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(Reaffirmed 1995)

Indian Standard

MEASUREMENT OF SOUND INSULATION IN BUILDINGS AND OF BUILDING ELEMENTS

PART VI LABORATORY MEASUREMENTS OF IMPACT SOUND INSULATION OF FLOORS

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(*Continued on page* 2)

(*Continued from page* 1)

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MEASUREMENT OF SOUND INSULATION IN BUILDINGS AND OF BUILDING ELEMENTS

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0. FOREWORD

0.1 This Indian Standard (Part VI) was adopted by the Indian Standards Institution on 3 December 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 impact sound insulation of floors is one 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 IV	Field measurements of airborne sound insulation between rooms
Part V	Field measurements of airborne sound insulation of facade elements and facades
Part VII	Field measurements of impact sound insulation of floors
Part VIII	Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a standard floor

0.3 The results obtained can be used to compare the sound insulation properties of floors and to classify floors according to their sound insulation properties.

0.4 While preparing this standard, assistance has been derived from ISO/DIS 140/VI 'Measurement of sound insulation in buildings and of building elements: Part VI Laboratory measurements of impact sound insulation of floors' issued by 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*.

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1. SCOPE

1.1 This standard (Part VI) specifies a laboratory method of measuring impact noise transmission through floors by using a standard tapping machine.

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 terms.

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:

$$L = 10 \log_{10} \frac{p_1^2 + p_2^2 + \dots\dots\dots + p_n^2}{n p_0^2} \text{ dB} \quad \dots\dots\dots(1)$$

where

$p_1, p_2 \dots\dots\dots p_n$ = the rms sound pressures at n different positions in the room, and

$p_0 = 20/\text{u}pa$ = the reference sound pressure.

2.2 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. The quantity is denoted by L_1.

2.3 Normalized Impact Sound Pressure Level — The impact sound pressure level L_1 reduced by a correction term which is given in

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

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

decibels, being ten times the common logarithm of the ratio between the reference equivalent absorption area A_0 and the measured equivalent absorption area A of the receiving room. This quantity is denoted by L_n:

$$L_n = L_i - 10 \log 10 \frac{A_0}{A} \text{ dB} \quad \ldots\ldots\ldots(2)$$

where

$A_0 = 10 \text{ m}^2$

In all cases where it is uncertain whether results are obtained without flanking transmission, the normalized impact sound pressure level should be denoted by L_n.

2.4 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* IS : 9901 (Part VIII)-1981*]. This quantity is denoted by ΔL.

3. EQUIPMENT

3.1 The tapping machine being constructed in accordance with the following specifications serves as a standardized impact sound source. Further, the equipment shall be suitable for meeting the requirements of **5**.

3.2 The tapping machine should have five hammers placed in a line, the distance between the two end hammers being about 400 mm.

3.3 The time between successive impacts should be 100 ± 5 ms. The effective mass of each hammer should be 0·5 kg (within ± 2·5 percent).

3.4 The drop of a hammer on a flat floor should be equivalent, with respect to the momentum, to a free drop without friction of 40 mm (within ± 2·5 percent).

3.5 The part of the hammer which strikes the floor should be a cylinder of brass or steel, 3 cm in diameter, with a spherical end having a radius of about 50 cm.

3.6 Alternatively, especially in the case of a fragile floor covering, hammers may be used having the part that strikes the floor coated with a layer of rubber, of which the dimensions, composition and vulcanization are specified as follows.

*Measurement of sound insulation in buildings and of building elements: Part VIII Laboratory measurement of the reduction of transmitted standard impact noise by floor coverings on a standard floor.

3.7 The hammer with a rubber coating should geometrically resemble the hammers of brass or steel only. The part of each hammer below a plane perpendicular to the axis of the cylinder, at 5 mm distance from the lowest point of the curved end of the hammer, should be of rubber of the composition and vulcanization 'Cure' shown in Table 1.

TABLE 1 SPECIFICATION FOR RUBBER FOR HAMMER

Composition	Parts by Mass
Natural rubber	100
Zinc oxide	15
Stearic acid	2
Carbon black EPC	40
Phenyl betanaphthylamine	1
2·2-Benzothiazyl disulphide (Altax)	1·2
Diphenylguanidine	0·4
Sulphur	3

Cure: 45 min at 142°C and 290 kPa.

3.8 The rubber layer thus has a plane and a curved surface, and a maximum thickness of 5 mm. It should be stuck or vulcanized on the metal.

3.9 The distance between the supports of the tapping machine and the hammer line should be at least 100 mm.

4. TEST ARRANGEMENT

4.1 Receiving Room

4.1.1 Laboratory test facilities should meet the requirements of IS : 9901 (Part I)-1981*.

4.2 Test Specimen

4.2.1 The size of the test specimen is determined by the size of the test opening of the laboratory test facility as it is defined in IS : 9779-1981† that is between 10 m² and 20 m² with the shorter edge length not less than 2·3 m. The size of floor test specimen and elements comprising that specimen should be made as close as possible to the sizes of field installation.

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

†Specification for sound level meters.

NOTE — The test specimen 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 points within the specimen. The mounting conditions should be stated in the test report.

4.2.2 The sound transmitted by any indirect path should be negligible compared with the sound transmitted through the test specimen.

5. TEST PROCEDURE AND EVALUATION

5.1 Generation of Sound Field

5.1.1 The impact sound shall be generated by the tapping machine (*see* **3**). The position of the tapping machine shall be in accordance with **5.5**.

5.2 Measurement of Impact Sound Pressure Level

5.2.1 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 of a continuously moving microphone with an integration of p^2.

5.2.2 The indicating device should be designed to determine rms values of the sound pressure or corresponding pressure levels. If a sound level meter is used, it should conform to IS : 9779-1981* for precision sound level meters. It is recommended to use the meter response 'slow'. The complete measuring system including the microphone shall be calibrated before each series of measurements to absolute values for measurements in diffuse sound fields.

5.2.3 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 Table 2 shall be applied.

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

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

5.2.6 In cases where the impact insulation is high, relative to the airborne sound insulation, the airborne sound pressure level 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

*Specification for sound level meters.

TABLE 2 CORRECTION TO SOUND PRESSURE LEVEL READINGS
(*Clause* 5.2.3)

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

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.

5.3 Frequency Range of Measurements

5.3.1 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 IS : 6964-1973*.

5.3.2 Third-octave band filters having at least the following centre frequencies 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 Hz

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.

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 m³. For other volumes, these times should be multiplied by the factor $(V/180)^{\frac{1}{3}}$ (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.

*Specificaton for 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 (2) 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:

$$A = \frac{0{\cdot}163\ V}{T} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

where

A = equivalent absorption area in square metres,

V = receiving room volume in cubic metres, and

T = reverberation time in seconds.

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 Position of the Tapping Machine

5.5.1 The tapping machine should be placed in at least four different positions on the floor under test. In the case of an isotropic floor construction (ribs, beams, etc) more positions may be necessary. Besides, the hammer connection 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.

5.5.2 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 40 mm for the fall of the hammer.

5.6 Measurement Procedure

5.6.0 Each organization should determine a manual test procedure which complies with this standard.

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

a) Number and sizes of diffusing elements;

b) Positions of the tapping machine;

c) Minimum distance between microphone and room boundaries with regard to near fields;

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

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

e) Averaging time of the level; and

f) Method for determination of the equivalent absorption area, which involves a number of repeated readings in each position.

5.6.1.1 An example of typical test conditions is given in Appendix A.

6. PRECISION

6.1 It is required that the measurement procedure should give satisfactory repeatability. This can be determined in accordance with the method shown in IS : 9901 (Part II)-1981* and should be checked from time to time, particularly when a change is made in procedure or 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 impact sound insulation of the test specimen, the normalized impact sound pressure level should be given at all frequencies of measurement, preferably in the form of a curve.

7.2 The bandwidth used for the measurement and for the presentation shall be stated in every graph or table. If a numerical adjustment is made for the third-octave to octave bands, the graph or table of results shall bear the caption octave band levels calculated from third-octave band measurements.

7.3 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 (*see* IS : 8159-1976†).

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 floor construction and mounting conditions, with sectional drawing including the size and the flanking construction;

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

†Scales and sizes for plotting frequency characteristics and polar diagrams.

d) Volume of the receiving room;

e) Type of filters used;

f) Normalized impact sound pressure level of test specimen as a function of frequency;

g) Type of hammers used (without or with rubber covering);

h) Brief description or details of procedure and equipment (*see* **5.6**);

j) Limit of measurement in case the sound pressure level in any band is not measurable on account of back-ground noise (acoustical or electrical) or transmission of airborne noise; and

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

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

APPENDIX A

(*Clause* 5.6.1.1)

EXAMPLE OF TEST PROCEDURE

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

A-2. Where the receiving room is substantially rectangular with a volume of about 50 m^3 it 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. The diffusers should not be suspended from the ceiling under test.

A-3. Six positions of the tapping machine are chosen randomly distributed on a rigid floor, no position being closer than 1·0 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 0·7 m to the room boundaries or diffusers.

A-4. The readings of sound pressure level are taken using an averaging time of 5 s in each frequency band at each position.

A-5. 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 should have an averaging time equal to the traverse time, which should be a minimum of 30 s.

A-6. The equivalent absorption area should be determined from readings taken using three microphones positions with two reverberation time analyses at each position.

APPENDIX B

[*Clause* 8.1 (k)]

MEASURING OF FLANKING TRANSMISSION

B-1. In case 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:

$$L_V = 10 \log 10 \frac{v^2_1 + v^2_2 + \ldots\ldots\ldots\ldots + v^2_n}{n_V {v^2}_0} \text{ dB} \ldots\ldots\ldots\ldots (4)$$

where

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

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

B-2. 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.

B-3. 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:

$$W_k = \rho_c \, S_k v^2_k \, \sigma_k \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where

v^2_k 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.

B-4. 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:

$$L_k = L_{vk} + 10 \log_{10} \frac{4S_k}{A} \text{ dB} \qquad \ldots\ldots(6)$$

B-5. The resulting sound pressure level of all flanking constructions is:

$$L_{Df} = 10 \log_{10} \left(\sum_k 10^{L_k/10} \right) \text{dB} \qquad \ldots\ldots(7)$$

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2