IS : 9901 (Part III) - 1981

Indian Standard

MEASUREMENT OF SOUND INSULATION IN BUILDINGS AND OF BUILDING ELEMENTS

PART III LABORATORY MEASUREMENTS OF AIRBORNE SOUND INSULATION OF BUILDING ELEMENTS

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(*Continued on page* 2)

(*Continued from page* 1)

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Indian Standard

MEASUREMENT OF SOUND INSULATION IN BUILDINGS AND OF BUILDING ELEMENTS

PART III LABORATORY MEASUREMENTS OF AIRBORNE SOUND INSULATION OF BUILDING ELEMENTS

0. FOREWORD

0.1 This Indian Standard (Part III) 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 This standard, which covers laboratory measurements of airborne sound insulation of building elements is a part of a 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 IV	Field measurements of airborne sound insulation between rooms
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
Part VIII	Laboratory measurements of the reduction of transmitted impact noise by floors coverings on a standard floor.

0.3 The test 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.

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

0.5 In reporting the result of a test made in accordance with this 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 III) specifies a laboratory method of measuring the airborne sound insulation of building elements such as walls, floors, doors, windows, facade elements and facades.

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:

$$L = 10 \log_{10} \frac{P_1^2 + P_2^2 + \ldots\ldots\ldots + P_n^2}{n p_0^2} \text{dB} \ldots\ldots\ldots (1)$$

where

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

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

2.2 Sound Reduction Index, Transmission Loss — Ten times the common logarithm 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:

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

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

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

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

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

where

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

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

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

A = the equivalent absorption area in the receiving room.

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

2.3 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':

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

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; and

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 reduction index may be evaluated from:

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

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.

3. EQUIPMENT

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

4. TEST ARRANGEMENT

4.1 Rooms — Laboratory test facilities shall meet the requirements of IS : 9901 (Part I)-1981*.

4.2 Test Specimen

4.2.1 *Partitions*

4.2.1.1 The size of the test partition is determined by the size of the test opening of the laboratory test facility, as defined in IS : 9901 (Part I)-1981*. These sizes are approximately 10m² for walls, and between 10m² and 20m² for floors, with the shorter edge length for both walls and floors not less than 2·3 m.

4.2.1.2 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 condition and to local variation in sound field.

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 shall be stated in the test report.

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

4.2.1.4 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.

NOTE 1 — For special laboratory facility, the value of R'_{max} shall 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 ($R'_{max} - 5$ dB), the indirect transmitted sound may be considered negligible.

*Measurement of sound insulation in buildings and of building elements: Part I Requirements for laboratories.

If R' is larger than ($R'_{max} - 5$ dB) the contribution of the flanking transmission for this special case shall be investigated with one of the methods mentioned in Appendix A.

NOTE 2 — If the test specimen is smaller than the test opening, a preliminary test shall 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 **A-1** of Appendix A.

4.2.2 *Doors, Windows, Facade Elements and Facades*

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

4.2.2.2 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 their dimensions, accurate values can be obtained only by measuring every actual size.

4.2.2.3 Doors shall be so inserted that the lower edge is situated directly above the floor of the test rooms according to the conditions in the field.

4.2.2.4 If the test specimen is intended to be openable, it shall be installed for test so that it can be opened and closed in the normal manner. It shall be opened and closed at least 10 times immediately before testing.

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 shall 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.

5.1.2 The sound power shall be sufficiently high so that the sound pressure level in the receiving room is at least 10 dB higher than the background level in any frequency band.

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

5.1.4 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.

5.3 Frequency Range of Measurements

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

5.3.2 Third-octave band filters having at least the following centre frequencies (in Hz) 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.

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 of 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 meters) except at high frequencies, where the air absorption is the predominant factor influencing the decay rate.

5.4 Measurement and Evaluation of the Equivalent Absorption Area

5.4.1 The correction term of equation (3), containing the equivalent absorption area, may preferably be evaluated from the reverberation time measured according to IS : 8225-1976† and evaluated using Sabine's formula:

$$A = \frac{0{\cdot}163V}{T} \quad \ldots\ldots\ldots (6)$$

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.

*Octave, half-octave and third-octave band filters for analysis of sound and vibrations.
†Method of measurement of absorption coefficient in a reverberation room.

5.4.2 An 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 test procedure which complies with the standard shall be determined.

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

a) Number and sizes of diffusing elements;
b) Number of sound sources;
c) Position(s) of the sound source or sources;
d) Minimum distance 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 B.

6. PRECISION

6.1 It is required that the measurement procedure shall give satisfactory repeatability. This can be determined in accordance with the method shown in IS : 9901 (Part I)-1981* and shall be checked from time to time, particularly when a change is made in procedure of instrumentation.

NOTE — Numerical requirements for repeatability are under consideration pending further experience with this test procedure.

7. EXPRESSION OF RESULTS

7.1 For the statement of the airborne sound insulation of the test specimen, the sound reduction index 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.

*Measurement of sound insulation in buildings and of building elements: Part I Requirements for laboratories.

8. TEST REPORT

8.1 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 and curing time (if any) of components;
d) Volume 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);
j) If the measured value of sound reduction index has been affected by flanking transmission, the value of R'_{max} (*see* Appendix A) should be given and those results affected by flanking transmission should be indicated;
k) 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.

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

APPENDIX A

[*Clauses* 4.2.1.4, 4.2.2.1 *and* 8.1 (j)]

MEASUREMENT OF FLANKING TRANSMISSION

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

A-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 shall contain the 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 flanking paths.

A-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:

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

where

$v_1, v_2 \ldots v_n$, are the rms normal surface velocities at n different positions on the wall or ceiling; and

$v_0 = 5 \times 10^{-8}$ 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

$$W_k = \rho c S_k^2 v_k^2 \sigma_k \quad \ldots\ldots\ldots (8)$$

where

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; 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,

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

APPENDIX B

(*Clause* 5.5.2)

EXAMPLE OF TEST PROCEDURE

B-1. An example of a test procedure which will normally be expected to give satisfactory repeatability is given below.

B-1.1 When the rooms have a similar shape and volume of about 50 m^3, each will contain at least 3 randomly orientated diffusing elements or an equivalent area of rotating vane, the former having a typical edge length of 1·2 m each.

B-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 bands. In the microphone channel one third-octave band filter is used as well. No microphone position shall be nearer than 0·7 m to the room boundaries or diffusers.

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

B-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 C

[*Clause* 8.1 (k)]

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 shall then be excited by a shaker driven by white noise in third-octave bands. From the measurements, the loss factor is calculated from the following equation:

$$\eta_{total} = \frac{2{\cdot}2}{f\,T}$$

where

f is the third-octave band centre frequency; and

T is the reverberation time of the partition.

INDIAN STANDARDS
ON
ACOUSTICS

IS:

1301-1958 Code of safety requirements for electric mains-operated audio amplifiers
1490-1959 Recommendations for minimum performance requirements of mains-operated public address amplifiers
1819-1961 Recommendations for general requirements of public address amplifiers
1881-1961 Code of practice for installation of indoor amplifying and sound distribution systems
1882-1961 Code of practice for outdoor installation of public address systems
1885 Electrotechnical Vocabulary:
(Part III/Sec 1)-1965 Physical acoustics
(Part III/Sec 2)-1966 Acoustical and electro-acoustical systems
(Part III/Sec 4)-1966 Sonics, ultrasonics and underwater acoustics
(Part III/Sec 5)-1966 Speech and hearing
(Part III/Sec 6)-1967 Acoustical instruments
(Part III/Sec 7)-1978 Music
(Part III/Sec 8)-1974 Architectural acoustics
2032 (Part XII)-1969 Graphical symbols used in electro-technology: Part XII Electro-acoustic transducers and recording and reproducing systems
2264-1963 Preferred frequencies for acoustical measurements
2382-1970 Recommended mounting dimensions of loudspeakers (*first revision*)
3028-1980 Methods of measurements of noise emitted by moving road vehicles (*first revision*)
3641-1976 Method of measurements on hearing aids (*first revision*)
4242-1967 Method of measurement of acoustical noise emitted by ballasts for gaseous discharge lamps
4406-1967 General requirements for hearing aids
4482-1967 Hearing aids
4755-1968 Reference zero for the calibration of pure tone audiometers
4758-1968 Methods of measurement of noise emitted by machines
6098-1971 Method of measurement of airborne noise emitted by rotating electrical machinery
6229-1980 Methods of measurement of real-ear protection of hearing protectors and physical attenuation of earmuffs (*first revision*)
6964-1973 Octave, half-octave and third-octave band filters for analysis of sound and vibrations
7136-1973 Megaphones
7194-1973 Assessment of noise exposure during work for hearing conservation purposes
7709-1975 Standard hydrophone
7741 loudspeakers
7741 (Part I)-1975 General requirements and tests
7741 (Part II)-1975 Direct radiator moving coil loudspeakers
7741 (Part III)-1975 Pressure unit operated horn loudspeakers
7741 (Part IV)-1977 Loudspeakers for community radio receivers
8146-1976 Method of measurement of reverberation time in auditoria
8159-1976 Scales and sizes for plotting frequency characteristics and polar diagram
8225-1976 Method of measurement of absorption coefficient in a reverberation room
9098-1979 Pure tone audiometers
9167-1979 Ear protectors
9302 Characteristics and methods of measurement for sound system equipment
9302 (Part I)-1979 General
9302 (Part II)-1979 Amplifiers
9302 (Part III)-1981 Microphones
9302 (Part IX/Sec 1)-1980 Programme level meters, Section 1 General
9302 (Part IX/Sec 2)-1980 Programme level meters, Section 2 Peak programme meters, Type 1
9302 (Part IX/Sec 3)-1981 Programme level meters, Section 3 Peak programme meters, Type 2
9302 (Part X)-1980 Preferred matching values for the interconnection of sound system components
9671-1980 Frequency weighting for the measurement of aircrafts noise (D-weighting)
9779-1981 Sound level meters