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Indian Standard

MEASUREMENT OF SOUND INSULATION IN BUILDINGS AND OF BUILDING ELEMENTS

PART IV FIELD MEASUREMENTS OF AIRBORNE SOUND INSULATION BETWEEN ROOMS

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0. FOREWORD

0.1 This Indian Standard (Part IV) was adopted by the Indian Standards Institution on 26 October 1981, after the draft finalized by the Acoustics Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 The purpose of this standard is:

a) To provide 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.

b) To provide field procedures to determine whether building elements have met specifications and to check whether faults have occurred during construction.

0.3 This standard, which covers field measurements of airborne sound insulation between rooms is a part of the series of Indian Standards on measurement of sound insulation in buildings and of building elements. Other standards in this series are:

Part I Requirements for laboratories,

Part II Statement of precision requirements,

Part III Laboratory measurements of airborne sound insulation of building elements,

Part V Field measurements of airborne sound insulation of facade elements and facades,

Part VI Laboratory measurements of impact sound insulation of floors, Part VII Field measurements of impact sound insulation of floors, and

Part VIII Laboratory measurements of the reduction of transmitted impact noise by floors coverings on a standard floor.

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

0.5 While preparing this standard, assistance has been derived from ISO/DIS 140/IV 'Measurement of sound insulation in buildings and of building elements : Part IV Field measurements of airborne sound insulation between rooms' issued by the International Organization for Standardization.

0.6 In reporting the result of a test made in accordance with the standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2 - 1960*.

1. SCOPE

1.1 This standard (Part IV) 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 against sound afforded to the occupants of the building.

2. TERMINOLOGY

2.0 For the purpose of this standard, the terms and definitions given in IS : 1885 (Part III/Sec 8)-1974† shall apply in addition to the following.

2.1 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:

$$L = 10 \log_{10} \frac{P^2{}_1 + P^2{}_2 + \dots P^2{}_n}{nP^2{}_0} \text{ dB} \qquad \dots\dots\dots(1)$$

*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabulary : Part III Acoustics, Section 8 Architectural acoustics.

where

$P_1, P_2, \ldots, P_n$ are the rms sound pressures at n different positions in the room;

$P_0 = 20\ \mu$Pa is the reference sound pressure.

2.2 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:

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

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.

2.3 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}:

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

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

$$T_0 = 0{\cdot}5 \text{ s} \qquad \ldots\ldots\ldots(4)$$

NOTE 1 — The standardizing of the level difference to a reverberation time of 0·5 s takes into account that is dwellings the reverberation time has been found to be — nearly independent of the volume and of frequency 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.

NOTE 2 — The standardizing of the level difference to the reverberation time in the receiving room of $T_0 = 0{\cdot}5$ s is equivalent to standardizing the level difference with respect to an equivalent absorption area of:

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

where

A_0 is the equivalent absorption area, in square metres;

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

NOTE 3 — When determining the protection from sound afforded to the occupants of the building, the standardized level difference is appropriate.

2.4 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' :

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

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 but 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 blanking constructions;

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

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

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

where

S is the area of the test specimen, and

A is the equivalent absorption area in the receiving room.

In the case of a door in a wall, 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 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 m², the measurement results cannot be expressed as R'.

NOTE 1 — 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 parent sound reduction index is independent of the measuring direction between the rooms if the sound fields are diffuse in both rooms.

NOTE 2 — When determining the sound insulation properties of a building element, the apparent reduction index is used.

3. EQUIPMENT

3.1 The equipment shall be suitable for meeting the requirements of **5.**

4. TEST ARRANGEMENT

4.1 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.

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

5. TEST PROCEDURE AND EVALUATION

5.1 Generation of Sound Field in the Source Room

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

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

5.1.3 The loudspeaker enclosure shall be so placed as 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.

5.2 Measurement of the Average Sound Pressure Level

5.2.1 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.

5.2.2 When in any frequency band the sound pressure level in the receiving room in less than 10 dB above the background level, the background level shall 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 1 shall be applied.

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

TABLE 1 CORRECTION TO SOUND PRESSURE LEVEL READINGS

(*Clause* 5.2.2)

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

5.2.4 If the difference is less than 3 dB, that is, the sound pressure level L_2 is less than the background level, a precise value of L_2 cannot be determined.

5.3 Frequency Range of Measurements

5.3.1 The sound pressure level should be measured using third-octave or octave band filters. The discrimination characteristics of the filters shall be in accordance with IS : 6964-1973*.

5.3.2 Third-octave band filters having at least the following centre frequencies shall be used:

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

NOTE 1 — Use of lower frequency is dependent on the distribution of natural frequency.

NOTE 2 — The minimum reverberation times for the empty room are adjusted to a volume 180 m^3. For other volumes, these times shall be multiplied by the factor $(V/180)^{1/3}$ (V being the volume of the room expressed in cubic metres) except at high frequencies, where the air absorption is the predominant factor influencing the decay rate.

5.3.3 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.

*Octave, half-octave and third-octave band filters for analysis of sound and vibrations.

5.4 Measurement and Evaluation of the Equivalent Absorption Area

5.4.1 The correction term of equation (6) containing the equivalent absorption area may be preferably evaluated from the reverberation time measured according to IS : 8225-1976* and evaluated using Sabine's formula:

$$A = \frac{0{\cdot}163\ V}{T} \qquad \text{.........(7)}$$

where

A is the equivalent absorption area, in square metres;

V is the receiving room volume, in cubic metres; and

T is the reverberation time, in seconds.

5.4.2 The alternative method of taking the equivalent absorption area into account is to measure the average sound pressure level produced by a sufficiently stable sound source the power output of which is known.

5.5 Measurement Procedure

5.5.1 A normal test procedure which complies with this standard shall be determined.

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

a) Number and sizes of diffusing elements (if any);

b) Number of sound sources;

c) Position(s) of sound sources;

d) Minimum distances between microphone and sound source(s) and microphone and room boundaries with regard to near fields;

e) Number of microphone positions or, in the case of a moving microphone, the microphone path;

f) Averaging time of the levels; and

g) 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 Appendix A.

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*Method of measurement of absorption coefficient in a reverberation room.

6. PRECISION

6.1 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 IS : 9901 (Part II)-1981*.

NOTE — It is recommended that different organizations periodically perform comparison measurements on the same test specimen to check the repeatability and the reproducibility of their test procedure.

7. EXPRESSION OF RESULTS

7.1 For the statement of results, the apparent reduction index R′ of the test specimen and/or the standardized level difference D_{nT} between the two rooms shall 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 shall be equal to the length for 10 dB, 25 dB or 50 dB on the ordinate scale.

8. TEST REPORT

8.1 The test report should state:

a) Name of organization that has performed the measurements;

b) Date of test;

c) Description of the building construction and test arrangement;

d) Volume 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* **5.5**);

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

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*Measurement of sound insulation in buildings and of building elements : Part II Statement of precision requirements.

k) The flanking transmission — if measured (*see* Appendix 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.

m) Total loss factor η_{total} — if measured (*see* Appendix C) — at all frequencies of measurement in tabular form and/or in the form of a curve;

n) Remarks when it is not possible to follow this standard in every detail.

With respect to the evaluation of a single value from the curve R' (f), *see* IS : 'Indian Standard Rating of sound insulation for dwellings' (*under preparation*).

APPENDIX A

(*Clause* 5.5.2)

EXAMPLE OF TEST PROCEDURE

A-1. 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.

A-1.1 When the empty rooms have identical shape, each will be modified in such a way that it shall 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.

A-1.2 One loudspeaker is placed separately in 2 different corners opposite the test specimen (but not directed at it) such that with 6 microphone positions randomly distributed throughout each room 3 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 band. In the microphone channel one third-octave band filter is used as well. No microphone position shall be nearer than 0·5 m to the room boundaries or diffusers.

A-1.3 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 shall have an averaging time equal to the traverse time, which shall be a minimum of 30 s.

A-1.4 The equivalent absorption area shall be determined from readings taken using 3 microphone positions with 2 reverberation time analyses at each position.

APPENDIX B

[*Clause* 8.1 (k)]

MEASUREMENT OF FLANKING TRANSMISSION

B-1. If the flanking transmission has to be investigated, this may be done in either of the following ways.

B-1.1 By covering the specimen on both sides by 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 absorbing material. With this measurement W_{Dd}, W_{Fd} and W_{Df} are suppressed, and the measured apparent reduction index is determined by W_{Ff}. Additional flexible layers, over particular flanking surfaces, may permit identification of the major paths.

B-1.2 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 10 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:

$$L_v = 10 \log_{10} \frac{v^2_1 + v^2_2 + \dots\dots\dots + v^2_n}{n v^2_0} \text{ dB} \qquad \dots\dots\dots(8)$$

where

v_1, v^2, ... v_n are the rms normal surface velocities at n different positions on the wall or ceiling.

$v_0 = 5 \times 10^{-8}$ ms^{-1} is the reference velocity.

The vibration transducer used shall be well attached to the surface and its mass impedance shall 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:

$$W_k = \rho c S_k \overline{v^2}_k \sigma k \quad \text{.........(9)}$$

where

$v^2{}_k$ is the spatial average of the mean square of the normal surface velocity;

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

ρc is the characteristic impedance of air.

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

$$R'_{Df+Ff} = 10 \log_{10} \frac{W_1}{W_{Df} + W_{Ff}} \text{ dB} \quad \text{........(10)}$$

APPENDIX C

[*Clause* 8.1 (m)]

CHECKING THE LOSS FACTOR η_{total} OF THE PARTITION

C-1. For the frequency region above the critical frequency, the total loss factor of the partition is important for its 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 then be excited by a shaker driven by white noise in third-octave bands. From the measurements the loss factor is calculated:

$$\eta_{total} = \frac{2{\cdot}2}{fT} \qquad \text{.........(11)}$$

where

f is the third-octave band centre frequency,

T is the reverberation time of the partition.