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Acoustics – Measurement of sound insulation in buildings and of building elements – Part III : Laboratory measurements of airborne sound insulation of building elements

Acoustique – Mesurage de l'isolation acoustique des immeubles et des éléments de construction – Partie III : Mesurage en laboratoire de l'isolation aux bruits aériens des éléments de construction

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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/III 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	Sweden
Canada	Japan	Switzerland
Czechoslovakia	Korea, Rep. of	Turkey
Denmark	Mexico	United Kingdom
Finland	Netherlands	U.S.A.
France	New Zealand	U.S.S.R.
Germany	Norway	
Hungary	Poland	

The member body of the following country expressed disapproval of the document of technical grounds :

Spain

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

Annexes A and C are integral parts of this International Standard.

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Acoustics — Measurement of sound insulation in buildings and of building elements — Part III : Laboratory measurements of airborne sound insulation of building elements

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a laboratory method of measuring the airborne sound insulation of building elements such as walls, floors, doors, windows, facade elements and facades.

The results obtained can be used to design building elements with appropriate acoustical properties, to compare the sound insulation properties of building elements and to classify such elements according to their sound insulation properties.

NOTE — Field measurements of airborne sound insulation between rooms and of facade elements and facades are dealt with in ISO 140/IV and ISO 140/V respectively.

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/IV, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part IV : Field measurements of airborne sound insulation between rooms.*

ISO 140/V, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part V : Field measurements of airborne sound insulation of facade elements and facades.*

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

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

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 sound reduction index; transmission loss : Ten times the common logarithm of the ratio of the sound power W_1 incident on a test specimen to the sound power W_2 transmitted through the specimen. This quantity is denoted by R :

$$R = 10 \lg \frac{W_1}{W_2} \text{ dB} \qquad \ldots (2)$$

The sound reduction index depends on the angle of incidence. If the sound fields are diffuse and if the sound is transmitted only through the specimen, the sound reduction index for diffuse incidence may be evaluated from

$$R = L_1 - L_2 + 10 \lg \frac{S}{A} \text{ dB} \qquad \ldots (3)$$

where

L_1 is the average sound pressure level in the source room;

L_2 is the average sound pressure level in the receiving room;

S is the area of the test specimen, which is normally equal to the free test opening;

A is the equivalent absorption area in the receiving room.

NOTE — If the sound fields are not completely diffuse, equation (3) is an approximation.

3.3 apparent sound reduction index; apparent transmission loss : Ten times the common logarithm of the ratio of the sound power W_1 incident on a partition under test to the total sound power W_3 transmitted into the receiving room. This quantity is denoted by R' :

$$R' = 10 \lg \frac{W_1}{W_3} \text{ dB} \qquad \ldots (4)$$

In general, the sound power transmitted into the receiving room consists of the sum of the following components :

W_{Dd} which has entered the partition directly and is radiated from it directly;

W_{Df} which has entered the partition directly but is radiated from flanking constructions;

W_{Fd} which has entered flanking constructions and is radiated from the partition directly;

W_{Ff} which has entered flanking constructions and is radiated from flanking constructions;

W_{leak} which has been transmitted (as airborne sound) through leaks, ventilation ducts, etc.

Also in this case, under the assumption of diffuse sound fields in the two rooms, the apparent sound reduction index may be evaluated from

$$R' = L_1 - L_2 + 10 \lg \frac{S}{A} \text{ dB} \qquad \ldots (5)$$

Thus, in the apparent sound reduction index the sound power transmitted into the receiving room is related to the sound power incident on the common partition as in equation (3) irrespective of actual conditions of transmission.

4 EQUIPMENT

The equipment shall be suitable for meeting the requirements of clause 6.

5 TEST ARRANGEMENT

5.1 Rooms

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

5.2 Test specimen

5.2.1 *Partitions*

The size of the test partition is determined by the size of the test opening of the laboratory test facility as it is defined in ISO 140/I. These sizes are approximately 10 m² for walls, and between 10 m² and 20 m² for floors, with the shorter edge length for both walls and floors not less than 2,3 m.

A smaller size may be used if the wavelength of free flexural waves at the lowest frequency considered is smaller than half the minimum dimension of the specimen. The smaller the specimen, however, the more sensitive the results will be to edge constraint conditions and to local variations in sound fields.

NOTE — The test partition 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 partition. The mounting conditions should be stated in the test report.

If the test specimen is installed in an aperture between the source room and the receiving room, aperture depths on each side should be approximately equal unless this is inconsistent with the practical use of the test specimen (for example windows in facades).

NOTE — The position of the test specimen within the test opening as well as the volume of the rooms and the size of the test opening are under consideration.

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.

NOTES

1 For the laboratory facility, the value of R'_{max} should be measured. This may be done by measuring R' with a highly insulating construction inserted in the test opening. If further improvements of the insulating properties of this construction give no increase in R', this value of R' is considered as R'_{max}.

If the measured value of R' for a test specimen is less than $(R'_{max} - 10 \text{ dB})$, the indirect transmitted sound may be considered negligible.

If R' is larger than $(R'_{max} - 10 \text{ dB})$ the contribution of the flanking transmission for this special case should be investigated using one of the methods mentioned in annex A.

2 If the test specimen is smaller than the test opening, a preliminary test should be carried out, to ensure that energy transmitted through the surrounding partition is small compared with the energy transmitted through the test specimen. This may be checked by the method described in clause A.1 of annex A.

5.2.2 *Doors, windows, facade elements and facades*

The test specimen should be tested in the same manner as a partition (see 5.2.1). If the test specimen is smaller than the test opening, a special partition of sufficiently high sound insulation should be built in the test opening and the specimen should be placed in that partition. The sound transmitted through this partition and any other indirect path should be negligible compared with the sound transmitted through the test specimen (see annex A).

For windows, doors, etc., the area S is the area of the free opening in which the element (including a possible frame and sealing) is mounted.

NOTE — As the sound insulation of windows, doors and small facade elements depends on the dimensions, accurate values can be obtained only by measuring every actual size.

Doors should be so inserted that the lower edge is situated as near to the level of the floor of the test rooms as will reproduce conditions in the actual building.

If the test specimen is intended to be openable, it should be installed for test so that it can be opened and closed in the normal manner. It should be opened and closed at least ten times immediately before testing.

6 TEST PROCEDURE AND EVALUATION

6.1 Generation of sound field in the source room

The sound generated in the source room should be steady and have a continuous spectrum in the frequency range considered. Filters with a bandwidth of at least one-third octave may be used.

The sound power should be sufficiently high for the sound pressure level in the receiving room to be at least 10 dB higher than the background level in any frequency band.

If the sound source contains more than one loudspeaker operating simultaneously, the loudspeakers should be contained in one enclosure, the maximum dimension of which should not exceed 0,7 m. The loudspeakers should be driven in phase.

The loudspeaker enclosure should be placed to give a sound field as diffuse as possible and at such a distance from the test specimen that the direct radiation upon it is not dominant.

6.2 Measurement of the average sound pressure level

The average sound pressure level may be obtained by using a number of fixed microphone positions or a continuously moving microphone with an integration of p^2.

6.3 Frequency range of measurements

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

One-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		

6.4 Measurement and evaluation of the equivalent absorption area

The correction term of equation (3) 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 :

$$A = \frac{0,163\ V}{T} \qquad \ldots (6)$$

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 procedure by a sufficiently stable sound source the power output of which is known.

6.5 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;
- position of the sound source;
- minimum distances between microphone and sound source and 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 B.

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 airborne sound insulation of the test specimen, the sound reduction index should be given at all frequencies of measurement, in tabular form and/or in the form of a curve. 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 test specimen with sectional drawing and mounting conditions, including size, thickness, mass per unit area, curing time (if any) of components;

d) volumes of both reverberant rooms;

e) type of noise and filters used;

f) sound reduction index of test specimen as a function of frequency;

g) brief description of details of procedure and equipment (see 6.5);

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

i) if the measured value of sound reduction index has been affected by flanking transmission, the value of R'_{max} (see annex A) should be given and those results affected by flanking transmission should be indicated;

j) total loss factor η_{total} – if measured (see annex C) – at all frequencies of measurement in tabular form and/or in the form of a curve.

For the evaluation of the single figure rating from the curve $R(f)$, 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

MEASUREMENT OF FLANKING TRANSMISSION

If the flanking transmission has to be investigated, this may be done in either of the following ways :

A.1 By covering the specimen on both sides with additional flexible layers, for example 13 mm gypsum board on a separate frame at a distance which gives a resonance frequency of the system of layer and airspace well below the frequency range of interest. The airspace should contain sound absorbing material. With this measurement W_{Dd}, W_{Df} and W_{Fd} are suppressed, and the measured apparent reduction index is determined by W_{Ff}. W_{leak} is assumed to be negligible under laboratory conditions. Additional flexible layers, over particular flanking surfaces, may permit identification of the major flanking paths.

A.2 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 the 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 :

$$L_v = 10 \lg \frac{v_1^2 + v_2^2 + \ldots + v_n^2}{n v_0^2} \text{ dB} \qquad \ldots (7)$$

where

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

$v_0 = 10^{-9}$ 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 (7) 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

$$W_k = \varrho c\, S_k\, \overline{v_k^2}\, \sigma_k \qquad \ldots (8)$$

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.

If, for instance, the power radiated from the flanking constructions is determined in this way, the measurement can be used to calculate

$$R'_{Df+Ff} = 10 \lg \frac{W_1}{W_{Df} + W_{Ff}} \text{ dB} \qquad \ldots (9)$$

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

ANNEX B

EXAMPLE OF A TEST PROCEDURE

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

When the rooms have a similar shape and volume of about 50 m^3, each 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.

One loudspeaker is placed separately in two different corners opposite the test specimen (but not directed at it) such that with six microphone positions randomly distributed throughout each room, three can have readings taken for each loudspeaker position, using an averaging time of 5 s in each frequency band at each position. The loudspeaker is fed with white noise in one-third octave bands. In the microphone channel one-third octave band filters are used as well. No microphone position should be nearer than 0,7 m to the room boundaries or diffusers.

As an alternative, the sound field sampling procedure can be carried out using a rotating microphone device having a sweep radius of 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 C

CHECKING THE LOSS FACTOR η_{total} OF THE PARTITION

For the frequency region above the critical frequency, the total loss factor of the partition influences the sound reduction index. The total loss factor is affected by the boundary conditions and may be checked by measuring the reverberation time of the partition as a function of frequency. The partition should be excited by a shaker driven by white noise in one-third octave bands. From the measurements, the loss factor is calculated from the following equation :

$$\eta_{total} = \frac{2,2}{fT} \qquad \dots (10)$$

where

f is the one-third octave band centre frequency;

T is the reverberation time of the partition.