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

Acoustique — Mesurage de l'isolation acoustique des immeubles et des éléments de construction — Partie VII : Mesurage sur place de l'isolation des sols aux bruits de chocs

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 140/VII 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 and VI, 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 VII : Field measurements of impact sound insulation of floors

0 INTRODUCTION

The purpose of this International Standard is

— to give a procedure to measure the impact sound insulation between two rooms in buildings, thus making it possible to check whether the desired acoustical conditions have been obtained;

— to give a field procedure to determine whether building elements have met specifications and to check whether faults have occurred during construction.

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies field methods for measuring the impact sound insulation properties of floors between two rooms by using a standard tapping machine and for determining the protection afforded by floors to the occupants of the building.

The results obtained can be used to compare the impact sound insulation between rooms and to compare the actual impact sound insulation with specified requirements.

When determining the impact sound insulation properties of a building element, the normalized impact sound level (see 3.3) is used.

When determining the protection afforded to the occupants of the building, the standardized impact sound level (see 3.4) is appropriate.

NOTE — Laboratory measurements of impact sound insulation of floors are dealt with in ISO 140/VI.

2 REFERENCES

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

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

ISO 140/VIII, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part VIII : Laboratory measurements 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;

$p_0 = 20$ μPa 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 $A_0 = 10\ \text{m}^2$.

3.4 standardized impact sound pressure level : The impact sound pressure level L_i reduced by a correction term which is given in decibels, being ten times the common logarithm of the ratio between the measured reverberation time T of the receiving room and the reference reverberation time T_0. This quantity is denoted by L'_{nT} :

$$L'_{nT} = L_i - 10 \lg \frac{T}{T_0} \text{dB} \quad \ldots (3)$$

For dwellings T_0 is given by

$$T_0 = 0{,}5 \text{ s}$$

NOTES

1 The standardizing of the impact sound pressure level to a reverberation time of 0,5 s takes into account that in dwellings the reverberation time has been found to be (nearly independent of the volume and of frequency) equal to 0,5 s.

2 The standardizing of the impact sound pressure level to the reverberation time of $T_0 = 0{,}5$ s is equivalent to standardizing the impact sound pressure level to an equivalent absorption area of

$$A_0 = 0{,}32\, V$$

where

A_0 is the equivalent absorption area, in square metres;

V is the volume of the receiving room, in cubic metres.

3.5 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 standardized impact sound source, i.e. the tapping machine, should conform to ISO 140/VI. The further equipment shall be suitable for meeting the requirements of clause 6.

5 TEST ARRANGEMENT

For the test arrangement to be used in the field, it is not possible to standardize the area of the test specimen and the volume and shape of the rooms.

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 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 the table shall be applied.

TABLE – **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 :

$$A = \frac{0{,}163\ V}{T} \qquad \ldots (4)$$

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 measurement are shown below :

— number and sizes of diffusing elements where used;

— 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 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. For the instrumentation and in specific cases for the complete measurement conditions, this can be determined in accordance with the method shown in ISO 140/II.

It is recommended that different organizations in the same country should periodically perform comparison measurements on the same test specimen to check the repeatability and the reproducibility of their test procedures.

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, in tabular form and/or in the form of a curve.

For the statement of the protection afforded to the occupants of the building, the standardized impact sound pressure level should be given at all frequencies, in tabular form and/or 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 from 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 the floor construction, with sectional drawing including the size and the flanking construction;

d) volume of the receiving room;

e) type of filters used;

f) either normalized impact sound pressure level of test specimen or standardized impact sound pressure level in the receiving room, whichever is appropriate, as a function of frequency;

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

h) 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 $L'_n(f)$, see ISO/R 717.

ANNEX A

EXAMPLE OF A TEST PROCEDURE

An example of a test procedure which will normally be expected to give satisfactory repeatability in cases where the room volume exceeds 25 m^3 is given below :

Six positions of the tapping machine are chosen randomly distributed on a floor, no position being closer than 1 m to its edges. 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 0,5 m to the room boundaries.

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 minimum sweep radius of 0,7 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.*