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Acoustics — Measurement of sound insulation in buildings and of building elements — Part VI : Laboratory measurements of impact sound insulation of floors

Acoustique — Mesurage de l'isolation acoustique des immeubles et des éléments de construction — Partie VI : Mesurage en laboratoire de l'isolation des sols aux bruits de chocs

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ISO 140/VI-1978 (E)

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 140/VI was developed by Technical Committee ISO/TC 43, *Acoustics*, and was circulated to the member bodies in May 1976.

It has been approved by the member bodies of the following countries :

Australia	India	Romania
Austria	Israel	South Africa, Rep. of
Belgium	Italy	Spain
Canada	Japan	Sweden
Czechoslovakia	Korea, Rep. of	Switzerland
Denmark	Mexico	Turkey
Finland	Netherlands	United Kingdom
France	New Zealand	U.S.A.
Germany	Norway	U.S.S.R.
Hungary	Poland	

No member body expressed disapproval of the document.

This International Standard, together with International Standards ISO 140/I, III, IV, VI and VII, cancel and replace ISO Recommendation R 140-1960, of which they constitute a technical revision.

Annex B is an integral part of this International Standard.

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Acoustics — Measurement of sound insulation in buildings and of building elements — Part VI : Laboratory measurements of impact sound insulation of floors

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a laboratory method of measuring impact noise transmission through floors by using a standard tapping machine.

The results obtained can be used to compare the sound insulation properties of floors and to classify floors according to their sound insulation properties.

NOTES

1 Laboratory measurements of the reduction of transmitted standard impact machine noise by floor coverings on a standard floor are dealt with in ISO 140/VIII.

2 Field measurements of impact sound insulation of floors are dealt with in ISO 140/VII.

2 REFERENCES

ISO 140/I, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part I : Requirements for laboratories.*

ISO 140/II, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part II : Statement of precision requirements.*

ISO 140/VII, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part VII : Field measurements of impact sound insulation of floors.*

ISO 140/VIII, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part VIII : Laboratory measurement of the reduction of transmitted impact noise by floor coverings on a standard floor.*

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

ISO/R 717, *Rating of sound insulation for dwellings.*

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

3.1 average sound pressure level in a room : Ten times the common logarithm of the ratio of the space and time average of the sound pressure squared to the square of the reference sound pressure, the space average being taken over the entire room with the exception of those parts where the direct radiation of a sound source or the near field of the boundaries (wall, etc.) is of significant influence. This quantity is denoted by L :

$$L = 10 \lg \frac{p_1^2 + p_2^2 + \ldots + p_n^2}{n p_0^2} \text{ dB} \qquad \ldots (1)$$

where

$p_1, p_2, \ldots, p_n$ are the r.m.s. sound pressures at n different positions in the room;

$p_0 = 20\ \mu\text{Pa}$ is the reference sound pressure.

3.2 impact sound pressure level : The average sound pressure level in a specific frequency band in the receiving room when the floor under test is excited by the standardized impact sound source. This quantity is denoted by L_i.

3.3 normalized impact sound pressure level : The impact sound pressure level L_i increased by a correction term which is given in decibels, being ten times the common logarithm of the ratio between the measured equivalent absorption area A of the receiving room and the reference equivalent absorption area A_0. This quantity is denoted by L_n :

$$L_n = L_i + 10 \lg \frac{A}{A_0} \text{ dB} \qquad \ldots (2)$$

where $A_0 = 10\ \text{m}^2$.

In all cases where it is uncertain whether results are obtained without flanking transmission, the normalized impact sound pressure level should be denoted by L'_n.

3.4 reduction of impact sound pressure level (improvement of impact sound insulation) : The difference between the average sound pressure levels in the receiving room before and after installation of, for example, a floor covering; see ISO 140/VIII. This quantity is denoted by ΔL.

4 EQUIPMENT

The tapping machine being constructed in accordance with the following specifications serves as a standardized impact sound source. The further equipment shall be suitable for meeting the requirements of clause 6.

The tapping machine should have five hammers placed in a line, the distance between the two end hammers being about 400 mm.

The time between successive impacts should be 100 ± 5 ms. The effective mass of each hammer should be 0,5 kg (within ± 2,5 %).

The drop of a hammer on a flat floor should be equivalent, with respect to the momentum, to a free drop without friction of 40 mm (within ± 2,5 %).

The part of the hammer which strikes the floor should be a cylinder of brass or steel, 3 cm in diameter, with a spherical end having a radius of about 50 cm.

Alternatively, especially in the case of a fragile floor covering, hammers may be used having the part that strikes the floor coated with a layer of rubber, of which the dimensions, composition and vulcanization are specified as follows.

The hammers with rubber coating should geometrically resemble the hammers of brass or steel only. The part of each hammer below a plane perpendicular to the axis of the cylinder, at 5 mm distance from the lowest point of the curved end of the hammer, should be of rubber of the composition and vulcanization ("cure") shown in table 1.

TABLE 1 — **Specification for rubber for hammer**

Composition	Parts by mass
Natural rubber	100
Zinc oxide	15
Stearic acid	2
Carbon black EPC	40
Phenylbetanaphthylamine	1
2,2-Benzothiazyl disulphide (Altax)	1,2
Diphenylguanidine	0,4
Sulphur	3
Cure : 45 min at 142 °C (2,9 bar)	

The rubber layer thus has a plane and a curved surface, and a maximum thickness of 5 mm. It should be stuck or vulcanized on the metal.

The distance between the supports of the tapping machine and the hammer line should be at least 100 mm.

5 TEST ARRANGEMENT

5.1 Receiving room

Laboratory test facilities should meet the requirements of ISO 140/I.

5.2 Test specimen

The size of the test specimen is determined by the size of the test opening of the laboratory test facility as it is defined in ISO 140/I, i.e. between 10 m^2 and 20 m^2 with the shorter edge length not less than 2,3 m. The size of floor test specimen and elements comprising that specimen should be made as close as possible to the sizes of field installation.

NOTE — The test specimen should preferably be installed in a manner as similar as possible to the actual construction with a careful simulation of normal connections and sealing conditions at the perimeter and at joints within the specimen. The mounting conditions should be stated in the test report.

In laboratories with suppressed radiation from flanking elements, the sound transmitted by any indirect path should be negligible compared with the sound transmitted through the test specimen.

6 TEST PROCEDURE AND EVALUATION

6.1 Generation of sound field

The impact sound shall be generated by the tapping machine (see clause 4). Concerning the position of the tapping machine, see 6.5.

6.2 Measurement of impact sound pressure level

The impact sound pressure level in the receiving room should be an average over space and time. This average may be obtained by using a number of fixed microphone positions or a continuously moving microphone with an integration of p^2.

The indicating device should be designed to determine r.m.s. values of the sound pressure or corresponding pressure levels. If a sound level meter is used, it should conform to IEC Publication 179 for precision sound level meters. It is recommended to use the meter response "slow". The complete measuring system including the microphone shall be adjusted before each series of measurements to enable absolute values of sound pressure level to be obtained. For sound level meters calibrated in a sound field of progressive plan waves a correction for the diffuse sound field must be applied. (See IEC Publication 179, clause 8.2.)

When in any frequency band the sound pressure level in the receiving room is less than 10 dB above the background level, then the background level should be measured just before and after the determination of sound pressure level due to the sound source and a correction as given in table 2 shall be applied.

TABLE 2 – **Correction to sound pressure level readings**

Difference between sound pressure level measured with tapping machine operating and background level alone	Correction to be subtracted from sound pressure level measured with tapping machine operating to obtain sound pressure level due to tapping machine alone
dB	dB
3	3
4 to 5	2
6 to 9	1

The above corrections, if any, are to be made to the individual readings.

If the difference is less than 3 dB, i.e. the impact sound pressure level is less than the background level, a precise value of the impact sound pressure level cannot be determined.

In cases where the impact insulation is high, relative to the airborne sound insulation, the airborne sound produced in the source room by the tapping machine may be transmitted to the receiving room at a higher level than the transmitted impact sounds. By measuring the airborne sound pressure level in the upper room and the airborne sound insulation between the rooms on both sides of the floor, the minimum measurable impact sound pressure level can be calculated.

6.3 Frequency range of measurements

The sound pressure level should be measured by using third-octave or octave band filters. The discrimination characteristics of the filters should be in accordance with IEC Publication 225.

Third-octave band filters having at least the following centre frequencies in hertz should be used :

100	125	160	200	250	315
400	500	630	800	1 000	1 250
1 600	2 000	2 500	3 150		

If octave band filters are used, as a minimum the series beginning with centre frequency 125 Hz and ending at 2 000 Hz should be used.

6.4 Measurement and evaluation of the equivalent absorption area

The correction term of equation (2) containing the equivalent absorption area may preferably be evaluated from the reverberation time measured according to ISO/R 354 and evaluated using Sabine's formula :

$$A = \frac{0{,}163\, V}{T} \qquad \ldots (3)$$

where

A is the equivalent absorption area, in square metres;

V is the receiving room volume, in cubic metres;

T is the reverberation time, in seconds.

An alternative method of determining the equivalent absorption area is to measure the average sound pressure level produced by a sufficiently stable sound source the power output of which is known.

6.5 Position of the tapping machine

The tapping machine should be placed in at least four different positions on the floor under test. In the case of anisotropic floor constructions (ribs, beams, etc.) more positions may be necessary. The hammer connecting line should be orientated at 45° to the direction of the beams or ribs. The distance of the tapping machine from the edges of the floor should be at least 0,5 m.

If the tapping machine is placed on a very resilient layer, hard pads may be necessary under the supports of the tapping machine to guarantee a fall of 40 mm for the hammers.

6.6 Measurement procedure

Each organization should determine a normal test procedure which complies with this International Standard.

The necessary criteria which affect the repeatability of the measurements are shown below :

- number and sizes of diffusing elements;
- positions of the tapping machine;
- minimum distances between microphone and room boundaries with regard to near fields;
- number of microphone positions or, in the case of a moving microphone, the microphone path;
- averaging time of the levels;
- method for determining of the equivalent absorption area, which involves a number of repeated readings in each position.

An example of typical test conditions is given in annex A.

7 PRECISION

It is required that the measurement procedure should give satisfactory repeatability. This can be determined in accordance with the method shown in ISO 140/II and should be checked from time to time, particularly when a change is made in procedure or instrumentation.

NOTE – Tentative numerical requirements for repeatability are given in ISO 140/II.

8 EXPRESSION OF RESULTS

For the statement of the impact sound insulation of the test specimen, the normalized impact sound pressure level should be given at all frequencies of measurement, preferably in the form of a curve.

The band width used for the measurement and for the presentation shall be stated in every graph or table. If a numerical adjustment is made for the third-octave to octave bands, the graph or table of results shall bear the caption : "octave band levels calculated from third-octave band measurements".

For graphs with the level in decibels plotted against frequency on a logarithmic scale, the length for a 10:1 frequency ratio should be equal to the length for 10 dB, 25 dB or 50 dB on the ordinate scale.

9 TEST REPORT

With reference to this International Standard the test report shall state :

a) name of organization that has performed the measurements;

b) date of test;

c) description of floor construction and mounting conditions, with sectional drawing including the size and the flanking construction;

d) volume of the receiving room;

e) type of filters used;

f) normalized impact sound pressure level of test specimen as a function of frequency;

g) type of hammers used (without or with rubber covering);

h) brief description of details of procedure and equipment (see 6.6);

i) limit of measurement in case the sound pressure level in any band is not measurable on account of background noise (acoustical or electrical) or transmission of airborne noise;

j) the flanking transmission — if measured (see annex B) — in the same form as L'_n. It should be stated as clearly as possible which part or parts of the transmitted sound are included in the flanking transmission measurement.

For the evaluation of a single figure rating from the curve $L_n(f)$ or $L'_n(f)$, see ISO/R 717. It should be clearly stated that the evaluation has been based on a result obtained by a laboratory method.

ANNEX A

EXAMPLE OF A TEST PROCEDURE

An example of a test procedure which will normally be expected to give satisfactory repeatability is given below.

Where the receiving room is substantially rectangular with a volume of about 50 m³ it will contain at least three randomly orientated diffusing elements or an equivalent area of rotating vane, the former having a typical edge length of 1,2 m each. The diffusers should not be suspended from the ceiling under test.

Six positions of the tapping machine are chosen randomly distributed on a floor, no position being closer than 1 m to its edges and to another. For each tapping machine position, one of six randomly distributed microphone positions is chosen in the receiving room. No microphone position should be nearer than 0,7 m to the room boundaries or diffusers.

The readings of sound pressure level are taken using an averaging time of 5 s in each frequency band at each position.

As an alternative, the sound field sampling procedure can be carried out using a rotating microphone device having a sweep radius between 1 m and 1,5 m. In this case the plane of the traverse is inclined in relation to the room boundaries and the device should have a traverse time equal to the averaging time, which should be a minimum of 30 s.

The equivalent absorption area should be determined from readings taken using three microphone positions with two reverberation time analyses at each position.

ANNEX B

MEASUREMENT OF FLANKING TRANSMISSION

If the flanking transmission has to be investigated, this may be done by measuring the average velocity levels of the specimen and the flanking surfaces in the receiving room. The average surface velocity level L_v of a specimen in decibels is ten times the common logarithm of the ratio of the average of the mean square normal surface velocity of the specimen to the square of the reference velocity :

$$L_v = 10 \lg \frac{v_1^2 + v_2^2 + \ldots + v_n^2}{n v_0^2} \text{ dB} \qquad \ldots (4)$$

where

$v_1, v_2, \ldots, v_n$ are the r.m.s. normal surface velocities at n different positions on the wall or ceiling;

$v_0 = 10^{-9}$ m/s is the reference velocity.*

NOTE — In building acoustics, the reference velocity of $5 \cdot 10^{-8}$ m/s is also in use. Therefore, the reference velocity used in equation (4) must always be stated.

The vibration transducer used should be well attached to the surface and its mass impedance should be sufficiently low compared with the point impedance of the surface.

If the critical frequency of the specimen or the flanking objects is low compared with the frequency range of interest, the power W_k radiated from a particular element k with area S_k in the receiving room may be estimated from the formula

$$W_k = \varrho c \, S_k \, \overline{v_k^2} \, \sigma_k \qquad \ldots (5)$$

where

$\overline{v_k^2}$ is the spatial average of the mean square of the normal surface velocity;

σ_k is the radiation efficiency, a pure number of about 1 above the critical frequency;

ϱc is the characteristic impedance of air.

From the average surface velocity level L_v the average sound pressure level in the receiving room due to the radiation of the k-th flanking element may be calculated according to the formula

$$L_k = L_{v_k} + 10 \lg \frac{4 S_k}{A} \text{ dB} \qquad \ldots (6)$$

The resulting sound pressure level of all flanking constructions is :

$$L_{Df} = 10 \lg \left(\sum_k 10^{L_k/10} \right) \text{ dB} \qquad \ldots (7)$$

* See ISO 1683, *Acoustics — Preferred reference quantities for acoustic levels.*