BS EN ISO 16283-2:2015

BSI Standards Publication

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

Part 2: Impact sound insulation

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee EH/1/6, Building acoustics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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European foreword

This document (EN ISO 16283-2:2015) has been prepared by Technical Committee ISO/TC 43 "Acoustics" in collaboration with Technical Committee CEN/TC 126 “Acoustic properties of building elements and of buildings” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of aidentical text or by endorsement, at the latest by June 2016, and conflicting national standards shall be withdrawn at the latest by June 2016.

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Foreword

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

This first edition of ISO 16283-2 cancels and replaces 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*

— *Part 3: Façade sound insulation*

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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 and ISO 16283-3, respectively.

Field sound insulation measurements that were described previously in ISO 140-4, ISO 140-5, and ISO 140-7 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 (all parts) differs from ISO 140-4, ISO 140-5, and ISO 140-7 in that a) it applies to rooms in which the sound field might, or might 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.

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

Part 2: Impact sound insulation

1 Scope

This part of ISO 16283 specifies procedures to determine the impact sound insulation using sound pressure measurements with an impact source operating on a floor or stairs in a building. 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 impact sound insulation in unfurnished or furnished rooms where the sound field might, or might not approximate to a diffuse field.

Two impact sources are described: the tapping machine and the rubber ball. These impact sources do not exactly replicate all possible types of real impacts on floors or stairs in buildings.

The tapping machine can be used to assess a variety of light, hard impacts such as footsteps from walkers wearing hard-heeled footwear or dropped objects. A single number quantity can be calculated using the rating procedures in ISO 717-2. This single number quantity links the measured impact sound insulation using the tapping machine to subjective assessment of general impacts in dwellings that occur on floors or stairs in a building. The tapping machine is also well-suited to the prediction of impact sound insulation using ISO 15712-2. These two aspects facilitate the specification of impact sound insulation in national building requirements using only measurements with the tapping machine as an impact source.

The rubber ball can be used to assess heavy, soft impacts such as from walkers in bare feet or children jumping, as well as quantifying absolute values that can be related to human disturbance in terms of a Fast time-weighted maximum sound pressure level. At present, calculation procedures for a single number quantity do not currently exist in an ISO Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable to 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 717-2, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 2: Impact 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*

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*

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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

3.1
energy-average impact sound pressure level in a room
L_i
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 where the impact source is the tapping machine and the space average is taken over the central zone of the room where nearfield radiation from the room boundaries has negligible influence

Note 1 to entry: L_i is expressed in decibels.

3.2
corner impact sound pressure level in a room
$L_{i,Corner}$
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 Hz, 63 Hz, and 80 Hz one-third octave bands) where the impact source is the tapping machine

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

3.3
low-frequency energy-average impact sound pressure level in a room
$L_{i,LF}$
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 Hz, 63 Hz, and 80 Hz one-third octave bands) where the impact source is the tapping machine and 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 nearfield radiation from the room boundaries has negligible influence

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

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

3.4
energy-average maximum impact sound pressure level in a room
$L_{i,Fmax}$
ten times the common logarithm of the ratio of the space average of the squared maximum sound pressure with Fast time weighting to the square of the reference sound pressure where the impact source is the rubber ball and the space average is taken over the central zone of the room where nearfield radiation from the room boundaries has negligible influence

Note 1 to entry: $L_{i,Fmax}$ is expressed in decibels.

3.5
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.

3.6
background noise level
measured sound pressure level in the receiving room from all sources except the impact source

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3.7
fixed microphone
microphone that is fixed in space by using a device such as a tripod so that it is stationary

3.8
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°

3.9
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

3.10
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

3.11
partition
total surface of the floor or stair which is excited by the impact source

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.

3.12
common partition
part of the floor or stair that is common to both the room in which the impact source is used and the receiving room

3.13
standardized impact sound pressure level
L'_{nT}
impact sound pressure level, L_i, reduced by a correction term which is given in decibels, being ten times the common logarithm of the ratio of the measured reverberation time, T, to the reference reverberation time, T_0, which is calculated using Formula (1) when the impact source is the tapping machine:

$$L'_{nT} = L_i - 10 \lg \frac{T}{T_0} \tag{1}$$

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: L'_{nT} is expressed in decibels.

Note 2 to entry: The impact sound pressure level 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.

Note 3 to entry: L'_{nT} provides a straightforward link to the subjective impression of impact sound insulation.

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3.14
normalized impact sound pressure level
L'_n
impact sound pressure level, L_i, increased by a correction term which is given in decibels, being ten times the common logarithm of the ratio between the measured equivalent absorption area, A, of the receiving room and the reference equivalent absorption area, A_0, which is calculated using Formula (2) when the impact source is the tapping machine:

$$L'_n = L_i + 10\lg\frac{A}{A_0} \tag{2}$$

where

A is the equivalent absorption area in the receiving room;

A_0 is the reference equivalent absorption area; for dwellings, A_0 = 10 m^2.

Note 1 to entry: L'_n is expressed in decibels.

3.15
standardized maximum impact sound pressure level
$L'_{i,Fmax,V,T}$
maximum impact sound pressure level, $L_{i,Fmax}$, increased by a correction term for room volume and reduced by a correction term for reverberation time and Fast time weighting which is calculated using Formulae (3), (4) and (5) when the impact source is the rubber ball:

$$L'_{i,Fmax,V,T} = L_{i,Fmax} + 10\lg\frac{V}{V_0} - 10\lg\left[\frac{1-C_0^{-1}}{1-C^{-1}}\left(\frac{C^{(1-C)^{-1}} - C^{-\left(1-C^{-1}\right)^{-1}}}{C_0^{(1-C_0)^{-1}} - C_0^{-\left(1-C_0^{-1}\right)^{-1}}}\right)\right] \tag{3}$$

$$C_0 = \frac{T_0}{1.7275} \tag{4}$$

$$C = \frac{T}{1.7275} \tag{5}$$

where

T is the reverberation time in the receiving room;

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

V is the receiving room volume, in cubic metres;

V_0 is the reference receiving room volume; for dwellings, V_0 = 50 m^3.

Note 1 to entry: $L'_{i,Fmax,V,T}$ is expressed in decibels.

Note 2 to entry: Background information can be found in Reference [15].

3.16
equivalent absorption area
A
hypothetical area of a totally absorbing surface without diffraction effects which, if it were the only absorbing element in the room, would give the same reverberation time as the room under consideration and is calculated using Sabine's formula in Formula (6):

$$A = \frac{0{,}16V}{T} \tag{6}$$

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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 in accordance with IEC 61672-1 for random incidence application.

Filters shall meet the requirements for a class 0 or 1 instrument in accordance with IEC 61260.

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

The impact sources shall meet the requirements given in Annex A.

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 in accordance with 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.

NOTE Unless national regulations dictate otherwise, it is recommended that the sound calibrator be calibrated at intervals not exceeding one 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

5.1 Tapping machine as the impact source

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

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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.

5.2 Rubber ball as the impact source

All quantities shall be measured using one-third octave or octave band filters.

One-third octave band filters shall have at least the following centre frequencies, in hertz:

50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630

6 General

Determination of the impact sound insulation in accordance to this part of ISO 16283 requires that one room is chosen as the receiving room into which sound is radiated due to an impact source operating on a partition. The room or space in which the impact source is operated is referred to as the source room.

The measurements that are required include the sound pressure levels in the receiving room with the impact source operating, the background noise levels in the receiving room when the impact source is switched off and the reverberation times in the receiving room.

Two impact sources are described: the tapping machine and the rubber ball.

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 requires measurements to be taken in the central zone of a room at positions away from the room boundaries. With the tapping machine as the impact source, the default procedure for all frequencies is to obtain the energy-average sound pressure level using 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. With the rubber ball as the impact source, the default procedure for all frequencies is to obtain the energy-average sound pressure level using a fixed microphone or a manually-held microphone moved from one position to another or an array of fixed microphones.

For the sound pressure level and the background noise with the tapping machine as the impact source, the low-frequency procedure shall be used for the 50 Hz, 63 Hz, and 80 Hz one-third octave bands in the receiving room when its volume is smaller than 25 m^3 (calculated to the nearest cubic metre). This procedure should be carried out in addition to the default procedure and requires additional measurements of the sound pressure level in the corners of the 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.

NOTE 2 The low-frequency procedure is not used with the rubber ball because no link has yet been shown between any combination of measurements from the corners and central zone of a room for the maximum Fast time-weighted sound pressure level and the maximum Fast time-weighted sound pressure level that is spatially averaged over the entire room volume.

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NOTE 3 If necessary to avoid hearing damage, hearing protection is 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 receiving room when its volume is smaller than 25 m^3 (calculated to the nearest cubic metre).

If using methods of signal processing for reverberation times 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 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 the receiving room.

NOTE 4 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, 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 impact sound insulation determined using measurement methods without an operator inside the receiving room shall be taken to be the reference result.

NOTE 5 A reference result is defined because the background noise level with manual scanning is prone to variation in the self-generated noise from the operator. Significant variation 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 shall be used to determine the average level in the central zone of the receiving room with the impact source in operation, and the background noise level in the receiving room when the impact source is not operational.

7.2 Generation of sound field

7.2.1 General

The impact sound shall be generated using the tapping machine or the rubber ball as the impact source.

7.2.2 Impact source positions for the tapping machine as impact source

The tapping machine shall be placed in at least four different positions randomly distributed on the floor under test. The distance of the tapping machine from the edges of the floor shall be at least 0,5 m. In the case of anisotropic floor constructions with beams, ribs, etc., more positions may be necessary. The hammer connecting line should be orientated at 45° to the direction of the beams or ribs.

The impact sound pressure levels may reveal a time dependency after the tapping is started. In such a case the measurements should not begin until the noise level has become steady. If stable conditions are

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not reached after 5 min, then the measurements should be carried out over a well-defined measurement period. The measurement period shall be reported.

NOTE Time dependency sometimes occurs with soft or fragile floor surfaces as during each impact the hammers can change the contact stiffness or damage the surface directly underneath the hammers.

When floors with soft coverings are under test, the tapping machine shall fulfil the special requirements given in Annex A. Advice regarding the mounting of the tapping machine on soft floor coverings is given in Annex A.

7.2.3 Impact source positions for the rubber ball as impact source

The impact sound shall be generated by dropping the rubber ball vertically in a free fall from a height of 100 ± 1 cm measured from the bottom of the rubber ball to the surface of the floor under test.

The excitation by the rubber ball shall be made at four or more different positions on the floor or stairs under test. For a lightweight floor with joists, one of these positions should be above the joists and one position should be at the centre point of the floor.

7.3 Fixed microphone positions for the tapping machine or rubber ball as impact source

7.3.1 General

With the tapping machine or the rubber ball as the impact source, fixed microphones may be used without an operator in the room using a microphone fixed on a tripod. Alternatively, the operator may 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. For the tapping machine as the impact source, the averaging times shall satisfy the requirements in 7.7.1.

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.

7.3.2 Number of measurements

The number of microphone positions shall equal the number of tapping machine positions or integer multiples of the number of tapping machine positions.

The same number of microphone positions shall be used for each tapping machine position.

If four or five tapping machine positions are used, at least two measurements of impact sound pressure level shall be made for each tapping machine position. Measurements shall be made in at least two different microphone positions for each tapping machine position.

If six or more tapping machine positions are used, at least one measurement of impact sound pressure level shall be made for each tapping machine position. Measurements shall be carried out at a different microphone position for each tapping machine position.

7.3.3 Tapping machine operated at more than one position

Measure the sound pressure level in the receiving room for the first impact source position. Calculate the energy-average sound pressure level according to 7.8.1 then make any required correction for background noise according to 9.2. Calculate the standardized impact sound pressure level using Formula (1) or the normalized impact sound pressure level using Formula (2). Repeat this process for

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the other impact source position(s) then calculate the standardized impact sound pressure level using Formula (7) or the normalized impact sound pressure level using Formula (8):

$$L'_{\mathrm{n}T} = 10\lg\left(\frac{1}{m}\sum_{j=1}^{m} 10^{L'_{\mathrm{n}T,j}/10}\right) \tag{7}$$

$$L'_{\mathrm{n}} = 10\lg\left(\frac{1}{m}\sum_{j=1}^{m} 10^{L'_{\mathrm{n},j}/10}\right) \tag{8}$$

where

m is the number of tapping machine positions;

$L'_{\mathrm{n}T,j}$ is the standardized impact sound pressure level for tapping machine position j;

$L'_{\mathrm{n},j}$ is the normalized impact sound pressure level for tapping machine position j.

7.3.4 Rubber ball operated at more than one position

Measure the sound pressure level in the receiving room for the first impact source position. Calculate the energy-average maximum impact sound pressure level according to 7.8.3 then make any required correction for background noise according to Clause 9. Repeat this process for the other impact source position(s), then calculate the energy-average maximum impact sound pressure level using Formula (9):

$$L_{\mathrm{i,Fmax}} = 10\lg\left(\frac{1}{m}\sum_{j=1}^{m} 10^{L_{\mathrm{i,Fmax},j}/10}\right) \tag{9}$$

where

m is the number of rubber ball positions;

$L_{\mathrm{i,Fmax},j}$ is the maximum impact sound pressure level for rubber ball position j.

Calculate the standardized maximum impact sound pressure level using Formulae (3), (4) and (5).

7.4 Mechanized continuously-moving microphone for the tapping machine as impact source

7.4.1 General

With the tapping machine as the impact source, 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.

When using at least six tapping machine positions, the location of the fixed point about which the continuously-moving microphone moves may be changed.

7.4.2 Number of measurements

The same number of measurements shall be taken for each tapping machine position and at least one measurement shall be made for each tapping machine position.

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