is calculated in the same way as the weighted sound reduction index in accordance with ISO 717-1 except that the sound reduction index R shall be replaced by D_W.

7.4 Estimated noise insulation due to the enclosure for a specific noise spectrum

If the actual noise spectrum is known or can be assumed, the reduction in A-weighted sound power or sound pressure level due to the enclosure can be estimated according to the method given in annex D.

8 Uncertainty

When the actual sound source or the artificial sound source method is used, it is expected that measurements in confirmity with this part of ISO 11546 will yield standard deviations which are equal to or less than those given in the International Standard used.

If a declared value is given, it shall be verified in accordance with ISO 4871.

9 Information to be recorded

The information listed in 9.1 to 9.5, when applicable, shall be compiled and recorded for all measurements made in accordance with this part of ISO 11546.

9.1 Test object

a) Identification of the enclosure (name/trademark).

b) Detailed description (preferably including drawings) of the enclosure (panels, windows, doors, joints between panels, connection between enclosure and sound source, etc.).

c) Total weight of the enclosure.

d) Interior and exterior volumes, area and dimensions.

e) Fill ratio.

f) Leak ratio and description of openings.

g) Description of the interior surfaces.

h) Description of the floor mountings of the enclosure.

i) Method of sampling of test object and other circumstances (date of sampling and name of person responsible).

9.2 Test conditions

a) Environmental data during the test (air barometric pressure, relative humidity, etc.).

b) Description of the room used for the test (volume, dimensions, approximate reverberation time, scattering or shielding objects).

c) Description of the positions of test specimen, sound source and microphones, preferably shown on a sketch of the room.

d) Description of the floor construction.

9.3 Instrumentation

Identification of the test equipment and instruments used.

9.4 Acoustical data

a) Test method.

b) Any deviation from the test method.

c) For measurements carried out with the actual sound source, the following information shall be given:

1) sound power insulation, D_W;

2) A-weighted sound power insulation, D_{WA};

and, if relevant,

3) sound pressure insulation, D_p;

4) A-weighted sound pressure insulation, D_{pA}.

d) For measurements carried out using an artificial sound source:

1) sound power insulation, D_W;

and, if relevant,

2) sound pressure insulation, D_p.

e) Measurement uncertainty.

All measurement results shall be stated in decibels rounded to the nearest integer.

The sound insulation performance given in one-third-octave and octave bands shall be given in the form of a table and, preferably, a graph. For graphs with the sound insulation performance in decibels plotted against the frequency in hertz on a logarithmic scale, the length of the 10:1 frequency ratio shall be equal to the length of 25 dB on the ordinate scale.

For results obtained in accordance with this part of ISO 11546, it is preferred that one octave corresponds to 15 mm and 10 dB to 20 mm.

9.5 Further information

a) Name and address of the testing laboratory.

b) Identification number of the test report.

c) Name and address of manufacturer or supplier of the tested object.

d) Date of the test.

e) Signature of person carrying out the test.

10 Information to be reported

The information given in table 2 shall be contained in the report.

Table 2 — Data to be reported

Measurement with the actual sound source	Measurement with an artificial source[1)]
D_W , D_{WA} and, if relevant, D_p , D_{pA}	D_W and, if relevant, D_p
NOTE — According to ISO 3746 and ISO 11202, only A-weighted values can be stated.	
1) In addition the single-number values, $D_{W,w}$, $D_{WA,e}$ and $D_{pA,e}$ can be given. In these cases, frequency band data shall also be given.	

Whenever test results are reported, it shall be stated whether the actual or an artificial sound source has been used. If an artificial sound source has been used, the type of source shall be reported. Also the basic International Standard used shall be stated.

If the measurement environment is not qualified for the whole frequency range, the results may still be reported provided that frequencies outside the range of qualification are clearly indicated.

The name and address of the testing laboratory and date of the test shall be reported.

Apart from the above-mentioned information, only data (see clause 9) required for the purposes of the measurements are to be reported.

Annex A
(normative)

Artificial sound source

A schematic drawing of the artificial sound source is shown in figure A.1.

The artificial sound source shall be a stable mechanical broad-band noise source in accordance with the following requirements.

The sound source shall consist of a standard tapping machine tapping on an undamped steel plate.

The tapping machine shall fulfil the requirements of ISO 140-6.

The dimensions of the steel plate shall be 4 mm × 800 mm (approx.) × 300 mm (approx.).

The distance between the tapping machine and the steel plate shall correspond to the standardized drop length of the hammers (40 mm).

The distance between the steel plate and the supporting surface shall be 60 mm. Details in the set-up may vary depending on the make of tapping machine. However, it is important to avoid damping of the steel plate. Damping may change the spectrum and reduce the emitted sound.

The vibration-isolating support elements shall be chosen to give a high damping of structure-borne sound transmitted from the sound source to the supporting surface.

The artificial sound source shall be placed as close as possible to the position of the actual sound source. If the position is above floor level, the supporting surface of the artificial sound source shall be non-absorbing.

An example of a source spectrum for an artificial sound source constructed according to the guidelines given in this annex is shown in annex B, figure B.1. (The length of the steel plate used for this measurement was 600 mm.) For an actual artificial sound source constructed according to the guidelines stated in this annex, the spectrum may differ from the one shown in annex B. If the sound power level is essentially lower than that shown in annex B, the damping of the steel plate should be checked to see whether it is too high because of non-optimized bushings.

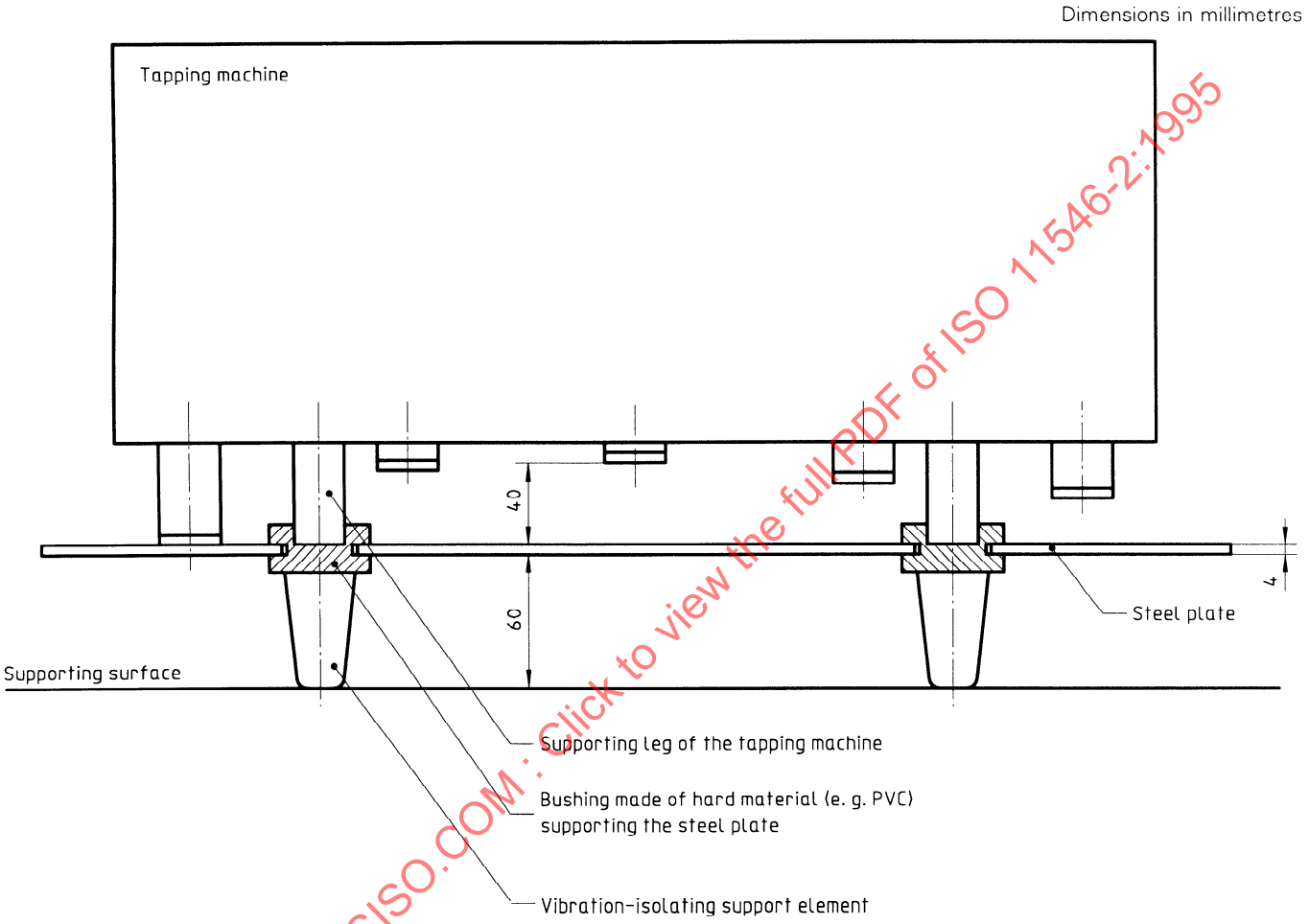
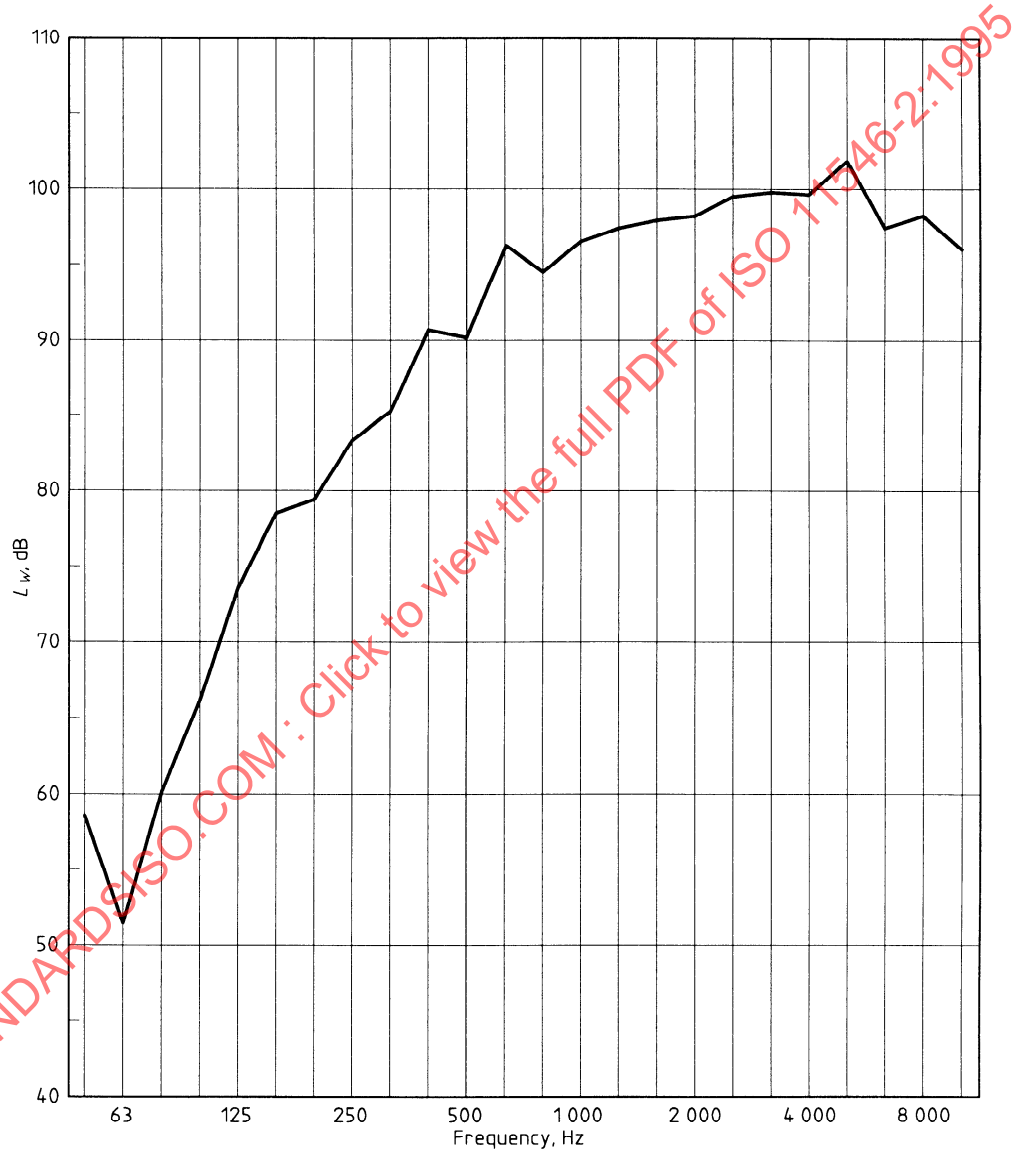


Figure A.1 — Artificial sound source (schematic)

Annex B
(informative)

Example of a source spectrum



NOTE — A-weighted sound power level L_{WA} = 110 dB

Figure B.1 — Source spectrum for an artificial sound source constructed according to the guidelines given in annex A (determined in accordance with ISO 3741)

Annex C
(informative)

Guidelines for evaluating the applicability of different test environments for *in situ* measurements

This part of ISO 11546 is related to the following International Standards: ISO 3743-1, ISO 3744, ISO 3746, ISO 3747, ISO 9614-1, ISO 9614-2, ISO 11201, ISO 11202 and ISO 11204. In these standards, detailed requirements concerning testing conditions and evironments are stated.

In this annex, guidelines are given to facilitate selection of the most relevant method for an actual measurement situation.

In ISO 3744, ISO 3746, ISO 11201, ISO 11202 and ISO 11204, the test environment is described in terms of the environmental correction K_2. The value of K_2 in a room is determined by the total area of the boundary surfaces of the room (S_v), the mean absorption coefficient of the room (α) and the area of the measurement surface enveloping the noise source (S). In table C.1 requirements for K_2 are stated. Furthermore, the minimum allowable difference between the background noise and the sound pressure level of the test object (ΔL) can be seen.

From figure C.1, corresponding values of α and the ratio S_v/S can be determined.

To obtain an estimate of the applicability of ISO 3744, ISO 3746, ISO 11201, ISO 11202 and ISO 11204 to an actual *in situ* measurement situation in a room, the following procedure can be used.

a) From table C.2, determine the approximate mean sound absorption coefficient, α.

b) From figure C.1, determine the value of S_v/S corresponding to α.

c) Calculate S_v/S for the actual situation (S_v/S_{actual})

d) If $S_v/S_{actual} \geqslant S_v/S$ determined from figure C.1, the test environment is estimated to be applicable.

The method stated above can be used only to obtain a rapid estimate of the applicability of the International Standards to an actual measurement situation. Detailed procedures for evaluation of the test environment are included in the individual standards.

Table C.1 — Requirements concerning environmental correction K_2 and background noise

Values in decibels

	ISO 3743-1[1]	ISO 3744	ISO 3746	ISO 3747[1]	ISO 9614-1 ISO 9614-2[2]	ISO 11201[3]	ISO 11202[3]	ISO 10204[3][4]
K_2	—	$\leqslant 2$	$\leqslant 7$	—	—	$\leqslant 2$	$\leqslant 7$	$\leqslant 7$
ΔL	$\geqslant 6$	$\geqslant 6$	$\geqslant 3$	$\geqslant 3$	—	$\geqslant 6$	$\geqslant 3$	$\geqslant 6$

1) ISO 3743-1 and ISO 3747 specify methods according to which a reference sound source is employed. Requirements in terms of K_2 are not used. In ISO 3743-1, it is stated that the mean sound absorption coefficient shall be less than 0,2 (see table C.2). ISO 3747 specifies no restrictions for the test environments.

2) ISO 9614-1 and ISO 9614-2 specify methods based on the sound-intensity technique. The intensity method can be used under less-restricted conditions than those required in the ISO 3740 series. The method seems to be suitable for *in situ* measurements in non-ideal test environments.

3) K_2 refers to an enveloping measurement surface on which the microphone is situated.

4) If $K_2 \leqslant 2$, the method specified in ISO 11204 is classified as an engineering method.

Table C.2 — Approximate values of the mean sound absorption coefficient, α, for different room configurations

Mean sound absorption coefficient, α	Description of room
0,05	Nearly empty room with smooth hard walls made of concrete, brick, plaster or tile
0,1	Partly empty room; room with smooth walls
0,15	Room with furniture; rectangular machinery room; rectangular industrial room
0,2	Irregularly shaped room with furniture; irregularly shaped machinery room or industrial room
0,25	Room with upholstered furniture; machinery or industrial room with a small amount of sound-absorbing material on ceiling or walls (e.g. partially absorptive ceiling)
0,35	Room with sound-absorbing materials on both ceiling and walls
0,5	Room with large amounts of sound-absorbing materials on ceiling and walls

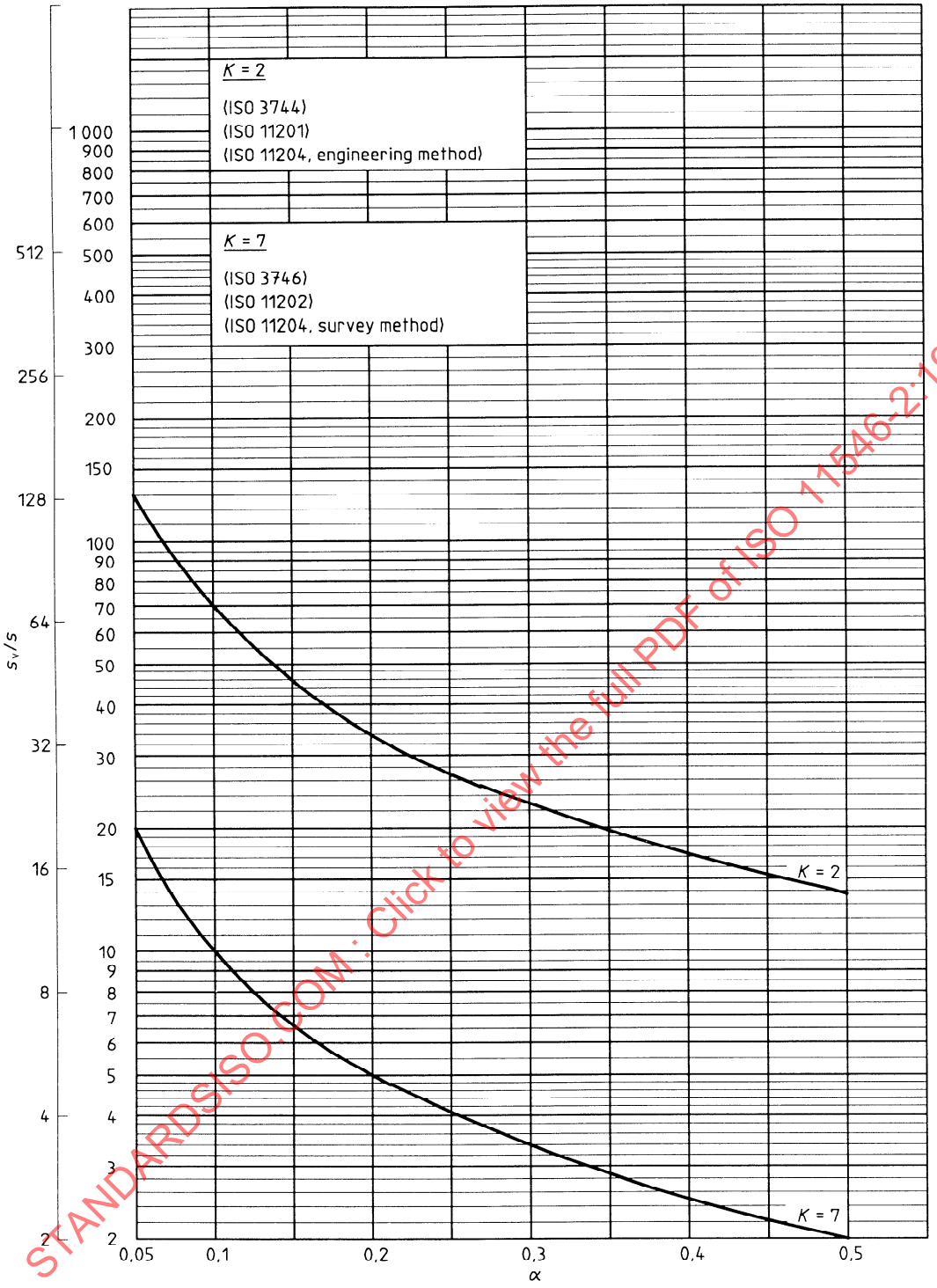


Figure C.1 — Corresponding values of α and S_v/S

Annex D
(informative)

Estimated noise insulation due to the enclosure for a specific noise spectrum

An estimate of the reduction in the A-weighted sound power level due to the enclosure, $D_{WA,e}$, can be calculated using a known or assumed spectrum of an actual noise source:

$$D_{WA,e} = L_A - 10 \lg \sum_{i=1}^{n} 10^{0,1(L_i - A_i - D_{w,i})} \text{ dB} \quad \ldots (D.1)$$

where

L_A is the A-weighted sound power level of the spectrum [$L_A = 10 \lg \Sigma 10^{0,1(L_i - A_i)}$ dB];

L_i is the sound power level for frequency band i of the spectrum;

n is the number of frequency bands used;

$D_{W,i}$ is the sound power insulation D_W for frequency band i;

A_i is the A-weighting attenuation for frequency band i.

Similar estimates of the noise insulation due to the enclosure, based on D_p, can be carried out according to the method given in this annex. (See 3.11.)

Any possible contribution to the noise level outside the enclosure from flanking transmission in the floor is not included in this calculation.