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

Acoustique — Mesurage de l'isolation acoustique des immeubles et des éléments de construction — Partie IV : Mesurage sur place de l'isolation aux bruits aériens entre les pièces

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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/IV 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 on technical grounds :

Spain

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

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

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

0 INTRODUCTION

The purpose of this International Standard is

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

– to give field procedures 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 airborne sound insulation properties of interior walls, floors and doors between two rooms under diffuse sound field conditions in both rooms and for determining the protection afforded to the occupants of the building.

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

When determining the protection afforded to the occupants of the building, the standardized level difference (see 3.3) is appropriate.

When determining the sound insulation properties of a building element, the apparent sound reduction index (see 3.4) is used.

NOTES

1 Laboratory measurements of airborne sound insulation of building elements are dealt with in ISO 140/III.

2 Field measurements of airborne sound insulation of facade elements and facades are dealt with in ISO 140/V.

2 REFERENCES

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

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

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 level difference : The difference in the space and time average sound pressure levels produced in two rooms by one or more sound sources in one of them. This quantity is denoted by D :

$$D = L_1 - L_2 \qquad \ldots (2)$$

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.

3.3 standardized level difference : The level difference corresponding to a reference value of the reverberation time in the receiving room. This quantity is denoted by D_{nT} :

$$D_{nT} = D + 10 \lg \frac{T}{T_0} \text{dB} \qquad \dots (3)$$

where

D is the level difference;

T is the reverberation time in the receiving room;

T_0 is the reference reverberation time.

For dwellings, T_0 is given by

$$T_0 = 0,5 \text{ s} \qquad \dots (4)$$

NOTES

1 The standardizing of the level difference to a reverberation time of 0,5 s takes into account that in dwellings with furniture the reverberation time has been found — nearly independently of the volume and of frequency — to be equal to 0.5 s. With this standardizing, D_{nT} is dependent on the direction of the sound transmission if the two rooms have different volumes.

2 The standardizing of the level difference to the reverberation time in the receiving room of $T_0 = 0,5$ s is equivalent to standardizing the level difference with respect 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.

3.4 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' :

$$R' = 10 \lg \frac{W_1}{W_3} \text{dB} \qquad \dots (5)$$

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.

Under the assumption of diffuse sound fields in the two rooms, the apparent sound reduction index may be evaluated from the formula

$$R' = L_1 - L_2 + 10 \lg \frac{S}{A} \text{dB} \qquad \dots (6)$$

where

S is the area of the test specimen;

A is the equivalent absorption area in the receiving room.

In the case of evaluation of R' of a door S is the area of the free opening in which the door including the frame is mounted. It must be proved that the sound transmission through the rest of the surrounding wall is negligible.

In the case of staggered rooms, S is that part of the area of the partition common to both rooms; if, however, the common area is less than 10 m^2, the value of S for insertion in equation (6) shall be 10 m^2 but the measurement results shall not be used for comparison with results obtained by measurement in laboratory.

NOTE — 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 irrespective of actual conditions of transmission.

The apparent sound reduction index is independent of the measuring direction between the rooms if the sound fields are diffuse in both rooms.

4 EQUIPMENT

The 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.

Measurements between empty rooms with equal dimensions should preferably be made with diffusers in each room. If diffusing elements are used, they should be sufficiently isolated from the building, for example by placing them on pads of resilient material.

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.

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.

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 sound source operating and background level alone	Correction to be subtracted from sound pressure level measured with sound source operating to obtain sound pressure level due to sound source alone
dB	dB
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 sound pressure level L_2 is less than the background level, a precise value of L_2 cannot be determined.

6.3 Frequency range of measurements

The sound pressure level should be measured 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 (6) 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 :

$$A = \frac{0{,}163\ V}{T} \qquad \ldots (7)$$

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 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 (if any);
- 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 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 condition, 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 results, the apparent sound reduction index R' of the test specimen and/or the standardized level difference D_{nT} between the two rooms 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 the building construction and test arrangement;

d) volumes of both rooms;

e) type of noise and filters used;

f) either apparent sound reduction index R' of test specimen or standardized level difference D_{nT} between the two rooms as a function of frequency, whichever is appropriate;

g) the area S used for evaluation of R';

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

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

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

k) 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 a single figure rating from the curve $R'(f)$, 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 volumes exceed 25 m^3 is given below :

When the empty rooms have identical shape, each will be modified in such a way that they will have a more random sound field. This can be achieved by means of portable diffusers such as sheets of building boards or pieces of furniture, whichever are the most convenient. Three or four objects will be sufficient in most cases.

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 0,5 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 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 in either of the following ways :

B.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.

B.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 :

$$L_v = 10 \lg \frac{v_1^2 + v_2^2 + \ldots + v_n^2}{n v_0^2} \text{ dB} \qquad \ldots (8)$$

where

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

$v_0 = 10^{-9}$ 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 (8) 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

$$W_k = \varrho c\, S_k\, \overline{v_k^2}\, \sigma_k \qquad \ldots (9)$$

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,

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

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 influenced 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

$$\eta_{\mathrm{total}} = \frac{2{,}2}{fT} \qquad \ldots (11)$$

where

f is the third-octave band centre frequency;

T is the reverberation time of the partition.

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