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Acoustics — Field measurement of sound insulation in buildings and of building elements —

Part 1:
Airborne sound insulation

Acoustique — Mesurage in situ de l'isolation acoustique des bâtiments et des éléments de construction —

Partie 1: Isolation des bruits aériens

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

This first edition of ISO 16283-1 cancels and replaces ISO 140-4:1998, ISO 140-5:1998, ISO 140-7:1998, and ISO 140-14:2004, which have been technically revised.

ISO 16283 consists of the following parts, under the general title *Acoustics — Field measurement of sound insulation in buildings and of building elements*:

— *Part 1: Airborne sound insulation*

— *Part 2: Impact sound insulation*[1)]

— *Part 3: Façade sound insulation*[2)]

1) To be published.

2) Under development.

Introduction

ISO 16283 (all parts) describes procedures for field measurements of sound insulation in buildings. Airborne, impact and façade sound insulation are described in ISO 16283-1, ISO 16283-2[3] and ISO 16283-3[4], respectively.

Field sound insulation measurements that were described previously in ISO 140-4, −5, and −7 were (a) primarily intended for measurements where the sound field could be considered to be diffuse, and (b) not explicit as to whether operators could be present in the rooms during the measurement. ISO 16283 differs from ISO 140-4, −5, and −7 in that (a) it applies to rooms in which the sound field may or may not approximate to a diffuse field, (b) it clarifies how operators can measure the sound field using a hand-held microphone or sound level meter and (c) it includes additional guidance that was previously contained in ISO 140-14.

NOTE Survey test methods for field measurements of airborne and impact sound insulation are dealt with in ISO 10052.

3) To be published.

4) Under development.

Acoustics — Field measurement of sound insulation in buildings and of building elements —

Part 1:
Airborne sound insulation

1 Scope

This part of ISO 16283 specifies procedures to determine the airborne sound insulation between two rooms in a building using sound pressure measurements. These procedures are intended for room volumes in the range from 10 m^3 to 250 m^3 in the frequency range from 50 Hz to 5 000 Hz. The test results can be used to quantify, assess and compare the airborne sound insulation in unfurnished or furnished rooms where the sound field may or may not approximate to a diffuse field. The measured airborne sound insulation is frequency-dependent and can be converted into a single number quantity to characterize the acoustic performance using the rating procedures in ISO 717-1.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 3382-2, *Acoustics — Measurement of room acoustic parameters — Part 2: Reverberation time in ordinary rooms*

ISO 12999-1, *Acoustics — Determination and application of measurement uncertainties in building acoustics — Part 1: Sound insulation*[1)]

ISO 18233, *Acoustics — Application of new measurement methods in building and room acoustics*

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61183, *Electroacoustics — Random-incidence and diffuse-field calibration of sound level meters*

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

1) To be published.

3.1
energy-average sound pressure level in a room
L
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, with the space average taken over the central zone of the room where the direct radiation from any loudspeaker or the nearfield radiation from the room boundaries has negligible influence

Note 1 to entry: *L* is expressed in decibels.

3.2
corner sound pressure level in a room
L_{Corner}
ten times the common logarithm of the ratio of the highest time average squared sound pressure from the set of corner measurements to the square of the reference sound pressure, for the low-frequency range (50, 63, and 80 Hz one-third octave bands)

Note 1 to entry: L_{Corner} is expressed in decibels.

3.3
low-frequency energy-average sound pressure level in a room
L_{LF}
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 in the low-frequency range (50, 63, and 80 Hz one-third octave bands) where the space average is a weighted average that is calculated using the room corners where the sound pressure levels are highest and the central zone of the room where the direct radiation from any loudspeaker or the nearfield radiation from the room boundaries has negligible influence

Note 1 to entry: L_{LF} is expressed in decibels.

Note 2 to entry: L_{LF} is an estimate of the energy-average sound pressure level for the entire room volume.

3.4
reverberation time
T
time required for the sound pressure level in a room to decrease by 60 dB after the sound source has stopped

Note 1 to entry: *T* is expressed in seconds.

3.5
background noise level
measured sound pressure level in the receiving room from all sources except the loudspeaker in the source room

3.6
fixed microphone
microphone that is fixed in space by using a device such as a tripod so that it is stationary

3.7
mechanized continuously-moving microphone
microphone that is mechanically moved with approximately constant angular speed in a circle, or is mechanically swept along a circular path where the angle of rotation about a fixed axis is between 270° and 360°

3.8
manually-scanned microphone
microphone attached to a hand-held sound level meter or an extension rod that is moved by a human operator along a prescribed path

3.9
manually-held microphone
microphone attached to a hand-held sound level meter or a rod that is hand-held at a fixed position by a human operator at a distance at least an arm's length from the trunk of the operator's body

3.10
partition
total surface of the separating partition between the source and receiving rooms

Note 1 to entry: For two rooms which are staggered vertically or horizontally, the total surface of the separating partition is not visible from both sides of the partition; hence it is necessary to define the partition as the total surface.

3.11
common partition
part of the partition that is common to both the source and receiving rooms

3.12
level difference
D
difference in the energy-average sound pressure levels between the source and receiving rooms with one or more loudspeakers in the source room which is calculated using Formula (1)

$$D = L_1 - L_2 \tag{1}$$

where

L_1 is the energy-average sound pressure level in the source room when its volume is larger than or equal to 25 m^3 or the low-frequency energy-average sound pressure level (50 Hz, 63 Hz and 80 Hz bands only) in the source room when its volume is smaller than 25 m^3;

L_2 is the energy-average sound pressure level in the receiving room when its volume is larger than or equal to 25 m^3 or the low-frequency energy-average sound pressure level (50 Hz, 63 Hz and 80 Hz bands only) in the receiving room when its volume is smaller than 25 m^3

Note 1 to entry: *D* is expressed in decibels.

3.13
standardized level difference
D_{nT}
level difference that is standardized to a reference value of the reverberation time in the receiving room and calculated using Formula (2)

$$D_{nT} = D + 10\lg\frac{T}{T_0} \tag{2}$$

where

T is the reverberation time in the receiving room;

T_0 is the reference reverberation time; for dwellings, T_0 = 0,5 s.

Note 1 to entry: D_{nT} is expressed in decibels.

Note 2 to entry: The level difference is referenced to a reverberation time of 0,5 s because in dwellings with furniture the reverberation time has been found to be reasonably independent of volume and frequency and to be approximately equal to 0,5 s. With this standardization, D_{nT} is dependent on the direction of the sound transmission if the source and receiving rooms have different volumes; D_{nT} will be higher when the test is carried out from a smaller source room to a larger receiving room compared to the reverse situation. For this reason, regulations that require testing to show compliance with a minimum standard of airborne sound insulation usually require that the smaller room is used as the receiving room so that the lowest D_{nT} values are measured.

Note 3 to entry: D_{nT} provides a straightforward link to the subjective impression of airborne sound insulation.

3.14
apparent sound reduction index
R’
ten times the common logarithm of the ratio of the sound power, W_1, which is incident on a test element to the total sound power radiated into the receiving room if, in addition to the sound power, W_2, radiated by the test element, the sound power, W_3, radiated by flanking elements or by other components, is significant

$$R' = 10 \lg \frac{W_1}{W_2 + W_3} \tag{3}$$

and the apparent sound reduction index is evaluated using Formula (4)

$$R' = D + 10 \lg \frac{S}{A} \tag{4}$$

where

S	is the area of the common partition, in square metres;
A	is the equivalent absorption area of the receiving room, in square metres.

Note 1 to entry: *R’* is expressed in decibels.

Note 2 to entry: In general, the sound power transmitted into the receiving room consists of the sum of several components from different elements (walls, floor, ceiling etc.).

Note 3 to entry: *R’* can be used to compare field measurements with laboratory measurements of the sound reduction index, *R*. In comparison to D_{nT} it has a weaker link to the subjective impression of airborne sound insulation.

Note 4 to entry: When *R’* is determined in the 50 Hz, 63 Hz and 80 Hz bands using the low-frequency procedure the link to sound power in Formula (3) is not exact.

3.15
equivalent absorption area
A
sound absorption area which is calculated using Sabine’s formula in Formula (5)

$$A = \frac{0{,}16V}{T} \tag{5}$$

where

V	is the receiving room volume, in cubic metres;
T	is the reverberation time in the receiving room.

Note 1 to entry: *A* is expressed in square metres.

4 Instrumentation

4.1 General

The instruments for measuring sound pressure levels, including microphone(s) as well as cable(s), windscreen(s), recording devices and other accessories, if used, shall meet the requirements for a class 0 or 1 instrument according to IEC 61672-1 for random incidence application.

Filters shall meet the requirements for a class 0 or 1 instrument according to IEC 61260.

The reverberation time measurement equipment shall comply with the requirements defined in ISO 3382-2.

4.2 Calibration

At the beginning and at the end of every measurement session and at least at the beginning and the end of each measurement day, the entire sound pressure level measuring system shall be checked at one or more frequencies by means of a sound calibrator meeting the requirements for a class 0 or 1 instrument according to IEC 60942. Each time the calibrator is used, the sound pressure level measured with the calibrator should be noted in the field documentation of the operator. Without any further adjustment, the difference between the readings of two consecutive checks shall be less or equal to 0,5 dB. If this value is exceeded, the results of measurements obtained after the previous satisfactory check shall be discarded.

4.3 Verification

Compliance of the sound pressure level measuring instrument, the filters and the sound calibrator with the relevant requirements shall be verified by the existence of a valid certificate of compliance. If applicable, random incidence response of the microphone shall be verified by a procedure from IEC 61183. All compliance testing shall be conducted by a laboratory being accredited or otherwise nationally authorized to perform the relevant tests and calibrations and ensuring metrological traceability to the appropriate measurement standards.

Unless national regulations dictate otherwise, it is recommended that the sound calibrator should be calibrated at intervals not exceeding 1 year, the compliance of the instrumentation system with the requirements of IEC 61672-1 should be verified at intervals not exceeding two years, and the compliance of the filter set with the requirements of IEC 61260 should be verified at intervals not exceeding two years.

5 Frequency range

All quantities 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

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

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

4 000, 5 000

NOTE Measurement of additional information in the low- and high-frequency ranges is optional.

6 General

Determination of the airborne sound insulation according to this part of ISO 16283 requires that one room is chosen as the source room which will contain the loudspeaker(s), and another is chosen as the receiving room. The measurements that are required include the sound pressure levels in both rooms with the source(s) operating, the background noise in the receiving room when all sources are switched off and the reverberation times in the receiving room.

Two measurement procedures are described that shall be used for the sound pressure level, the reverberation time and the background noise; a default procedure and an additional low-frequency procedure.

For the sound pressure level and the background noise, the default procedure for all frequencies is to use a fixed microphone or a manually-held microphone moved from one position to another, an array of fixed microphones, a mechanized continuously-moving microphone or a manually-scanned microphone. These measurements are taken in the central zone of a room at positions away from the room boundaries. Different approaches are described to sample the sound pressure so that the operator can choose the most suitable approach for the source room and receiving room. The main consideration for the source room concerns the hearing protection to be used by the human operator. For the receiving room the aim is to minimize the effect of background noise for which the operator has to decide whether it is advantageous to be present in the room in order to listen for intermittent background noise or to be outside the room to ensure that the background noise is unaffected by the operator.

For the sound pressure level and the background noise, the low-frequency procedure shall be used for the 50 Hz, 63 Hz, and 80 Hz one-third octave bands in the source and/or receiving room when its volume is smaller than 25 m^3 (calculated to the nearest cubic metre). This procedure is carried out in addition to the default procedure and requires additional measurements of the sound pressure level in the corners of the source and/or receiving room using either a fixed microphone or a manually-held microphone.

NOTE 1 The low-frequency procedure is necessary in small rooms due to large spatial variations in the sound pressure level of the modal sound field. In these situations, corner measurements are used to improve the repeatability, reproducibility and relevance to room occupants.

If necessary to avoid hearing damage, hearing protection should be worn by the operator when measuring the sound pressure level in the source room and, if necessary, when measuring reverberation times in the receiving room. When measuring sound pressure levels in the receiving room that will not cause hearing damage it is advisable to remove any hearing protection so that the operator is aware of short external noise events that could invalidate the measurement as well as helping the operator to minimize self-generated noise.

For the reverberation time, the low-frequency procedure shall be used for the 50 Hz, 63 Hz, and 80 Hz one-third octave bands in the source and/or receiving room when its volume is smaller than 25 m^3 (calculated to the nearest cubic metre).

If using methods of signal processing described in ISO 18233 the measurements shall be carried out using fixed microphones and shall not use a mechanized continuously-moving microphone, manually-held microphone or a manually-scanned microphone.

The sound fields in typical rooms (furnished or unfurnished) will rarely approximate to a diffuse sound field over the entire frequency range from 50 Hz to 5000 Hz. The default and low-frequency procedures allow for measurements to be taken without any knowledge as to whether the sound field can be considered as diffuse or non-diffuse. For this reason, the sound field should not be modified for the purpose of the test by temporarily introducing additional furniture or diffusers into one or both rooms (furnished or unfurnished).

NOTE 2 If measurements with additional diffusion are required, for example due to regulatory requirements or because the test result is to be compared with a laboratory measurement on a similar test element, then the introduction of three diffusers will usually be sufficient each with an area of at least 1,0 m^2.

All measurement methods for the default procedure or the low-frequency procedure are equivalent. In case of dispute, the airborne sound insulation determined using measurement methods without an operator inside the source and/or receiving room shall be taken to be the reference result.

NOTE 3 A reference result is defined for two reasons. Firstly, because an operator will introduce additional absorption in the source room that is not present when the operator is taking measurements in the receiving room. This potentially changes the sound field that is measured in both rooms, although in many situations the effect will be negligible. Secondly, the background noise level with manual scanning is prone to variation in the self-generated noise from the operator that does not tend to occur with fixed microphones or a mechanized continuously-moving microphone.

7 Default procedure for sound pressure level measurement

7.1 General

Sound pressure level measurements are used to determine the average level in the central zone of the source and receiving rooms with the loudspeaker(s) in operation, and the background noise level in the receiving room when the loudspeaker is switched off.

Sound shall be generated in the source room using loudspeakers operated simultaneously in at least two positions, or a single loudspeaker moved to at least two positions.

The sound power of the loudspeaker(s) should be sufficiently high for the sound pressure level in the receiving room to be significantly above the background noise level as described in Clause 9.

Additional guidance on measurement procedures is given in Annexes C, D and E.

7.2 Generation of sound field

7.2.1 General

Use a single loudspeaker or multiple loudspeakers operating simultaneously provided that they are of the same type and are driven at the same level by similar, but uncorrelated, signals. The loudspeaker(s) shall be stationary during the measurement. Each loudspeaker shall comply with the directivity requirements in Annex A.

The sound generated in the source room shall be steady and have a continuous spectrum over the frequency range that is measured. Parallel measurements over the required range of one-third octave bands can be taken using a broadband noise signal. If filtering of the source signal is used for each frequency band under test, use a filter with a corresponding centre-band frequency that has a bandwidth of at least one-third octave.

The energy-average sound pressure level in the source room shall not have a difference in level of more than 8 dB between adjacent one-third octave bands, at least above 100 Hz. In situations where this cannot be achieved with a broadband noise source, serial measurements in one-third octave bands shall be used with band-limited noise.

White or pink noise is recommended as a broadband noise signal. However, the spectrum might need to be shaped to ensure an adequate signal-to-noise ratio at high frequencies in the receiving room.

NOTE 1 A graphic equaliser is often essential as there may be situations where the 8 dB requirement cannot be met without shaping the source signal. If the 8 dB requirement is not satisfied at low-frequencies it may be possible to satisfy the requirement by changing the loudspeaker position as well as equalising the source signal.

7.2.2 Loudspeaker positions

The distance between the room boundaries and the loudspeaker shall be at least 0,5 m and should be at least 1,0 m when the boundary is the separating partition. This distance shall be measured from the boundary to the centre of the speaker unit that is closest to this boundary.

Different loudspeaker positions shall not be located within planes parallel to the room boundaries that are less than 0,7 m apart. The distance between different positions shall be at least 0,7 m. At least two positions shall be at least 1,4 m apart.

When measuring the airborne sound insulation of a floor with the loudspeaker(s) in the upper room, the base of the loudspeaker(s) shall be at least 1,0 m above the floor.

7.3 Fixed microphone positions

7.3.1 General

Fixed microphones may be used without an operator in the room by using a microphone fixed on a tripod. Alternatively the operator can be present in the room with the microphone fixed on a tripod, or with the operator using a manually-held microphone at a fixed position; in both cases the trunk of the operator's body shall remain at a distance at least an arm's length from the microphone. Averaging times shall satisfy the requirements in 7.7.1.

7.3.2 Number of measurements

a) When multiple loudspeakers are operated simultaneously, a minimum of five microphone positions shall be used in each room. These shall be distributed within the maximum permitted space throughout each room. No two microphone positions shall lie in the same plane relative to the room boundaries and the positions shall not be in a regular grid.

b) When using a single loudspeaker, a minimum of five microphone positions shall be used in each room for each loudspeaker position (additional sets of microphone positions may be different from the first set of positions). Each set of microphone positions shall be distributed within the maximum permitted space throughout each room. No two microphone positions shall lie in the same plane relative to the room boundaries and the positions shall not be in a regular grid.

7.3.3 Multiple loudspeakers operating simultaneously

Measure the sound pressure levels in both the source and receiving rooms. Calculate the energy-average sound pressure level in both the source and receiving rooms according to 7.8 then make any required correction for background noise according to 9.2. Calculate the standardized level difference using Formula (1) and Formula (2) or the apparent sound reduction index using Formula (1) and Formula (4).

7.3.4 Single loudspeaker operated at more than one position

Measure the sound pressure level in both the source and receiving rooms for the first loudspeaker position. Calculate the energy-average sound pressure level in both the source and receiving rooms according to 7.8 then make any required correction for background noise according to 9.2. For this loudspeaker position, calculate the standardized level difference using Formula (1) and Formula (2) or the apparent sound reduction index using Formula (1) and Formula (4). Both source and receiving room levels shall be measured before the loudspeaker is moved. Repeat this process for the other loudspeaker position(s). Calculate the standardized level difference using Formula (6) or the apparent sound reduction index using Formula (7):

$$D_{nT} = -10 \lg \frac{1}{m} \sum_{j=1}^{m} 10^{-D_{nT,j}/10} \qquad (6)$$

$$R' = -10\lg \frac{1}{m} \sum_{j=1}^{m} 10^{-R'_j/10} \qquad (7)$$

where

m is the number of loudspeaker positions;

$D_{nT,j}$ is the standardized level difference for loudspeaker position j;

R_j' is the apparent sound reduction index for loudspeaker position j.

7.4 Mechanized continuously-moving microphone

7.4.1 General

The microphone shall be mechanically moved with approximately constant angular speed in a circle, or shall be mechanically swept along a circular path where the angle of rotation about a fixed axis is between 270° and 360°. The sweep radius for the circular traverse shall be at least 0,7 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 that is less than 10° from any room surface (wall, floor or ceiling).

The duration of a single traverse shall be at least 15 s. Each complete traverse may need to be repeated to satisfy the requirements on the averaging time in 7.7.2.

7.4.2 Number of measurements

a) When multiple loudspeakers are operated simultaneously, at least one measurement shall be carried out using the continuously-moving microphone. The location of the fixed point about which the continuously-moving microphone moves shall be changed for each different set of loudspeaker positions. The same number of measurements shall be taken at each location.

b) When using a single loudspeaker, a minimum of one measurement using the continuously-moving microphone shall be carried out for each loudspeaker position. The location of the fixed point about which the continuously-moving microphone moves may be changed for each loudspeaker position. The same number of measurements shall be taken at each location.

7.4.3 Multiple loudspeakers operating simultaneously

Measure the sound pressure level in both the source and receiving rooms. Calculate the energy-average sound pressure level in both the source and receiving rooms according to 7.8 then make any required correction for background noise according to 9.2. Calculate the standardized level difference using Formula (1) and Formula (2) or the apparent sound reduction index using Formula (1) and Formula (4).

7.4.4 Single loudspeaker operated at more than one position

Measure the sound pressure level in both the source and receiving rooms for the first loudspeaker position. Calculate the energy-average sound pressure level in both the source and receiving rooms according to 7.8 for the first loudspeaker position then make any required correction for background noise according to 9.2. For this loudspeaker position, calculate a standardized level difference using Formula (1) and Formula (2) or an apparent sound reduction index using Formula (1) and Formula (4). Both source and receiving room levels shall be measured before the loudspeaker is moved. Repeat this process for the other loudspeaker positions. Calculate the standardized level difference using Formula (6) or the apparent sound reduction index using Formula (7).