INTERNATIONAL STANDARD

ISO 140-3

Second edition
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Acoustics — Measurement of sound insulation in buildings and of building elements —

Part 3: Laboratory measurements of airborne sound insulation of building elements

Acoustique — Mesurage de l'isolement acoustique des immeubles et des éléments de construction —

Partie 3: Mesurage en laboratoire de l'affaiblissement des bruits aériens par les éléments de construction

Reference number
ISO 140-3:1995(E)

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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 140-3 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

This second edition cancels and replaces the first edition (ISO 140-3:1978) and its amendment ISO 140-3:1978/Amd.1:1990.

ISO 140 consists of the following parts, under the general title *Acoustics — Measurement of sound insulation in buildings and of building elements*:

— *Part 1: Requirements for laboratory test facilities with suppressed flanking transmission*

— *Part 2: Determination, verification and application of precision data*

— *Part 3: Laboratory measurements of airborne sound insulation of building elements*

— *Part 4: Field measurements of airborne sound insulation between rooms*

— *Part 5: Field measurements of airborne sound insulation of facade elements and facades*

— *Part 6: Laboratory measurements of impact sound insulation of floors*

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— *Part 7: Field measurements of impact sound insulation of floors*

— *Part 8: Laboratory measurement of the reduction of transmitted impact noise by floor coverings on a solid standard floor*

— *Part 9: Laboratory measurement of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it*

— *Part 10: Laboratory measurement of airborne sound insulation of small building elements*

— *Part 12: Laboratory measurement of room-to-room airborne and impact sound insulation of an access floor*

Annexes A, B and C form an integral part of this part of ISO 140. Annexes D, E, F and G are for information only.

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Acoustics — Measurement of sound insulation in buildings and of building elements —

Part 3:
Laboratory measurements of airborne sound insulation of building elements

1 Scope

This part of ISO 140 specifies a laboratory method of measuring the airborne sound insulation of building elements such as walls, floors, doors, windows, façade elements and façades, except those classified as small building elements (for which a measuring method is specified in ISO 140-10[1]).

The results obtained can be used to design building elements with appropriate acoustic properties, to compare the sound insulation properties of building elements and to classify such elements according to their sound insulation capabilities.

The measurements are performed in laboratory test facilities in which transmission of sound on flanking paths is suppressed. Results of measurements made in accordance with this part of ISO 140 therefore shall not be applied directly in the field without accounting for other factors affecting sound insulation, especially flanking transmission and loss factor.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 140. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 140 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 140-1:—[2], *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 1: Requirements for laboratory test facilities with suppressed flanking transmission.*

ISO 140-2:1991, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 2: Determination, verification and application of precision data.*

ISO 354:1985, *Acoustics — Measurement of sound absorption in a reverberation room.*

ISO 717-1:—[3], *Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation.*

IEC 225:1966, *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations.*

IEC 651:1979, *Sound level meters.*

1) ISO 140-10:1991, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 10: Laboratory measurement of airborne sound insulation of small building elements.*

2) To be published. (Revision of ISO 140-1:1990)

3) To be published. (Revision of ISO 717-1:1982)

IEC 804:1985, *Integrating-averaging sound level meters.*

IEC 942:1988, *Sound calibrators.*

3 Definitions

For the purposes 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 squared sound pressure 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 (walls, etc.) is of significant influence.

This quantity is denoted by L and is expressed in decibels.

If a continuously moving microphone is used, L is determined by

$$L = 10 \lg \frac{\frac{1}{T_m}\int_0^{T_m} p^2(t)\,dt}{p_0^2} \text{ dB} \qquad \ldots (1)$$

where

p is the sound pressure, in pascals;

p_0 is the reference sound pressure and is equal to 20 µPa;

T_m is the integration time, in seconds.

If fixed microphone positions are used, L is determined by

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

where $p_1, p_2 \ldots, p_n$ are r.m.s. sound pressures at n different positions in the room. In practice, usually the sound pressure levels L_i are measured. In this case L is determined by

$$L = 10 \lg \frac{1}{n} \sum_{i=1}^{n} 10^{L_i/10} \text{ dB} \qquad \ldots (3)$$

where L_i are the sound pressure levels L_1 to L_n at n different positions in the room.

3.2 sound reduction index: Ten times the common logarithm of the ratio of the sound power W_1 which is incident on a partition under test to the sound power W_2 transmitted through the specimen.

This quantity is denoted by R and is expressed in decibels.

$$R = 10 \lg \frac{W_1}{W_2} \text{ dB} \qquad \ldots (4)$$

In this part of ISO 140 the sound reduction index is evaluated from

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

where

L_1 is the average sound pressure level in the source room, in decibels;

L_2 is the average sound pressure level in the receiving room, in decibels;

S is the area of the test specimen, in square metres, which is equal to the free test opening;

A is the equivalent sound absorption area in the receiving room, in square metres.

NOTES

1 The derivation of equation (5) from equation (4) assumes that the sound fields are perfectly diffuse and that the sound radiated into the receiving room is transmitted only through the specimen.

2 The expression "sound transmission loss" (TL) is also in use in English-speaking countries. It is equivalent to "sound reduction index".

3.3 apparent sound reduction index: Ten times the common logarithm of the ratio of the sound power W_1 which is incident on a partition under test to the total sound power transmitted into the receiving room if, in addition to the sound power W_2 transmitted through the specimen, the sound power W_3, transmitted by flanking elements or by other components, is significant.

This quantity is denoted by R' and is expressed in decibels.

$$R' = 10 \lg \left(\frac{W_1}{W_2 + W_3} \right) \text{ dB} \qquad \ldots (6)$$

In general, the sound power transmitted into the receiving room consists of the sum of several components. Also in this case, under the assumption that there are sufficiently diffuse sound fields in the two rooms, the apparent sound reduction index in this part of ISO 140 is evaluated from

$$R' = L_1 - L_2 + 10 \lg \frac{S}{A} \text{ dB} \qquad \ldots (7)$$

Thus, in the apparent sound reduction index, the sound power transmitted into the receiving room is related to the sound power which is incident on the test specimen as in equation (5), irrespective of the actual conditions of transmission.

4 Equipment

The equipment shall comply with the requirements of clause 6.

The accuracy of the sound level measurement equipment shall comply with the requirements of accuracy classes 0 or 1 defined in IEC 651 and IEC 804. Diffuse field calibration of the measurement equipment is required unless microphones with the same diffuse field frequency response are used in both the source and the receiving room.

If absolute values of sound pressure levels have to be obtained, the complete measuring system including the microphone shall be adjusted before each measurement using a sound calibrator which complies with the requirements of accuracy class 1 defined in IEC 942.

The third-octave band filters shall comply with the requirements defined in IEC 225.

The reverberation time measurement equipment shall comply with the requirements defined in ISO 354.

Requirements for the sound source are given in 6.1 and annex C.

NOTE 3 For pattern evaluation (type testing) and regular verification tests, recommended procedures for sound level meters are given in OIML R58 and OIML R88[4)].

5 Test arrangement

5.1 Rooms

Laboratory test facilities shall comply with the requirements of ISO 140-1.

5.2 Test specimen

The sound transmission of a specimen can depend on the temperature and relative humidity in the test rooms at time of test and/or during curing or conditioning of the test specimen. The conditions shall be reported.

5.2.1 Partitions

The size of the test partitions is determined by the size of the test opening of the laboratory test facility, as it is defined in ISO 140-1. These sizes are approximately 10 m^2 for walls, and between 10 m^2 and 20 m^2 for floors, with the shorter edge length for both walls and floors being not less than 2,3 m.

A smaller size is permissible 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 conditions and to local variations in sound fields.

Preferably install the test partition 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.

The sound reduction index of solid walls and floors depends strongly on coupling to surrounding structures. In order to describe properly the effect of the mounting, it is recommended to measure and to report the loss factor in these cases (see annex E).

If the test specimen is installed in an aperture between the source room and the receiving room, the ratio of the aperture depths shall be approximately 2:1 unless this is inconsistent with the practical use of the test specimen.

If the specimen has one surface which is significantly more absorbent than the other, the surface with the

4) OIML R58:1984, *Sound level meters.*

OIML R88:1989, *Integrating-averaging sound level meters.*

These documents may be obtained from: Organisation internationale de métrologie légale, 11, rue Turgot, 75009 Paris, France.

higher absorption shall face the source room. Install diffusing elements in the source room in such cases.

In laboratories complying with ISO 140-1, ensure that the sound transmitted by any indirect path is negligible compared with the sound transmitted through the test specimen. In order to verify this, the value of R'_{max} for the laboratory facility shall be measured. This is done with a highly insulating construction inserted in the test opening. The procedure to determine R'_{max} is given in annex A of ISO 140-1:—.

If the measured value of R' for a test specimen is less than or equal to (R'_{max} − 15 dB), the indirectly transmitted sound may be considered negligible and the result is called R.

If R' is larger than (R'_{max} − 15 dB), the contribution of the flanking transmission for this special case shall be investigated. The methods mentioned in annex D may be used. If necessary, try an improvement in flanking path suppression of the test facility.

Appropriate statements in the test report are necessary [see l) of clause 9] if finally R' is larger than (R'_{max} − 15 dB). No calculated corrections shall be applied with the exception of measurements on doors, windows, glazings and façade elements (see annex B).

If the test specimen is smaller than the test opening, a preliminary test shall be carried out to ensure that sound power transmitted through the surrounding partition is small compared with the sound power transmitted through the test specimen. This may be checked by the methods described in annex D.

5.2.2 Doors, windows, glazings and façade elements

5.2.2.1 General

The test specimen shall be tested in the same manner as a partition (see 5.2.1). If the test specimen is smaller than the test opening, a special partition of sufficiently high sound insulation shall be built into the test opening and the specimen shall be placed in that partition. The sound transmitted through this partition and any other indirect path should be negligible compared with the sound transmitted through the test specimen. If this is not the case, the test results shall be corrected (see annex B).

If the test specimen is intended to be readily 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 five times immediately before testing.

Doors shall be inserted so that the lower edge is situated as near as possible to the level of the floor of the test rooms to reproduce conditions in the actual building.

For glazings, windows, doors, etc., the area S is the area of the opening in the filler wall required to accomodate the test specimen.

The sound insulation of certain glazing systems or elements, especially those incorporating laminated glass, may be dependent on the room temperature during the measurements. It is recommended that the sound insulation measurements on such test specimens are made at 20 °C ± 3 °C in both rooms. The test specimens should be stored for 24 h at the test temperature. In addition, it can be advantageous to make measurements at temperatures similar to those for which the test object is designed.

NOTES

4 As the sound insulation of windows, doors and small façade elements depends on the dimensions, the sound insulation in practice could differ considerably if a construction has an area other than the one tested in the laboratory.

It is unlikely that test specimens (especially window panes) whose areas have a ratio of up to 2:1 will show differences in sound insulation greater than 3 dB in the single-number quantity. With an area greater than that which has been tested, a lower sound insulation will generally result. Accurate, reliable values can be obtained only by measuring a test object of the size of interest.

5 Measurements on square specimens can yield smaller sound insulation than measurements on rectangular ones with the same area.

5.2.2.2 Installation of windows

The installation of a window assembly shall be as near as possible to the method which would be used in practice. When the window is mounted in the test opening, the niches on both sides of the windows shall have different depths, preferably in a ratio of about 2:1, unless this conflicts with the particular design of the window. However, it is to be expected that results obtained with niche depths of different ratios will differ.

The gap between the window and the test opening (about 10 mm to 13 mm around the window when mounted in the test opening) should be filled with absorbing material (for example, mineral wool) and made airtight using an elastic sealant on both sides or in accordance with the manufacturer's instructions.

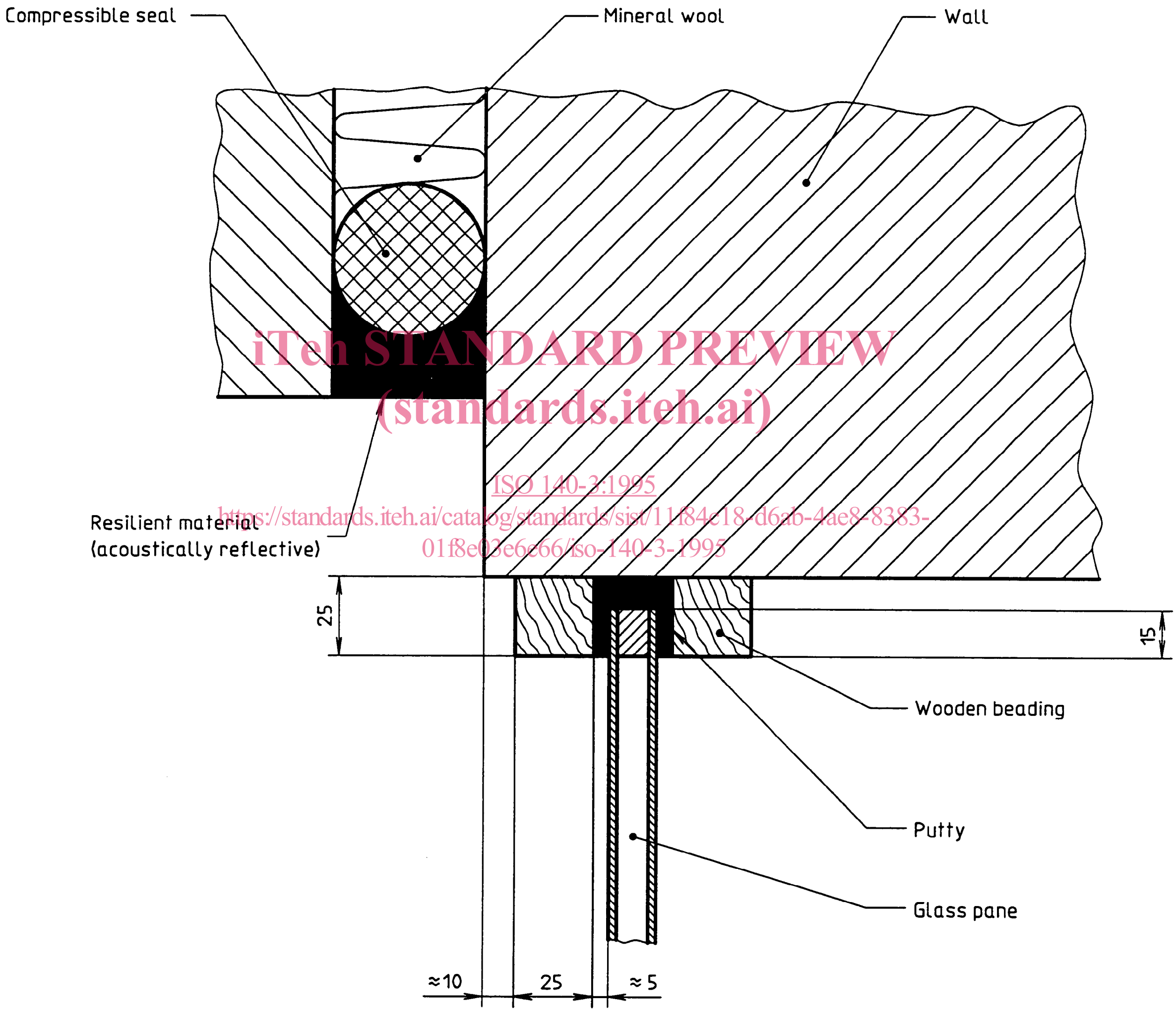
5.2.2.3 Installation of glass panes

The glass pane shall be installed into the test opening so that the niches on both sides of the glass pane have different depths with a ratio of 2:1. A gap of about 10 mm shall remain between the glass and the reveal of the test opening. This gap shall be filled with putty as specified in annex A.

To fix the test specimen, two wooden beads (25 mm × 25 mm) shall be used (see figure 1). The space between the pane and the locking ledge shall be filled with putty, as described in annex A, about 5 mm thick. The beads shall cover not more than 15 mm and not less than 12 mm of the glass[5].

NOTE 6 The sound insulation measured for a type of glazing does not necessarily represent the sound insulation of a window with that glazing. Preferably, therefore, the complete windows should be measured as well to obtain information on sound insulation of the windows and not only of the glazing.

Dimensions in millimetres



NOTE — This example shows a double-glazed pane installed directly into the (smaller) aperture of a double filler wall (see ISO 140-1:—, annex C for more details).

Figure 1 — Installation of a glass pane

5) This method of mounting and sealing a glass pane into the test opening is given as a practical, quick, airtight and reproducible solution, although this is not the type of mounting in practice.

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 have a continuous spectrum in the frequency range considered. If filters are used, use those with a bandwidth of at least one-third octave. If broad-band noise is used, the spectrum may be shaped to ensure an adequate signal-to-noise ratio at high frequencies in the receiving room (white noise is recommended). In either case, the sound spectrum in the source room shall not have differences in level greater than 6 dB between adjacent one-third-octave bands.

The sound power should be sufficiently high for the sound pressure level in the receiving room to be at least 15 dB higher than the background level in any frequency band. If this is not fulfilled, corrections shall be applied as shown in 6.5.

If the sound source enclosure contains more than one loudspeaker operating simultaneously, the loudspeakers shall be driven in phase or it shall be assured in other ways that the radiation is uniform and omnidirectional, as specified in C.1.3. It is permissible to use multiple sound sources simultaneously, provided that they are of the same type and are driven at the same level by similar, but uncorrelated, signals. Continuously moving loudspeakers may be used. When using a single sound source, it shall be operated in at least two positions. They shall be in the same room or the measurements shall be repeated in the opposite direction by changing source and receiving room with one or more source positions in each room. If one surface of the test object is significantly more absorbent than the other, the measurements shall be made in one direction only (see 5.2.1).

Place the loudspeaker enclosure so 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. The sound fields in the rooms depend strongly on the type and on the position of the sound source. Qualification of the loudspeakers and of the loudspeaker positions shall be performed using the procedures given in annex C. Guidance for the use of continuously moving loudspeakers is given in C.2.5.

6.2 Measurement of average sound pressure level

6.2.1 General

Obtain the average sound pressure level by using a single microphone moved from position to position, or by an array of fixed microphones, or by a continuously moving microphone, or by swinging the microphone. The sound pressure levels at the different microphone positions shall be averaged on an energy basis [see equations (1) to (3)] for all sound source positions.

6.2.2 Microphone positions

As a minimum, five microphone positions shall be used in each room; these shall be distributed within the maximum permitted space throughout each room, spaced uniformly (see annex C for guidance on the position of microphones).

The following separating distances are minimum values and shall be exceeded where possible:

0,7 m between microphone positions;

0,7 m between any microphone position and room boundaries or diffusers;

1,0 m between any microphone position and the sound source;

1,0 m between any microphone position and the test specimen.

When using a moving microphone, the sweep radius shall be at least 1 m. The plane of the traverse shall be inclined in order to cover a large proportion of the permitted room space and shall not lie in any plane within 10° of a room surface. The duration of a traverse period shall be not less than 15 s.

6.2.3 Averaging time

At each individual microphone position, the averaging time shall be at least 6 s at each frequency band with centre frequencies below 400 Hz. For bands of higher centre frequencies, it is permissible to decrease the time to not less than 4 s. Using a moving microphone, the averaging time shall cover a whole number of traverses and shall be not less than 30 s.

6.3 Frequency range of measurements

The sound pressure level shall be measured using one-third-octave band filters having at least the following centre frequencies, in hertz:

100	125	160	200	250	315
400	500	630	800	1 000	1 250
1 600	2 000	2 500	3 150	4 000	5 000

If additional information in the low-frequency range is required, use one-third-octave band filters with the following centre frequencies, in hertz:

50 63 80

Guidance is given in annex F for such additional measurements in the low-frequency bands.

6.4 Measurement of reverberation time and evaluation of the equivalent sound absorption area

The correction term of equation (5) containing the equivalent sound absorption area is evaluated from the reverberation time measured according to ISO 354 and determined using Sabine's formula

$$A = \frac{0{,}16V}{T} \qquad \ldots (8)$$

where

A is the equivalent sound absorption area, in square metres;

V is the receiving room volume, in cubic metres;

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

Following ISO 354, the evaluation of the reverberation time from the decay curve shall begin about 0,1 s after the sound source has been switched off, or from a sound pressure level a few decibels lower than that at the beginning of the decay. The range used shall not be less than 20 dB, and should not be so large that the observed decay cannot be approximated by a straight line. The bottom of this range shall be at least 10 dB above the background noise level.

The minimum number of decay measurements required for each frequency band is six. At least one loudspeaker position and three microphone positions with two readings in each case shall be used.

Moving microphones which meet the requirements of 6.2.2 may be used but the traverse time shall be not less than 30 s.

6.5 Correction for background noise

Measurements of background noise levels shall be made to ensure that the observations in the receiving room are not affected by extraneous sound such as noise from outside the test room, electrical noise in the receiving system, or electrical cross-talk between the source and the receiving systems. To check the latter condition, replace the microphone by a dummy microphone or replace the loudspeaker by an equivalent impedance. The background level shall be at least 6 dB (and preferably more than 15 dB) below the level of signal and background noise combined.

If the difference in levels is smaller than 15 dB but greater than 6 dB, calculate corrections to the signal level according to the equation

$$L = 10 \lg\left(10^{L_{sb}/10} - 10^{L_b/10}\right) \text{ dB} \qquad \ldots (9)$$

where

L is the adjusted signal level, in decibels;

L_{sb} is the level of signal and background noise combined, in decibels;

L_b is the background noise level, in decibels.

If the difference in levels is less than or equal to 6 dB in any of the frequency bands, use the correction 1,3 dB corresponding to a difference of 6 dB. In that case, R shall be given in the measurement report so that it clearly appears that the reported R values are the limit of measurement [see l) of clause 9].

7 Precision

It is required that the measurement procedure gives satisfactory repeatability. This shall be determined in accordance with the method shown in ISO 140-2 and shall be verified from time to time, particularly when a change is made in the procedure or instrumentation.

NOTE 7 Numerical requirements for repeatability are given in ISO 140-2.

8 Expression of results

For the statement of the airborne sound insulation of the test specimen, the values of the sound reduction index shall be given at all frequencies of measurement, to one decimal place, in tabular form and in the form of a curve. Graphs in the test report shall show