International Standard 140/9

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Acoustics — Measurements of sound insulation in buildings and of building elements — Part 9 : Laboratory measurement of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it

Acoustique — Mesurage de l'isolation acoustique des immeubles et des éléments de construction — Partie 9 : Mesurage en laboratoire de l'isolation au bruit aérien de pièce à pièce par un plafond suspendu surmonté d'un vide d'air

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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Acoustics — Measurements of sound insulation in buildings and of building elements — Part 9 : Laboratory measurement of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it

1 Scope and field of application

This part of ISO 140 specifies a laboratory method of measuring the airborne sound insulation of a suspended ceiling with a plenum of defined height mounted above an acoustical barrier which separates two rooms of a specified test facility.

This method utilizes a laboratory space so arranged that it simulates a pair of horizontally adjacent, typical offices or rooms sharing a common suspended ceiling system, plenum space and a dividing wall. The dividing wall extends to the underside of the ceiling system which at the junction is either continuous or discontinuous.

The quantity being measured is the airborne sound insulation between two rooms of a specified test facility when the sound transmitted by paths other than the suspended ceiling and common plenum space is negligible. This quantity is called the suspended ceiling normalized level difference.

The method may be extended to include the study of composite ceiling systems comprising the ceiling material and other components such as luminaires and ventilating systems.

The method may also be extended to the study of the additional sound insulation that may be achieved by auxiliary systems, such as material used either as plenum barriers or as backing for all of, or part of, the ceiling.

2 References

ISO 140/2, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 2 : Statement of precision requirements.*

ISO 354, *Acoustics — Measurement of sound absorption in a reverberation room.*

ISO 717/1, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 1 : Airborne sound insulation in buildings and of interior building elements.*

IEC Publication 225, *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations.*

3 Definitions

For the purpose of this part of ISO 140, the following definitions apply.

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 and is expressed in decibels.

$$L = 10 \lg \frac{p_1^2 + p_2^2 + \ldots + p_n^2}{n p_0^2} \quad \ldots (1)$$

where

$p_1, p_2, \ldots, p_n$ are the r.m.s. sound pressures at n different positions in the room;

$p_0 = 20$ µPa 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 a sound source in one of the rooms. This quantity is denoted by D and is expressed in decibels.

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

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 suspended ceiling normalized level difference : The level difference corresponding to a reference value of absorption area in the receiving room. This quantity is denoted by $D_{n,c}$, and is expressed in decibels.

$$D_{n,c} = D - 10 \lg \frac{A}{A_0} \quad \ldots (3)$$

where

D is the level difference;

A is the equivalent absorption area in the receiving room;

A_0 is the reference absorption area. (For the laboratory, $A_0 = 10\ m^2$.)

3.4 plenum space : The whole of the void above the suspended ceilings in both rooms in the test facility, disregarding any sound-absorbing material stuck to the walls or laid on the back of the suspended ceiling.

4 Measuring equipment

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

5 Test arrangement

5.1 Requirements for the laboratory

The laboratory test facility is divided into two rooms of approximately equal volumes by a wall. The essential features of the test facility are specified in 5.1.1 to 5.1.6 and are shown schematically in the figure.

5.1.1 Construction of the test facility

The test facility shall be a rectangular parallelepiped. It is recommended that a vibration break be provided in the outer walls, floor and roof of the facility in order to ensure that flanking transmission by paths other than the suspended ceiling and common plenum space is negligible.

The level of the background noise shall be sufficiently low to permit a measurement of the sound transmitted from the source room, taking into consideration the power output of the source room and the isolating properties of the specimens for which the laboratory is intended. The reverberation time in each room shall be greater than 1 s at all one-third octave bands of measurement with no plenum lining and no test specimen in place.

NOTE — For the purposes of determining the reverberation time of each room, a suitable impervious plenum barrier should be installed between the top of the dividing wall and the roof.

5.1.2 Dimensions of the test facility

The width of the test facility shall be 4,5 ± 0,5 m and the height from the ground to the underside of the face of the suspended ceiling shall be 2,8 ± 0,2 m when all dimensions are measured internally.

The volume V of each room shall be at least 50 m^3 and the dividing wall shall be positioned such that the two room volumes differ by at least 10 % when the suspended ceiling is in position.

NOTES

1 It is realized that existing facilities may have room volumes less than 50 m^3, as low as 40 m^3. Such facilities will be allowable in accordance with this part of ISO 140 in cases where diffusing elements are used.

2 The requirements and recommendations, as stated above, are intended to improve reproducibility between measurements made by different organizations on similar materials.

5.1.3 Dividing wall

The dividing wall is the acoustical barrier which divides the test facility below the suspended ceiling into two rooms. The wall shall be tapered at its upper extremity so that its overall thickness at the capping is not greater than 100 mm. The tapering between the widest part of the wall and the capping shall be achieved by means of an angle not exceeding 30° from the vertical. The construction of the dividing wall shall be of such materials that its sound insulation is 10 dB more than that of any ceiling which is likely to be tested.

NOTE — For checking the sound insulation of the facility, a suitable plenum barrier of construction similar to the dividing wall can be installed between the top of the dividing wall and the roof.

5.1.4 Plenum depth

The plenum depth shall be between 650 and 760 mm as measured from the upper face of the suspended ceiling to the underside of the roof of the test facility.

5.1.5 Plenum lining

One sidewall and both endwalls of the plenum shall be lined with suitable sound-absorbing material. This material shall have such properties that when tested as a plane absorber in accordance with ISO 354, it has sound absorption coefficients not less than those shown in the table.

Table

Centre frequency Hz	125	250	500	1 000	2 000	4 000
Sound absorption coefficient, α_s	0,65	0,80	0,80	0,80	0,80	0,80

For the other sidewall and the roof, the sound absorption coefficient shall be less than 0,10 at all frequencies given in the table.

For practical purposes, the thickness of the lining shall not exceed 150 mm.

5.1.6 Diffusers

If necessary, diffusing elements may be installed in the rooms so as to improve the diffusion conditions.

5.2 Installation of the test ceiling

The detail of joining the ceiling to the top of the dividing wall is of critical importance and care shall be taken to simulate actual field conditions.

The area of a continuous ceiling shall be equal to the area given by the length and width of the test facility.

For a discontinuous ceiling, it may be necessary to add additional capping to the top of the dividing wall to complete the junction. The area of a discontinuous ceiling shall then be equal to the area given by the length and width of the test facility less the area of the capping on the top of the dividing wall.

The ceiling components shall be representative of those used in practice in actual field installations. The ceiling shall be installed in accordance with the recommended practice of the manufacturer or with the recommended practice of an installation standard.

6 Test procedure and evaluation

6.1 Generation of sound field in the source room

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

The sound power shall 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 shall be contained in one enclosure, the maximum dimension of which shall not exceed 0,7 m. The loudspeakers shall be driven in phase.

The loudspeaker enclosure shall be placed in each room to give as diffuse a sound field as possible and at such a distance from the suspended ceiling that the direct radiation upon it is not dominant.

6.2 Measurement of the average sound pressure level

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

One-third octave band filters having at least the following centre frequencies, in hertz, shall 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 shall be evaluated from the reverberation time measured in accordance with ISO 354 using the following formula :

$$A = \frac{0{,}163\,V}{T} \qquad \ldots (4)$$

where

A is the equivalent absorption area, in square metres;

V is the receiving room volume, in cubic metres, with the test ceiling in place;

T is the reverberation time of the receiving room, in seconds.

6.5 Measurement procedure

Each organization shall determine a normal test procedure which complies with this part of ISO 140.

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

— number, type and size 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 sound pressure 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 the annex.

6.6 Evaluation of suspended ceiling normalized level difference

The test procedure shall be repeated reversing the source and receiving rooms. The reported value of $D_{n,c}$ shall be the arithmetic average of the two results.

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 described in ISO 140/2.

It is recommended that different organizations in the same country should periodically perform comparison measurements on the same test specimen to check repeatability and reproducibility of their test procedures.

8 Statement of results

For the statement of results, the suspended ceiling normalized level difference of the test specimen 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 10 : 1 frequency ratio shall be equal to the length for 10 dB, 25 dB or 50 dB on the ordinate scale.

9 Test report

The test report shall make reference to this part of ISO 140 and shall include the following information :

a) the name of organization which performed the measurements;

b) the date of test;

c) a detailed description of the suspended ceiling tested, with sectional drawing and mounting conditions, including size, thickness, mass per unit area, number of suspension hangers and whether the ceiling is continuous or discontinuous at the partition capping, together with details of any luminaires, ventilating elements or other openings;

d) the ceiling test material, for example, acoustic tile. This information shall include the origin of manufacture and the manufacturer's descriptive code number;

e) the dimensions of the rooms used, including volume of rooms and plenum height of test facility;

f) the cross-sectional area above the dividing wall and construction of the plenum barrier (see 5.3) (if any);

g) the specification (and thickness) of any materials used in the plenum either as a barrier or a lining on the back of the specimen (or both);

h) a description of the junction of the dividing wall and the ceiling;

j) the type of noise and of filters used;

k) a brief description of details of test procedure and equipment (see 6.5);

m) the suspended ceiling normalized level difference as a function of frequency;

n) the equivalent sound absorption area measured in both rooms as function of frequency;

p) the limit of measurement in cases where the sound pressure level in any band is not measurable on account of background noise (acoustical or electrical).

For the evaluation of a single-number quantity from the curve $D_{n,c}(f)$, see ISO 717/1. This quantity is called the weighted suspended ceiling normalized level and is denoted by $D_{n,c,w}$.

Annex

Example of a test procedure

(This annex does not form an integral part of the standard.)

An example of a test procedure which will normally be expected to give repeatability as indicated in ISO 140/2 is given below.

The dimensions and shape of the test facility are shown in the figure. The walls, floor and roof of this structure are preferably constructed from heavy masonry.

The measurement is carried out in both directions with a loudspeaker installed in each room during the entire test. The suspended ceiling normalized level difference is measured separately for each direction of test; the value reported is the arithmetic average of the two results.

The loudspeaker is placed facing one corner of each room and the sound field in each room sampled with six randomly distributed microphone positions. No microphone is placed closer than 0,7 m to any surface and microphone positions are separated by a distance of at least 0,5 m. Sound pressure level readings are taken at each microphone position using an averaging time of at least 5 s in each frequency band at each position. One-third octave band filters are used.

The equivalent absorption area is determined from decay curves measured using six microphone positions with one reverberation time analysis at each position. The reverberation time is evaluated from the averaged slope over a convenient range beginning about one-tenth of a second or a few decibels down from the beginning of the decay, the range used being at least 20 dB, but not so large that the slope changes by 20 %, nor so that background noise interferes with the results.

Dimensions in millimetres

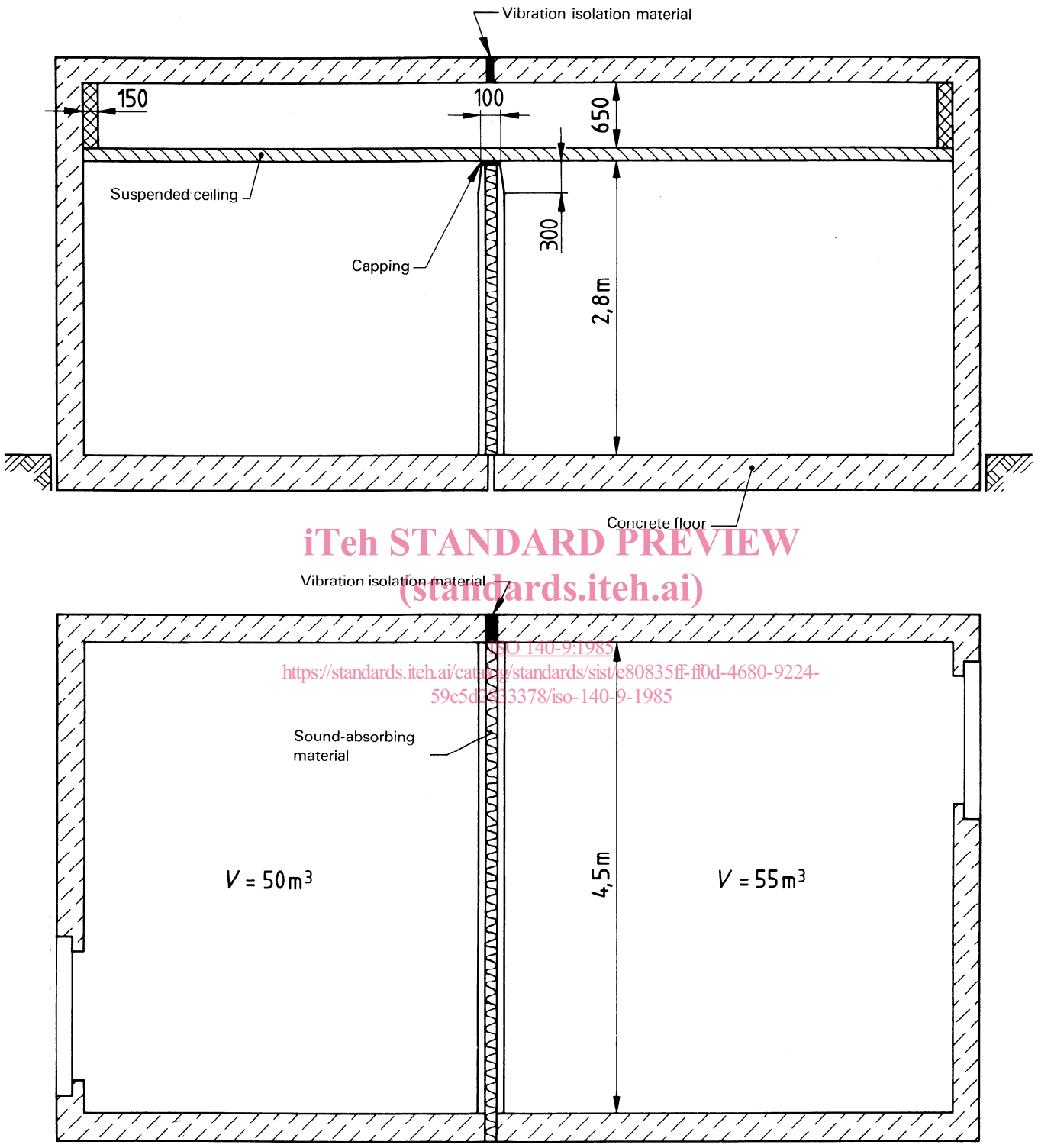

Figure — Cross-section and plan of the test facility
(The dimensions given are by way of example; the general requirements are specified in clause 5.)