INTERNATIONAL STANDARD

ISO 140-5

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

Part 5:
Field measurements of airborne sound insulation of façade elements and façades

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

Partie 5: Mesurages in situ de la transmission des bruits aériens par les éléments de façade et les façades

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 140-5 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

This second edition cancels and replaces the first edition (ISO 140-5:1978), which has been technically revised.

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 of laboratory test facilities with suppressed flanking transmission*

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

— *Part 3: Laboratory measurement 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 façade elements and façades*

— *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 measurements of the reduction of transmitted impact noise by floor coverings on a heavyweight 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*

Annexes A and B form an integral part of this part of ISO 140. Annexes C to F are for information only.

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

Part 5:
Field measurements of airborne sound insulation of façade elements and façades

1 Scope

This part of ISO 140 specifies two series of methods (element methods and global methods) for measurement of the airborne sound insulation of façade elements and whole façades, respectively. The element methods aim to estimate the sound reduction index of a façade element, for example a window. The most accurate element method uses a loudspeaker as an artificial sound source. Other, less accurate, element methods use available traffic noise. The global methods, on the other hand, aim to estimate the outdoor/indoor sound level difference under actual traffic conditions. The most accurate global methods use the actual traffic as sound source. In addition, a loudspeaker may be used as an artificial sound source. An overview of the methods is given in table 1.

The element loudspeaker method yields an apparent sound reduction index which, under certain circumstances [e.g. taking account of measurement precision (see 7.1)], can be compared with the sound reduction index measured in laboratories in accordance with ISO 140-3 or ISO 140-10. This method is the preferred method when the aim of the measurement is to evaluate the performance of a specified façade element in relation to its performance in the laboratory.

The element road traffic method will serve the same purposes as the element loudspeaker method. It is particularly useful when, for different practical reasons, the element loudspeaker method cannot be used. These two methods will often yield slightly different results. The road traffic method tends to result in lower values of the sound reduction index than the loudspeaker method. In annex D this road traffic method is supplemented by the corresponding aircraft and railway traffic methods.

The global road traffic method yields the real reduction of a façade in a given place relative to a position 2 m in front of the façade. This method is the preferred method when the aim of the measurement is to evaluate the performance of a whole façade, including all flanking paths, in a specified position relative to nearby roads. The result cannot be compared with that of laboratory measurements.

The global loudspeaker method yields the sound reduction of a façade relative to a position 2 m in front of the façade. This method is particularly useful when, for different practical reasons, the real noise source cannot be used. The result cannot be compared with that of laboratory measurements.

Table 1 — Overview of the different measurement methods

No.	Method	Reference	Result	Field of application
	Element			
1	Element loudspeaker	Clause 5	$R'_{45°}$	Preferred method to estimate the apparent sound reduction index of façade elements
2	Element road traffic	Clause 6	$R'_{tr,s}$	Alternative to method No.1 when road traffic noise of sufficient level is available
3	Element railway traffic	Annex D (informative)	$R'_{rt,s}$	Alternative to method No.1 when railway traffic noise of sufficient level is available
4	Element air traffic	Annex D (informative)	$R'_{at,s}$	Alternative to method No.1 when air traffic noise of sufficient level is available
	Global			
5	Global loudspeaker	Clause 5	$D_{ls,2m,nT}$ $D_{ls,2m,n}$	Alternative to methods Nos. 6, 7 and 8
6	Global road traffic	Clause 6	$D_{tr,2m,nT}$ $D_{tr,2m,n}$	Preferred method to estimate the global sound insulation of a façade exposed to road traffic noise
7	Global railway traffic	Annex D (informative)	$D_{rt,2m,nT}$ $D_{rt,2m,n}$	Preferred method to estimate the global sound insulation of a façade exposed to railway traffic noise
8	Global air traffic	Annex D (informative)	$D_{at,2m,nT}$ $D_{at,2m,n}$	Preferred method to estimate the global sound insulation of a façade exposed to air traffic noise

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 edition of the standards indicated below. Members of IEC and ISO maintain registers of currently valid international standards.

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 140-3:1995, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 3: Laboratory measurements of airborne sound insulation of building elements.*

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

ISO 717-1:1996, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation.*

IEC 60651:1979, *Sound level meters.*

IEC 60804:1985, *Integrating-averaging sound level meters.*

IEC 60942:1991, *Sound calibrators.*

IEC 61260:1995, *Electroacoustics — Octave band filters and fractional — Octave band filters.*

3 Definitions

For the purposes of this part of ISO 140, the definitions given in ISO 140-3 and the following definitions apply.

3.1 average sound pressure level on a test surface, $L_{1,s}$: Ten times the logarithm to the base 10 of the ratio of the surface and time average of the sound pressure squared to the square of the reference sound pressure, the surface average being taken over the entire test surface including reflecting effects from the test specimen and façade; it is expressed in decibels.

3.2 average sound pressure level in a room, L_2: Ten times the logarithm to the base 10 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, window, etc.) is of significant influence; it is expressed in decibels.

3.3 equivalent continuous sound pressure level, L_{eq}: Value of the sound pressure level of a continuous steady sound that, within the measurement time interval, has the same mean square sound pressure as the sound under consideration, the level of which varies with time; it is expressed in decibels.

3.4 sound reduction index, R: Ten times the logarithm to the base 10 of the ratio of the sound power W_1 incident on the test specimen to the sound power W_2 transmitted through the specimen:

$$R = 10 \lg \left(\frac{W_1}{W_2} \right) \text{ dB} \quad \text{. . . (1)}$$

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

3.5 apparent sound reduction index, R'**:** Ten times the logarithm to the base 10 of the ratio of the sound power W_1 which is incident on the test specimen to the total sound power transmitted into the receiving room, if, in addition to the sound power W_2 radiated by the specimen, sound power W_3 radiated by flanking elements or by other components is significant:

$$R' = 10 \lg \left(\frac{W_1}{W_2 + W_3} \right) \text{ dB} \quad \text{. . . (2)}$$

3.6 apparent sound reduction index, $R'_{45°}$: Measure of the airborne sound insulation of a building element when the sound source is a loudspeaker and when the angle of sound incidence is 45°. The angle of sound incidence is the angle between the loudspeaker axis directed towards the centre of the test specimen and the normal to the surface of the façade. The apparent sound reduction index is then calculated from equation (3):

$$R'_{45°} = L_{1,s} - L_2 + 10 \lg \left(\frac{S}{A} \right) \text{ dB} - 1{,}5 \text{ dB} \quad \text{. . . (3)}$$

where

$L_{1,s}$ is the average sound pressure level on the surface of the test specimen, as defined in 3.1;

L_2 is the average sound pressure level in the receiving room, as defined in 3.2;

S is the area of the test specimen, determined as given in annex A;

A is the equivalent sound absorption area in the receiving room.

NOTE This equation is based on the assumption that the sound is incident from one angle only, 45°, and that the sound field in the receiving room is perfectly diffuse.

3.7 apparent sound reduction index, $R'_{tr,s}$: Measure of the airborne sound insulation of a building element when the sound source is traffic noise and the outside microphone position is on the test surface. The apparent sound reduction index is then calculated from equation (4):

$$R'_{tr,s} = L_{eq,1,s} - L_{eq,2} + 10 \lg\left(\frac{S}{A}\right) \text{dB} - 3 \text{ dB} \quad \ldots (4)$$

where

$L_{eq,1,s}$ is the average value of the equivalent continuous sound pressure level on the surface of the test specimen including reflecting effects from the test specimen and façade;

$L_{eq,2}$ is the average value of the equivalent continuous sound pressure level in the receiving room;

S and A are as given in 3.6.

3.8 level difference, D_{2m}: Difference, in decibels, between the outdoor sound pressure level 2 m in front of the façade, $L_{1,2m}$, and the space and time averaged sound pressure level, L_2, in the receiving room:

$$D_{2m} = L_{1,2m} - L_2 \quad \ldots (5)$$

NOTE If traffic noise is used as the sound source, the notation is $D_{tr,2m}$. If a loudspeaker is used, it is $D_{ls,2m}$.

3.9 standardized level difference, $D_{2m,nT}$: Level difference, in decibels, corresponding to a reference value of the reverberation time in the receiving room:

$$D_{2m,nT} = D_{2m} + 10 \lg\left(\frac{T}{T_0}\right) \text{dB} \quad \ldots (6)$$

where T_0 = 0,5 s.

NOTE If traffic noise is used as the sound source, the notation is $D_{tr,2m,nT}$. If a loudspeaker is used, it is $D_{ls,2m,nT}$.

3.10 normalized level difference, $D_{2m,n}$: Level difference, in decibels, corresponding to the reference absorption area in the receiving room:

$$D_{2m,n} = D_{2m} - 10 \lg \frac{A}{A_0} \text{ dB} \quad \ldots (7)$$

where A_0 = 10 m^2.

NOTE If traffic noise is used as the sound source, the notation is $D_{tr,2m,n}$. If a loudspeaker is used, it is $D_{ls,2m,n}$.

4 Equipment

4.1 General

The microphone shall have a maximum diameter of 13 mm.

The sound pressure level measurement equipment shall meet the requirements of a class 0 or 1 instrument according to IEC 60651 or IEC 60804. The measurement chain shall be calibrated by using a class 1 or better acoustical calibrator according to IEC 60942.

The one-third-octave band filters and, if relevant, the octave band filters shall meet the requirements of IEC 61260.

The reverberation time measurement equipment shall meet the requirements of ISO 354.

4.2 Loudspeaker

The directivity of the loudspeaker in a free field shall be such that the local differences in the sound pressure level in each frequency band of interest are less than 5 dB, measured on an imaginary surface of the same size and orientation as the test specimen.

NOTE If the loudspeaker method is adapted to large test specimens, i.e. specimens where one dimension exceeds 5 m, differences up to 10 dB can be accepted. This should then be reported in the measurement report.

5 Measurement with loudspeaker noise

5.1 General

Two methods, the element and the global loudspeaker method, are described.

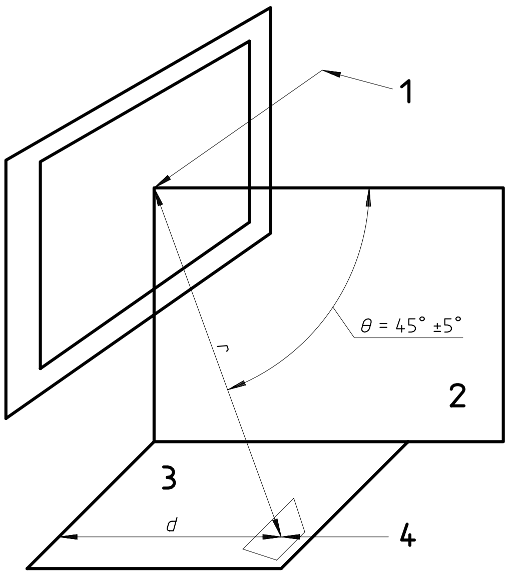
The element loudspeaker method will yield an estimate of the apparent sound reduction index which, under specified circumstances, can be compared with the sound reduction index for the corresponding façade elements obtained in laboratories.

The global loudspeaker method will quantify the airborne sound insulation of a whole façade or even a whole building in a specified situation. This result cannot be compared with laboratory measurements.

5.2 Principle

The loudspeaker is placed in one or more positions outside the building at a distance d from the façade, with the angle of sound incidence equal to $(45 \pm 5)°$ (see figure 1).

The average sound pressure level is determined either directly on the test specimen (the element method) or 2 m in front of the façade (the global method), as well as in the receiving room. The apparent sound reduction index $R'_{45°}$ or the level difference $D_{ls,2m}$ is calculated.



Key

1 Normal to the façade
2 Vertical plane
3 Horizontal plane
4 Loudspeaker

Figure 1 — Geometry of the loudspeaker method

5.3 Generation of sound field

The sound field generated shall be steady and have a continuous spectrum in the frequency range considered. If the measurements are made in one-third-octave bands, frequency bands with centre frequencies from at least 100 Hz to 3 150 Hz, preferably from 50 Hz to 5 000 Hz, shall be used. If the measurements are made in octave bands, frequency bands with centre frequencies from at least 125 Hz to 2 000 Hz, preferably from 63 Hz to 4 000 Hz, shall be used. In addition, the differences between the sound power levels in the one-third-octave bands belonging to an octave band shall not be greater than 6 dB in the 125 Hz octave band, 5 dB in the 250 Hz band, and 4 dB in bands of higher centre frequencies.

In all relevant frequency bands, the sound power level of the sound source shall be high enough to give a sound pressure level in the receiving room that exceeds the background noise level by at least 6 dB.

5.4 Position of the loudspeaker

Choose the position of the loudspeaker and the distance d to the façade so that the variation of the sound pressure level on the test specimen is minimized. This implies that the sound source is preferably placed on the ground. Alternatively, place the sound source as high above the ground as is possible in practice.

The distance r from the sound source to the centre of the test specimen shall be at least 5 m (d > 3,5 m) for the element loudspeaker method, and at least 7 m (d > 5 m) for the global loudspeaker method. The angle of the sound incidence shall be (45±5)°(see figure 1).

5.5 Measurements in the receiving room

5.5.1 General

Obtain the average sound pressure level in the receiving room by using a single microphone moved from position to position, or by an array of fixed microphones, or by a continuously moving or oscillating microphone. The sound pressure levels at the different microphone positions shall be averaged on an energy basis for all sound source positions. In addition, determine the background noise level L_b.

5.5.2 Microphone positions

As a minimum, five microphone positions shall be used in each room to obtain the average sound pressure level of each sound field. These positions shall be distributed within the maximum permitted space throughout each room, spaced uniformly.

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

— 0,7 m between microphone positions;

— 0,5 m between any microphone position and room boundaries or objects in the room;

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

When using a moving microphone, the sweep radius shall be at least 0,7 m. The plane of the traverse shall be inclined in order to cover a large portion 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.

5.5.3 Corrections for background noise

Measure background noise levels 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 receiving systems.

The background level should be at least 6 dB (and preferably more than 10 dB) below the level of the signal and background noise combined. If the difference in levels is smaller than 10 dB but greater than 6 dB, calculate corrections to the signal level according to equation (8):

$$L = 10 \lg \left(10^{L_{sb}/10} - 10^{L_b/10} \right) \text{ dB} \qquad \dots (8)$$

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 indicate D_n, D_{nT} or R' values in the measurement report so that it is clear that the reported values are the limit of measurement [see i) of clause 9].

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

The correction term in equation (6) containing the equivalent sound absorption area is evaluated from the reverberation time measured in accordance with ISO 354 and determined using Sabine's formula:

$$A = \frac{0{,}16\, V}{T} \qquad \dots (9)$$

where

A is the equivalent 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, begin the evaluation of the reverberation time from the decay curve 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. Use a range neither less than 20 dB nor 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 6.3.2 may be used, but the traverse time shall be not less than 30 s.

NOTE If the reverberation time is extremely short (e.g. shorter than about 0,4 s), a moving microphone may be problematical.

5.6 Element loudspeaker method

5.6.1 Test requirements

If the purpose of the measurement is to obtain results as comparable as possible to those of laboratory measurements, carry out the following steps:

a) verify that the façade element under test is in accordance with the specified construction and is properly mounted according to the manufacturer's instructions;

b) estimate the sound reduction index of the façade to ensure that the sound transmission through the wall surrounding the test specimen does not contribute significantly to the sound pressure level in the receiving room.

If the purpose of the measurement is to compare the sound insulation of a window with the results of laboratory measurements, verify in addition that the area of the test opening is representative of that of the laboratories and that the niche opening and the window position in the niche do not deviate from the requirements given in ISO 140-3.

Annex C outlines some examples for carrying out these checks. In case of doubt about unacceptably high sound transmission through the wall surrounding the test specimen, the procedure described in annex B shall be carried out.

5.6.2 Measurements on the outer surface of the façade element

Determine the average sound pressure level $L_{1,s}$ on the test surface. Carry out the measurements either with the microphone fastened directly on the actual test specimen with its axis parallel to the plane of the façade and directed upwards or downwards, or with its axis pointing in the direction normal to the test specimen. The distance from the test specimen to the centre of the microphone membrane shall be 10 mm or shorter, depending on the diameter of the microphone, if the axis of the microphone is parallel to the test surface, and 3 mm or shorter if the axis is normal to the test surface. If fastened, the microphone shall be fastened to the test specimen with a strong, adhesive tape. Equip the microphone with a hemispherical windscreen (see figure 2).

If simultaneous measurements are carried out outdoors and indoors, only microphone types which, including cables, have been shown not to affect the sound insulation of the test specimen should be used if the microphone is fastened to the test specimen.

Choose between three and ten measurement positions depending on the difference in the sound pressure levels between the positions. Distribute the measurement positions evenly but asymmetrically on the measurement surface. It is recommended to begin with three measurement positions (n=3). If the difference in the sound pressure level between two positions in one frequency is more than n, increase the number of measurement positions up to ten. If the test specimen is mounted in a recess of the façade, always choose ten measurement positions. If the difference in the sound pressure levels between the measurement positions is more than 10 dB, this shall be stated in the measurement report.

As an alternative to several fixed positions, a scanning microphone is allowed provided that the distance to the façade element can be kept constant and provided that the background noise is kept at least 10 dB below the signal level.

Average the n positions as given by equation (10):

$$L_{1,s} = 10 \lg(10^{L_1/10} + 10^{L_2/10} + .. + 10^{L_n/10}) - 10 \lg(n) \text{ dB} \qquad (10)$$

where L_1, L_2 ,...., L_n are the sound pressure levels in positions 1,2,..., n.

NOTE The differences in the sound pressure levels depend among other things on the height h above the ground, recesses, balconies and the position of the test specimen.

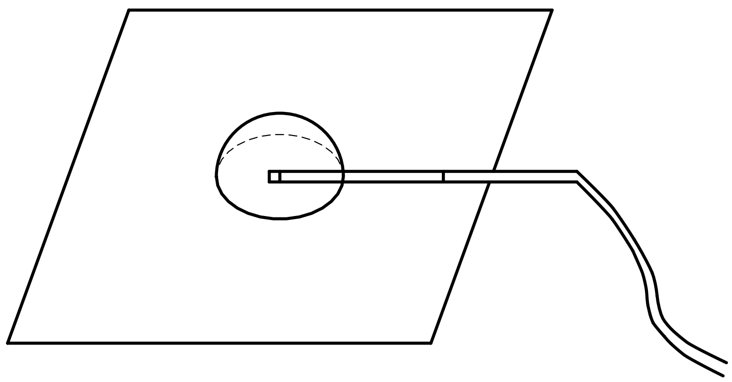


Figure 2 — Flush-mounted microphone