INTERNATIONAL STANDARD

ISO 10140-5

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Acoustics — Laboratory measurement of sound insulation of building elements —

Part 5: Requirements for test facilities and equipment

Acoustique — Mesurage en laboratoire de l'isolation acoustique des éléments de construction —

Partie 5: Exigences relatives aux installations et appareillages d'essai

Reference number
ISO 10140-5:2010(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 10140-5 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

This first edition of ISO 10140-5, together with ISO 10140-1, ISO 10140-2, ISO 10140-3 and ISO 10140-4, cancels and replaces ISO 140-1:1997, ISO 140-3:1995, ISO 140-6:1998, ISO 140-8:1997, ISO 140-10:1991, ISO 140-11:2005 and ISO 140-16:2006, which have been technically revised.

It also incorporates the Amendments ISO 140-1:1997/Amd.1:2004 and ISO 140-3:1995/Amd.1:2004.

ISO 10140 consists of the following parts, under the general title *Acoustics — Laboratory measurement of sound insulation of building elements*:

— *Part 1: Application rules for specific products*

— *Part 2: Measurement of airborne sound insulation*

— *Part 3: Measurement of impact sound insulation*

— *Part 4: Measurement procedures and requirements*

— *Part 5: Requirements for test facilities and equipment*

Introduction

ISO 10140 (all parts) concerns laboratory measurement of the sound insulation of building elements (see Table 1).

ISO 10140-1 specifies the application rules for specific elements and products, including specific requirements for preparation, mounting, operating and test conditions. ISO 10140-2 and ISO 10140-3 contain the general procedures for airborne and impact sound insulation measurements, respectively, and refer to ISO 10140-4 and this part of ISO 10140 where appropriate. For elements and products without a specific application rule described in ISO 10140-1, it is possible to apply ISO 10140-2 and ISO 10140-3. ISO 10140-4 contains basic measurement techniques and processes. This part of ISO 10140 contains requirements for test facilities and equipment. For the structure of ISO 10140 (all parts), see Table 1.

ISO 10140 (all parts) was created to improve the layout for laboratory measurements, ensure consistency and simplify future changes and additions regarding mounting conditions of test elements in laboratory and field measurements. It is intended for ISO 10140 (all parts) to present a well-written and arranged format for laboratory measurements.

It is intended to update ISO 10140-1 with application rules for other products. It is also intended to incorporate ISO 140-18 into ISO 10140 (all parts).

Table 1 — Structure and contents of ISO 10140 (all parts)

Relevant part of ISO 10140	Main purpose, contents and use	Detailed content
ISO 10140-1	It indicates the appropriate test procedure for elements and products. For certain types of element/product, it can contain additional and more specific instructions about quantities and test element size and about preparation, mounting and operating conditions. Where no specific details are included, the general guidelines are according to ISO 10140-2 and ISO 10140-3.	Appropriate references to ISO 10140-2 and ISO 10140-3 and product-related, specific and additional instructions on: — specific quantities measured; — size of test element; — boundary and mounting conditions; — conditioning, testing and operating conditions; — additional specifics for test report.
ISO 10140-2	It gives a complete procedure for airborne sound insulation measurements according to ISO 10140-4 and ISO 10140-5. For products without specific application rules, it is sufficiently complete and general for the execution of measurements. However, for products with specific application rules, measurements are carried out according to ISO 10140-1, if available.	— Definitions of main quantities measured — General mounting and boundary conditions — General measurement procedure — Data processing — Test report (general points)
ISO 10140-3	It gives a complete procedure for impact sound insulation measurements according to ISO 10140-4 and ISO 10140-5. For products without specific application rules, it is sufficiently complete and general for the execution of measurements. However, for products with specific application rules, measurements are carried out according to ISO 10140-1, if available.	— Definitions of main quantities measured — General mounting and boundary conditions — General measurement procedure — Data processing — Test report (general points)
ISO 10140-4	It gives all the basic measurement techniques and processes for measurement according to ISO 10140-2 and ISO 10140-3 or facility qualifications according to ISO 10140-5. Much of the content is implemented in software.	— Definitions — Frequency range — Microphone positions — SPL measurements — Averaging, space and time — Correction for background noise — Reverberation time measurements — Loss factor measurements — Low-frequency measurements — Radiated sound power by velocity measurement
ISO 10140-5	It specifies all information needed to design, construct and qualify the laboratory facility, its additional accessories and measurement equipment (hardware).	Test facilities, design criteria: — volumes, dimensions; — flanking transmission; — laboratory loss factor; — maximum achievable sound reduction index; — reverberation time; — influence of lack of diffusivity in the laboratory. Test openings: — standard openings for walls and floors; — other openings (windows, doors, small technical elements); — filler walls in general. Requirements for equipment: — loudspeakers, number, positions; — tapping machine and other impact sources; — measurement equipment. Reference constructions: — basic elements for airborne and impact insulation improvement; — corresponding reference performance curves.

Acoustics — Laboratory measurement of sound insulation of building elements —

Part 5: Requirements for test facilities and equipment

1 Scope

This part of ISO 10140 specifies laboratory test facilities and equipment for sound insulation measurements of building elements, such as:

— components and materials;

— building elements;

— technical elements (small building elements);

— sound insulation improvement systems.

It is applicable to laboratory test facilities with suppressed radiation from flanking elements and structural isolation between source and receiving rooms.

This part of ISO 10140 specifies qualification procedures for use when commissioning a new test facility with equipment for sound insulation measurements. It is intended that these procedures be repeated periodically to ensure that there are no issues with the equipment and the test facility.

2 Normative references

The following referenced documents are indispensable for the application of this document. 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 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 9052-1:1989, *Acoustics — Determination of dynamic stiffness — Part 1: Materials used under floating floors in dwellings*

ISO 10140-1, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 1: Application rules for specific products*

ISO 10140-2, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurements of airborne sound insulation*

ISO 10140-3, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 3: Measurements of impact sound insulation*

ISO 10140-4:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 4: Measurement procedures and requirements*

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

IEC 60942:2003, *Electroacoustics — Sound calibrators*

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

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

IEC 61672-2, *Electroacoustics — Sound level meters — Part 2: Pattern evaluation tests*

IEC 61672-3, *Electroacoustics — Sound level meters — Part 3: Periodic tests*

3 Laboratory test facilities for airborne sound insulation measurements

3.1 General

The laboratory test facility shall consist of two adjacent reverberant rooms with a test opening between them, in which the test element is inserted.

The area of the test opening can vary depending on the type of test element. This part of ISO 10140 defines full-sized test openings, a specific small-sized test opening and alternative reduced-size test openings.

For measurement of the improvement of sound reduction index by acoustical linings, these rooms shall be separated by a standard basic element on which the lining under test is installed (see Annex B).

3.2 Test rooms

3.2.1 Volume

The volumes of the test rooms shall be at least 50 m^3. Volumes and corresponding dimensions of the two test rooms should not be exactly the same. A difference of at least 10 % in room volumes and in the linear dimensions is recommended.

Choose the ratios of the room dimensions such that the eigen mode frequencies in the low-frequency bands are spaced as uniformly as possible.

When measuring the sound insulation of walls or floors, theoretical calculation as well as experiments have indicated that the test element should cover a total partition wall or ceiling of the test room, i.e. the test opening should extend from wall to wall and from floor to ceiling. In such a case, a volume of 50 m^3 to 60 m^3 is appropriate in view of the recommended size of the test opening.

3.2.2 Diffusion

Large variations of the sound pressure level in the room indicate the presence of dominating strong standing waves. In this case, diffusing elements shall be installed in the rooms. The positioning and number of diffusing elements should be arranged in such a way that the sound reduction index is not influenced when further diffusing elements are installed.

NOTE For some kinds of test element, as for elements with one surface significantly more absorbent than the other (see ISO 10140-2), the installation of diffusing elements is mandatory.

3.2.3 Reverberation time

The reverberation time in the rooms under normal test conditions (with negligible absorption by the test element) should not be excessively long or short. When the reverberation time at frequencies at and above 100 Hz exceeds 2 s or is less than 1 s, check whether the measured sound reduction index depends on the reverberation time. When such a dependence is found, even with diffusers in the rooms, the rooms shall be modified to adjust the reverberation time, T, such that:

$$1 \leqslant T \leqslant 2(V/50)^{2/3} \tag{1}$$

where

V is the value of the room volume, in cubic metres;

T is the reverberation time, in seconds.

Measurement of the reverberation time is given in ISO 10140-4.

3.2.4 Background noise

The background noise level in the receiving room shall be sufficiently low to permit measurements of the sound transmitted from the source room, considering the power output in the source room and the sound insulation of the test elements for which the laboratory is intended (see ISO 10140-4:2010, 4.3).

3.2.5 Suppression of flanking transmission

In laboratory test facilities designed for measuring the sound reduction index, the sound transmitted by any indirect path should be negligible compared with the sound transmitted through the test element. One approach to achieve this in such facilities is to provide sufficient structural isolation between source and receiving rooms. Another approach is to cover all surfaces of both rooms with linings that reduce the flanking transmission in such a way that the requirements on room volumes and reverberation times are still met.

Annex A gives methods for estimating the maximum achievable sound reduction index, R'_{max}, which is determined by indirect paths.

3.3 Test opening

A horizontal and a vertical full-sized test opening, as well as a specific vertical small-sized test opening are defined. Other reduced-size test openings may be applied under certain restrictions.

3.3.1 Full-sized test opening

The area of the full-sized test opening shall be approximately 10 m^2 for walls, and between 10 m^2 and 20 m^2 for floors, with the length of the shorter edge being not less than 2,3 m for both walls and floors.

3.3.1.1 General frame specification

The measured sound reduction index of a test element can be affected by the connections to the laboratory structure surrounding the element. The mass ratio of the tested structure to the surrounding structure should be taken into consideration. For tests on lightweight structures ($m < 150$ kg/m^2), there are no special requirements to be taken into account. For heavier structures under test, it should be ensured that the loss factor, η, of the test element is not less than that given by Equation (2):

$$\eta_{min} = 0{,}01 + \frac{0{,}3}{\sqrt{f}} \tag{2}$$

where f is the test frequency value, in hertz.

To check this requirement, use as the test element a brick or block wall having a mass of (400 ± 40) kg/m^2 plastered on one side. Measurement of the loss factor is given in ISO 10140-4.

3.3.1.2 Specific requirements on the frame for lightweight twin-leaf partitions

With lightweight twin-leaf partitions, the sound reduction index is affected by vibration transmission between the wall leaves via the frame of the test opening (see Figure 1). This is influenced by the mounting conditions in the laboratory test opening and by the material properties and dimensions of the frame(s). Vibration transmission between the coupled structures of the partition itself (e.g. common or coupled studs) is dependent on the specific construction of the partition and is a property of the test element itself. This vibration transmission is not treated in this part of ISO 10140.

In order to improve the reproducibility of the sound reduction index between laboratories for walls, guidance is given for the mass per unit area of the frame of the test opening. If there is an acoustic break in the laboratory test opening, the frame on one side of that break should be considered. The mass per unit area of the frame shall be much larger than the mass per unit area of the heaviest leaf of the double partition. The ratio of the mass per unit area of the heaviest leaf of the double partition to that of the frame of the test opening shall be at least 1:6. The minimum thickness of the frame should be 100 mm and the minimum depth should be 200 mm. The frame shall have a density of at least 2 000 kg/m^3. The cross-sectional surface mass shall be more than 450 kg/m^2. In addition, the frame(s) shall consist of a homogeneous, massive construction, such as dense concrete or masonry. Wood or metal frames connecting the two leaves shall not be used.

The surface mass per unit area is calculated from the density, ρ, and the thickness, t, of the elements, as shown in Figure 2, using Equations (3) and (4):

$$m'_{\mathrm{L}} = \rho_{\mathrm{L}}\, t_{\mathrm{L}} \tag{3}$$

where

m'_{L} is the mass per unit area of the test facility wall, in kilograms per square metre;

ρ_{L} is the density of the test facility wall, in kilograms per cubic metre;

t_{L} is the thickness of the test facility wall, in metres.

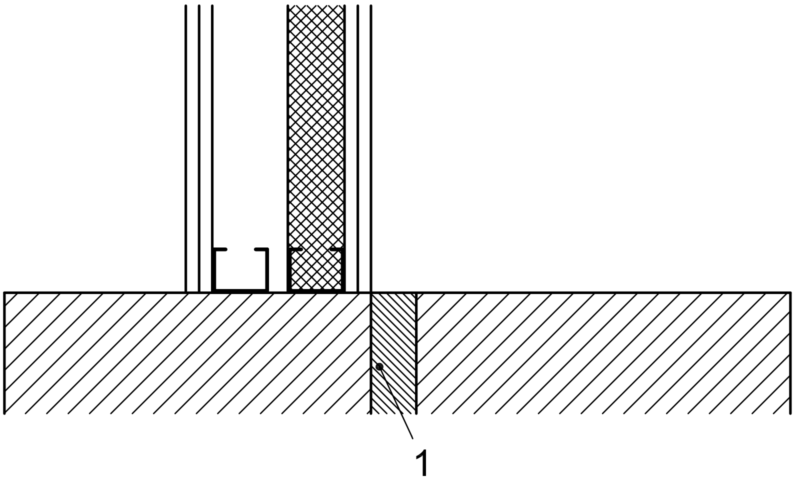
$$m'_{\mathrm{e}} = \rho_{\mathrm{e}}\, t_{\mathrm{e}} \tag{4}$$

where

m'_{e} is the mass per unit area of the element, in kilograms per square metre;

ρ_{e} is the density of the element, in kilograms per cubic metre;

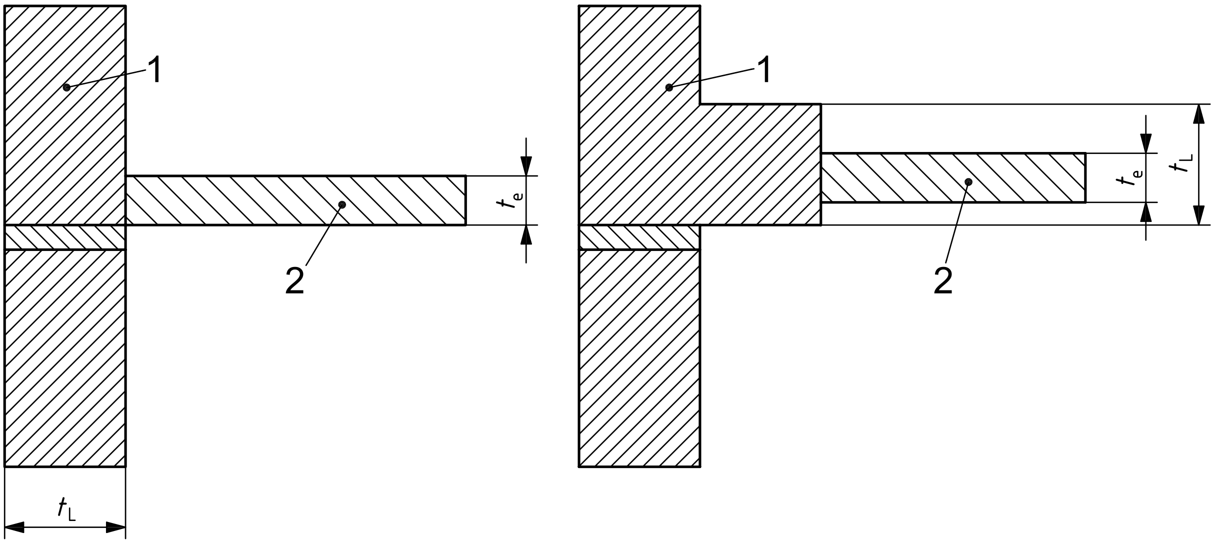
t_{e} is the thickness of the element, in metres.



Key

1 frame of the test opening

Figure 1 — Vibration transmission across the border frame of the test opening



Key

1 test facility wall

2 element under test

t_L thickness of the test facility wall

t_e thickness of the test element

Figure 2 — Determination of the mass per unit area of the elements

3.3.2 Reduced-size test opening

The test opening may have a reduced area:

a) if the test element area is smaller than the full-sized test opening;

b) if special acoustical conditions are met on the test element;

c) if the test element is a small technical element.

Reduced-size test openings are specified in ISO 10140-1 and ISO 10140-2.

3.3.3 Specific small-sized test opening

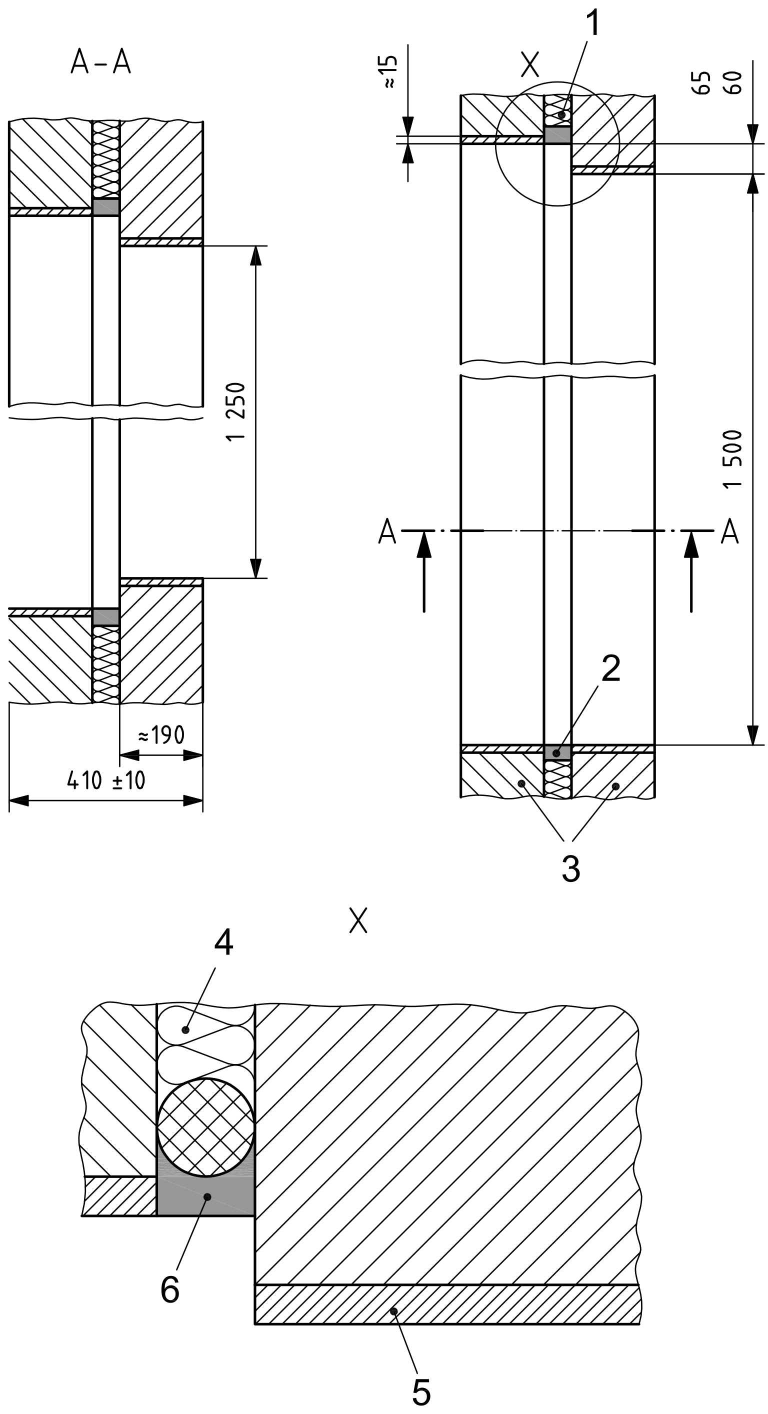
Specific small-sized test openings are 1 250 mm in width and 1 500 mm in height, with an allowable tolerance on each dimension of ± 50 mm, preferably maintaining the same aspect ratio. The test opening has a maximum depth of 500 mm, with staggered niches with a reflective finish. The larger niche is 60 mm to 65 mm wider at the sides and the top only.

The wall with the test opening is constructed from two walls of about equal thickness made of concrete, plastered bricks or similar material with a density of at least 1 800 kg/m^3. The gap between the two walls is filled with mineral wool and shall be covered with an airtight reflecting material. This wall may be a filler wall in the full-sized test opening.

A vertical and a horizontal section are shown in Figure 3 with a detail of the gap as an example of the test opening within the specifications given. The dimensions of the niches in the horizontal section shall be the same as in the vertical section.

The minimum distance between the small-sized test opening and any wall, floor or ceiling of either room shall be 500 mm. The opening should not be symmetrical in the separating wall.

Dimensions in millimetres



Key

1 mineral wool

2 resilient material (acoustically reflective)

3 double partition wall

4 mineral wool

5 reflective finishing

6 resilient material (acoustically reflective)

Care should be taken to ensure that the resilient material does not add flanking transmission by coupling the two walls.

Figure 3 — Example of the construction of the specific small-sized test opening

4 Laboratory test facilities for impact sound insulation measurements

4.1 General

The laboratory test facility consists of two vertically adjacent rooms, the upper one being designated the "source room" and the lower one, the "receiving room". There are no specific requirements for the shape and size of the source room for impact sound measurements.

For measurements of the reduction of transmitted impact sound by floor coverings, these rooms shall be separated by a standard test floor on which the floor covering under test is installed (see Annex C).

4.2 Receiving room

4.2.1 Volume

The volume of the receiving room shall be not less than 50 m^3. The ratio of the receiving room dimensions shall be chosen so that the eigen mode frequencies in the low-frequency bands are spaced as uniformly as possible.

Theoretical calculations as well as experiments have indicated that it may be advisable that the test element cover the total ceiling area of the receiving room, i.e. the test opening should extend from wall to wall. In such a case, a volume of 50 m^3 to 60 m^3 is appropriate in view of the recommended size of the test opening.

4.2.2 Further requirements

The room shall fulfil the same requirements as the rooms for airborne sound insulation specified in 3.2.2, 3.2.3, 3.2.4 and 3.2.5.

In addition, the airborne sound insulation between the receiving room and the space with the tapping machine shall be sufficiently high that the sound field measured in the receiving room is only that generated by impact excitation of the floor under test.

4.3 Test opening

4.3.1 Full-sized test opening

The size of the test opening for floors shall be between 10 m^2 and 20 m^2, with the shorter edge length not less than 2,3 m.

4.3.2 Frame specification

The measured impact sound insulation of a test element can be affected by the connections to the laboratory structure surrounding the element. The mass ratio of the tested structure to the surrounding structure should be taken into consideration. For tests on lightweight structures ($m < 150$ kg/m^2), there are no special related requirements to be taken into account. For heavier structures under test, it should be ensured that the loss factor, η, of the test element is not less than

$$\eta_{\text{min}} = 0{,}01 + \frac{0{,}3}{\sqrt{f}} \qquad (5)$$

where f is the value of test frequency, in hertz.

To check this requirement, use a concrete floor having a mass of (300 ± 30) kg/m^2 as the test element. For measurement of the loss factor, see ISO 10140-4.

5 Equipment

5.1 Airborne sound field

The sound field in the rooms depends on the type and position of the sound source. The sound source should be positioned and operated to try and achieve a diffuse sound field. The positions and directivity of the source shall permit microphone positions to be used outside the direct field of the source and shall ensure that the direct radiation from the source is not dominant on the surface of the test element. This shall be achieved using a sound source at fixed positions or along a moving path that complies with the requirements in Annex D. Sound sources may be used at fixed positions simultaneously, provided they are of the same type and are driven at the same level by similar, but uncorrelated, signals.

The sound generated in the source room shall be steady and have a continuous spectrum in the frequency range considered. If filtering of the source signal is used, use a bandwidth of at least one-third octave. If broadband noise is used (white noise is recommended), the spectrum may be shaped to ensure an adequate signal-to-noise ratio at high frequencies in the receiving room. In either case, the average sound spectrum in the source room, at least above 100 Hz, shall not have a difference in level of more than 6 dB between adjacent one-third octave bands. Sound field specifications are given in ISO 10140-4 and ISO 18233 gives equivalent alternatives.

The source room should be the larger room.

When measuring the airborne sound insulation of a floor in a vertical transmission test facility with the source(s) in the upper room, the base of each source shall be at least 1,5 m above the floor.

5.2 Impact sound source

The impact sound source that shall be used is the standard tapping machine as specified in Annex E.

Annex F gives information on two alternative impact sources that may be used, as explained in Clause 1 of ISO 10140-3.

5.3 Measurement system

The instrumentation system, including the microphones and cables, shall meet the requirements of a Class 1 instrument in accordance with IEC 61672-1[1)] and the filters shall meet the requirements for a Class 0 or 1 instrument in accordance with IEC 61260. A sound calibrator shall meet the requirements of Class 1 in accordance with IEC 60942.

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

Compliance of the instrumentation system with the requirements of IEC 61672-1, compliance of the sound calibration device with the requirements of IEC 60942:2003, Annex A, and compliance of the filters with IEC 61260 shall be verified by the existence of a valid pattern evaluation certificate issued by a competent laboratory.

NOTE In those cases where instruments are in conformance with withdrawn standards[2)], the competent national laboratory can issue pattern evaluation certification according to procedures given in OIML R 58 and OIML R 88.

Test procedures for pattern evaluation are given in IEC 61672-2 and test procedures for periodic testing in IEC 61672-3. The user shall ensure that compliance with these International Standards is verified periodically.

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1) Previously called Type 1 in accordance with IEC 60651 and IEC 60804, which have been withdrawn and replaced with IEC 61672-1 and IEC 61672-2.

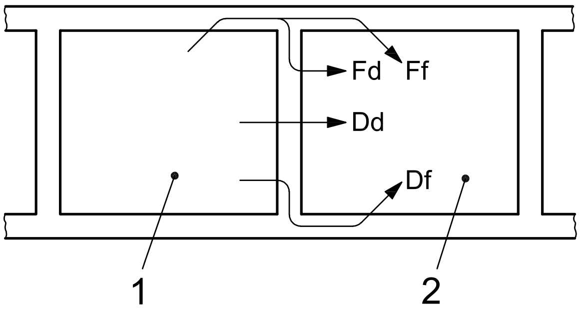
2) That is, IEC 60651 and IEC 60804, which have been withdrawn and replaced with IEC 61672-1 and IEC 61672-2.

Annex A
(normative)

Estimation of the maximum measurable sound reduction index

A.1 General

Figure A.1 shows a schematic representation of the different transmission paths between the rooms in a test facility. The direct path is Dd, whereas Fd, Ff and Df are flanking paths.



Key

1 source room

2 receiving room

Figure A.1 — Transmission paths in a test facility

The sound power transmitted into the receiving room can be assumed to consist of the sum of the following components:

W_{Dd} which has entered the partition directly and is radiated from it directly;

W_{Df} which has entered the partition directly, but is radiated from flanking constructions;

W_{Fd} which has entered flanking constructions and is radiated from the partition directly;

W_{Ff} which has entered flanking constructions and is radiated from flanking constructions;

W_{leak} which has been transmitted (as airborne sound) through leaks, ventilation ducts, etc.

The flanking transmission may be investigated using one of the following two ways:

a) by covering the test element on both sides with additional flexible layers, for example 13 mm gypsum board on a separate frame at a distance which gives a resonance frequency of the system of layer and airspace well below the frequency range of interest. The airspace should contain sound-absorbing material. With this measurement W_{Dd}, W_{Df} and W_{Fd} are suppressed, and the measured apparent sound reduction index is determined by W_{Ff} (W_{leak} is assumed to be negligible under laboratory conditions). Additional flexible layers, covering particular flanking surfaces, may permit identification of the major flanking paths;

b) by estimating the radiated sound power from flanking constructions in the receiving room using measurement of the average surface velocity levels or average sound intensity radiated by the surfaces (see ISO 10140-4).

If the power radiated from the flanking constructions, $W_{Df} + W_{Ff}$, is determined in this way, the measurement can be used for the calculation of the apparent sound reduction index, in decibels, as given in Equation (A.1):

$$R'_{Df+Ff} = 10\lg\left(\frac{W_1}{W_{Df} + W_{Ff}}\right) \text{ dB} \qquad (A.1)$$

The maximum sound reduction index of a building element that can be measured in a laboratory without being significantly affected by flanking transmission depends on the type of element being tested. Therefore, it is desirable to assess the contribution of flanking transmission whenever a high-performance element is tested, using one of the indicated methods. As this is impractical for general applications, R'_{max} shall be measured for a range of constructions which are representative of those normally tested (see ISO 10140-1).

A.2 Qualification procedures and requirements

A.2.1 Maximum measurable sound reduction index — R'_{max} facility

Six representative constructions are specified below. The constructions most similar to the elements normally tested by the laboratory shall be used for the R'_{max} tests, as specified in ISO 10140-2. Laboratories with a test opening for walls have either a permanent solid or cavity separating wall. When it is a cavity type, the two leaves of the representative construction may be built on the same side of the cavity or with one leaf on each side of the cavity. However, the values of R'_{max} obtained shall only apply to the configurations tested.

A.2.2 Representative constructions

For wall and floor constructions of type A (see A.2.2.1.1), the flanking path is mainly Ff and is only slightly influenced by the type of test construction. For wall and floor constructions of types B and C, flanking includes paths Ff, Fd, and Df, which are all influenced by the mass of the nominal separating construction. For wall and floor constructions of types B and C, the additional lining shall be applied to the heavyweight test construction in such a way that only transmission via path Dd is reduced.

A.2.2.1 Walls

A.2.2.1.1 Type A: Lightweight wall

For twin-leaf lightweight partitions, each leaf should comprise layers of plasterboard or other board material of similar mass per area (at least 30 kg/m^2). The cavity between the leaves shall be at least 200 mm wide and shall contain mineral wool at least 100 mm thick. The leaves shall be supported on timber or metal studs and shall not be connected to each other mechanically. The perimeter of the lightweight leaves shall not be rigidly bonded to the permanent structure.

A.2.2.1.2 Type B: Lightweight masonry wall

The lightweight masonry wall consists of a brick or block wall, plastered on one side, having a mass per unit area of (100 ± 10) kg/m^2. On one side an independent lining shall be constructed comprising two layers of 12,5 mm plasterboard supported on a timber or metal stud frame which is not connected to the wall. The lining shall be on that side of the wall facing that room on which the wall is supported. The perimeter of the lightweight lining shall not be rigidly bonded to the permanent structure. The cavity between the wall and the lining shall be at least 50 mm wide and shall contain mineral wool.

A.2.2.1.3 Type C: Heavyweight masonry wall

The heavyweight masonry wall consists of a brick or block wall, plastered on one side, having a mass per unit area of (400 ± 40) kg/m^2. On one side an independent lining shall be constructed comprising two layers of 12,5 mm plasterboard supported on a timber or metal stud frame which is not connected to the wall. The cavity between the wall and the lining shall be at least 50 mm wide and shall contain mineral wool. The lining shall be on the side of the wall facing that room on which the wall is supported. The perimeter of the lightweight lining shall not be rigidly bonded to the permanent structure.

A.2.2.2 Floors

A.2.2.2.1 Type A: Lightweight floor

The lightweight floor may be constructed with the ceiling supported from joists below those which support the floor. The construction details shall be equivalent to the lightweight wall described above.

A.2.2.2.2 Type B: Lightweight concrete floor

The lightweight concrete floor is constructed with a concrete base having a mass per unit area of (100 ± 10) kg/m^2, sealed on one side with plaster. A lining comprising two layers of 12,5 mm plasterboard should be suspended below the floor from independent joists, with mineral wool in the cavity. The perimeter of the lightweight suspended lining shall not be rigidly bonded to the permanent structure. Alternatively, the lining may “float” on the concrete, supported by 75 mm thick mineral wool.

A.2.2.2.3 Type C: Heavyweight concrete floor

The heavyweight concrete floor is constructed with a homogeneous, reinforced concrete slab of thickness 120^{+40}_{-20} mm (preferably 140 mm for the construction of new laboratories), meeting the requirements of the heavyweight reference floor in C.2. A lining comprising two layers of 12,5 mm plasterboard should be suspended below the concrete floor from independent joists, with mineral wool in the cavity. The lightweight suspended lining shall not be rigidly bonded to the permanent structure. Alternatively, the lining may “float” on the concrete floor, supported by 75 mm thick mineral wool.

Table A.1 gives typical values of R'_{max} for the laboratory capable of measuring walls and floors of type C having values of R_w up to 55 dB. The values in Table A.1 are for example only and should not be regarded as target values.

Table A.1 — Typical values of R'_{max} in a laboratory for testing walls and floors of type C

Frequency Hz	R'_{max} for paths Ff, Fd and Df dB
100	45,0
125	50,0
160	53,0
200	56,0
250	58,5
315	61,0
400	63,5
500	66,0
630	68,5
800	71,0
1 000	73,5
1 250	76,0
1 600	78,5
2 000	81,0
2 500	83,5
3 150	86,0
4 000	88,5
5 000	91,0

Annex B
(normative)

Standard basic elements for measuring the improvement of airborne sound insulation by linings

B.1 Standard basic elements

The constructions described in this annex can be used as standard basic elements for the application of linings. This annex also gives the standardized values of the sound reduction indices, R, for the standard basic elements. These are given in figures and in a table, together with the corresponding weighted sound reduction indices, R_{w}, and spectrum adaptation terms, C and C_{tr}, in accordance with ISO 717-1.

NOTE Figures B.1, B.2 and B.3 as well as Table B.1 give typical smoothed values for the sound reduction index of these basic elements used in the determination of the single-number rating; the measured values of the actual basic element are used to evaluate the improvement by a lining.

B.2 Standard wall with low critical frequency ("heavy wall")

This is constructed of masonry, homogeneous concrete or concrete blocks with a surface density, ρ_A, of (350 ± 50) kg/m^2. The material and thickness shall be chosen such that the critical frequency is located in the 125 Hz octave band. This may be calculated or measured. No cavities are allowed and there shall be no thickness resonances below 3 150 Hz. The density of the blocks or bricks shall be at least 1 600 kg/m^3. If the wall is not airtight, it shall be plastered on the side facing the lining.

For the reference curve of this wall, see Figure B.1 and Table B.1.

EXAMPLE Calcium silicate blocks with density 1 700 kg/m^3 $\leqslant \rho <$ 1 800 kg/m^3. Thickness of the blocks: 175 mm. 10 mm gypsum plaster on one side of the wall.

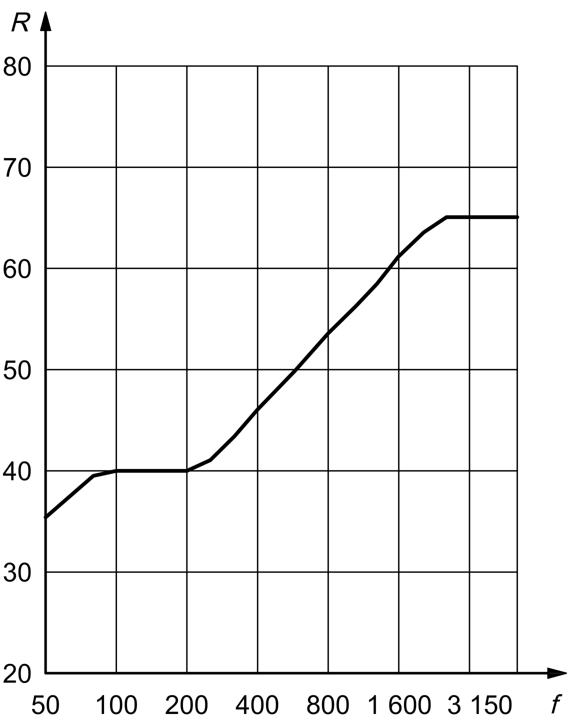


Figure B.1 — Reference curve for standard wall with low critical frequency

B.3 Standard floor with low critical frequency ("heavy floor")

A heavyweight homogeneous concrete floor shall be used as described in C.2.1.

For the reference curve of this floor, see Figure B.2 and Table B.1.

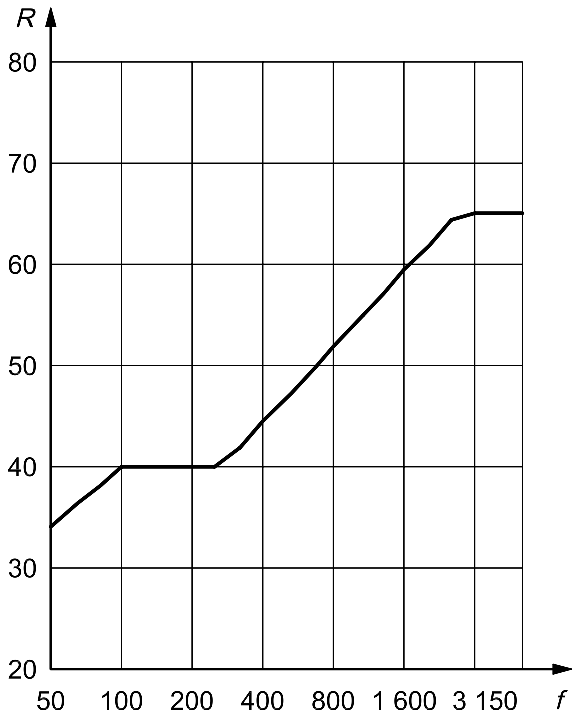


Figure B.2 — Reference curve for reference floor with low critical frequency

B.4 Standard wall with medium critical frequency ("lightweight wall")

This is constructed of a 10 cm thick wall of aerated concrete blocks, density $\rho = (600 \pm 50)$ kg/m^3, with 10 mm gypsum plaster on the side facing the lining.

This wall should have a mass per unit area of about 70 kg/m^2 and a critical frequency within the 500 Hz octave band.

NOTE Walls made from other material are allowed, as long as the same ranges of mass per unit area and critical frequencies are maintained.

For the reference curve of this wall, see Figure B.3 and Table B.1.

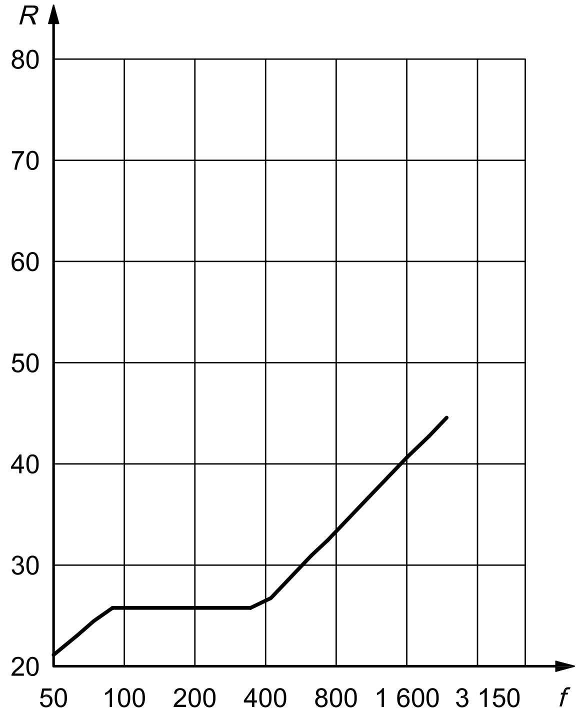


Figure B.3 — Reference curve for standard wall with medium critical frequency

Table B.1 — One-third octave band values of the reference curve for the sound reduction index of standard walls and floor with the corresponding single-number rating

Frequency Hz	R for heavy wall dB	R for heavy floors dB	R for lightweight walls dB
50	35,3	34,0	21,3
63	37,3	36,0	23,3
80	39,4	38,1	25,3
100	40,0	40,0	27,0
125	40,0	40,0	27,0
160	40,0	40,0	27,0
200	40,0	40,0	27,0
250	41,0	40,0	27,0
315	43,5	41,8	27,0
400	46,1	44,4	27,0
500	48,5	46,8	27,0
630	51,0	49,3	28,0
800	53,6	51,9	30,5
1 000	56,0	54,4	32,8
1 250	58,4	56,8	35,1
1 600	61,1	59,5	37,6
2 000	63,6	61,9	40,0
2 500	65,0	64,3	42,3
3 150	65,0	65,0	44,6
4 000	65,0	65,0	47,1
5 000	65,0	65,0	49,4
R_{w}	53	52	33
C	–1	–1	–1
$C_{100\text{-}5\,000}$	0	0	0
$C_{50\text{-}3\,150}$	–1	–1	–1
$C_{50\text{-}5\,000}$	0	0	0
C_{tr}	–5	–5	–2
$C_{\text{tr},100\text{-}5\,000}$	–5	–5	–2
$C_{\text{tr},50\text{-}3\,150}$	–5	–5	–3
$C_{\text{tr},50\text{-}5\,000}$	–5	–5	–3

Annex C
(normative)

Standard floors for measuring the improvement of impact sound insulation by floor coverings

C.1 Standard reference elements

Corresponding to the application of floor coverings, the constructions described in this annex may be used as standard reference elements. In this annex, the constructions are described and the standardized values of the impact sound pressure level, L_n, of the standard reference elements are given together with the corresponding weighted impact sound pressure level, $L_{n,w}$, and spectrum adaptation term, C_I, in accordance with ISO 717-2.

NOTE Table C.1 gives the typical smoothed values for the normalized impact sound pressure level of these reference elements used in the determination of the single-number rating; the measured values of the actual reference element are used to evaluate the improvement by floor coverings.

C.2 Heavyweight reference floor

C.2.1 General

The floor on which the test coverings are installed shall consist of a reinforced concrete slab of thickness 120^{+40}_{-20} mm, preferably 140 mm for the construction of new laboratories. It should be homogeneous and shall be of uniform thickness. The surface area viewed from the receiving room shall be at least 10 m^2.

C.2.2 Condition of floor surface

The surface of the test floor shall be flat to ± 1 mm in a horizontal distance of 200 mm, and sufficiently hard to endure the impacts of the tapping machine. If a screed is applied to the surface of the test floor, it shall be ensured that it adheres perfectly at all points, and that it does not chip, crack or become pulverized.

C.3 Lightweight reference floors

C.3.1 General

The floor on which the test covering is installed shall be chosen from the lightweight reference floors described in this annex; see Annex G for an alternative.

The surface area, viewed from the receiving room, shall be at least 10 m^2.

C.3.2 Condition of floor surface

The surface of the test floor shall be flat to ± 2 mm in a horizontal distance of 200 mm, and sufficiently hard to endure the impacts of the tapping machine.

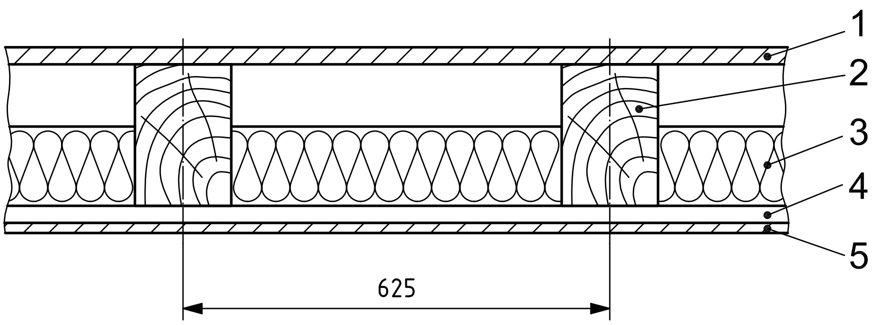
C.3.3 Types of lightweight reference floors

C.3.3.1 General

The following types of floors shall be chosen as lightweight reference floors for the measurement of the reduction of impact sound pressure level in accordance with ISO 10140-3.

Different kinds of lightweight floor constructions are used in the world. The following three types of floor (see C.3.3.2, C.3.3.3 and C.3.3.4) are generally representative of these floors. It is recommended that the reference floor be chosen according to the aim of the measurement.

C.3.3.2 Lightweight reference floor C1



Key

1 subfloor
- thickness: (22 ± 2) mm
- fastening: screwed to the joists, distance of screws: (300 ± 50) mm
- material: wooden chipboard with a mass density of (660 ± 20) kg/m^3

2 wooden joists
- dimensions: 120 mm width and 180 mm height
- spacing: 625 mm centres

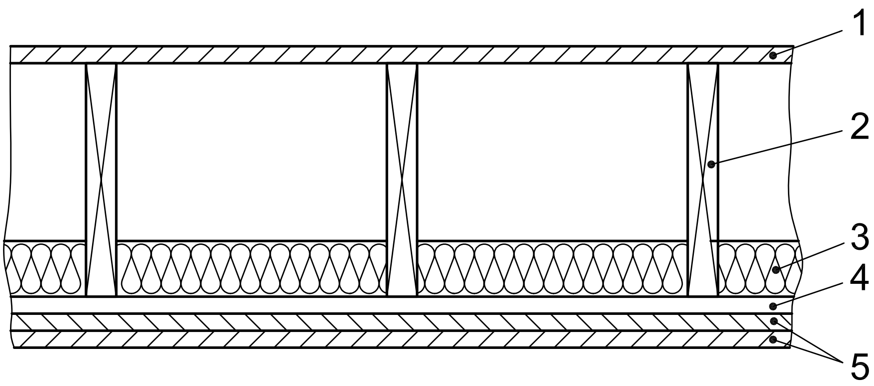
3 absorbent
- material: mineral wool
- thickness: 100 mm
- airflow resistivity: 5 kPa s/m^2 to 10 kPa s/m^2 according to ISO 9053

4 wooden ceiling battens
- dimensions: 24 mm width and 48 mm height
- spacing: 625 mm centres

5 plaster board ceiling
- thickness: 12,5 mm
- mass density: (800 ± 50) kg/m^3
- fastening: screwed to the battens, distance of screws: (300 ± 50) mm

Figure C.1 — Lightweight reference floor C1

C.3.3.3 Lightweight reference floor C2



Key

1 subfloor

thickness:	(20 ± 2) mm
fastening:	(50 ± 10) mm screws spaced (150 ± 10) mm along butt joints supported by the joists and (300 ± 10) mm elsewhere
material 1:	tongued and grooved oriented strand board or plywood with a mass density of (580 ± 100) kg/m^3
material 2:	tongued and grooved chipboard with a mass density of (680 ± 100) kg/m^3

NOTE Select either subfloor material 1 or 2 depending on the availability of materials.

2 joists

material:	solid soft wood (e.g. spruce, pine or fir)
dimensions:	(42 ± 8) mm width and (225 ± 25) mm height
mass density:	(400 ± 75) kg/m^3
spacing:	(610 ± 10) mm between centre planes and, if necessary, (405 ± 10) mm between centre planes

3 absorbent

material:	mineral wool (e.g. glass fibre batts)
dimensions:	(100 ± 10) mm thickness, completely filling the width and length of the cavity (placed immediately above the resilient channels)
airflow resistivity:	5 kPa s/m^2 to 10 kPa s/m^2 according to ISO 9053

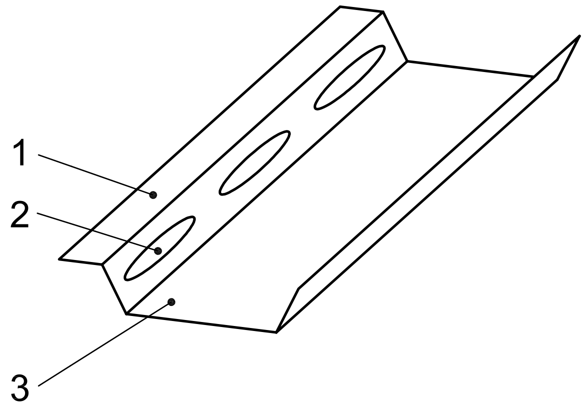
4 resilient metal channels

material:	cold-rolled steel of thickness (0,5 ± 0,1) mm having a “Z” profile (see Figure C.3).
spacing:	(405 ± 10) mm oriented perpendicular to the joists

5 plaster board ceiling

material:	two layers of plaster board, thickness: (13,5 ± 1,5) mm, mass density: (800 ± 50) kg/m^3
fastening:	screws spaced (305 ± 5) mm into each resilient channel. The screw pattern is selected such that the screws penetrate the flange of the resilient channel and do not touch the joists

Figure C.2 — Lightweight reference floor C2



Key

1 flange used to attach the channel to the framework

2 web

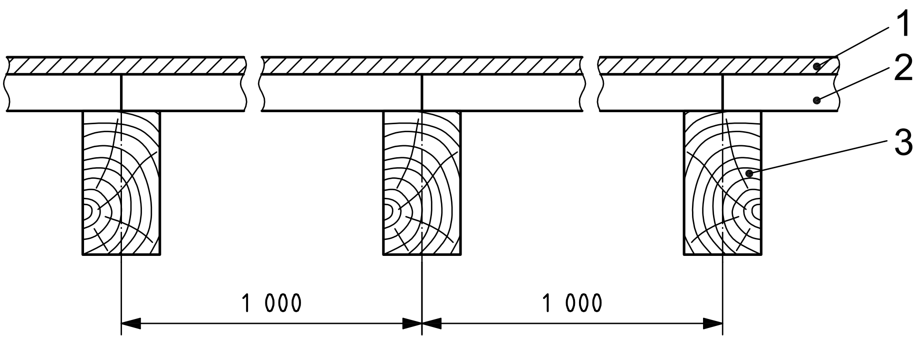
3 flange used to attach the gypsum board to the channel

Figure C.3 — Generic resilient channel used to isolate the gypsum board ceiling

Figure C.3 shows a sketch of the generic resilient channels used to isolate the gypsum board ceiling. Typical dimensions are: height 13 mm, gypsum board attachment flange 32 mm, framework attachment flange 11 mm. It is possible for the web to have cut-outs. The flange used to attach the gypsum board can have a more complicated profile (with bumps or ridges).

C.3.3.4 Lightweight reference floor C3

Dimensions in millimetres



Key

1 subfloor

material: two layers of plywood, thickness: (15 ± 1) mm, mass density: (550 ± 50) kg/m^3

fastening: 50 mm screws spaced 500 mm along the joists

2 joists

material: solid soft wood

dimensions: 45 mm width and 60 mm height

mass density: (525 ± 125) kg/m^3

spacing: 300 mm centres

3 beams

material: solid soft wood

dimensions: 120 mm width and 240 mm height

mass density: (525 ± 125) kg/m^3

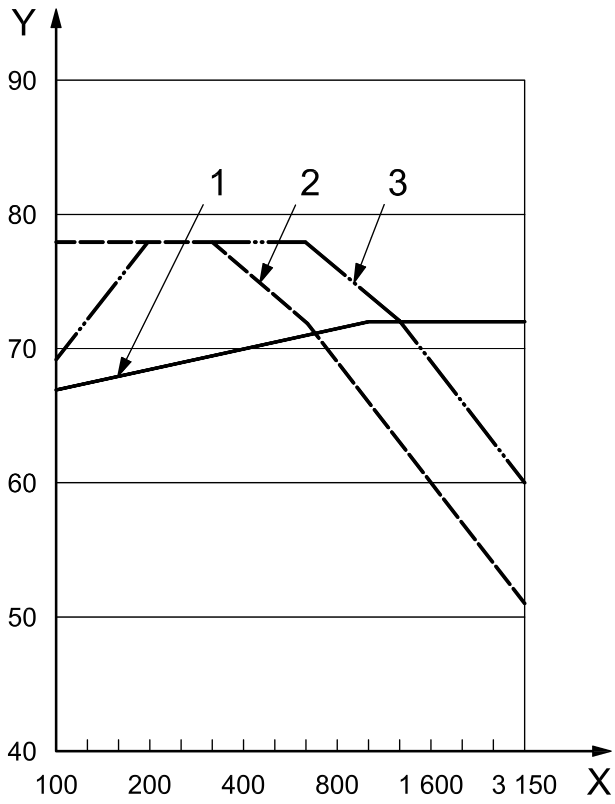
spacing: 1 000 mm centres

Figure C.4 — Lightweight reference floor C3

Table C.1 — One-third octave band values of the reference curve for all reference floors with the corresponding single-number rating

Frequency Hz	$L_{n,r,0}$ **for heavyweight floors** dB	$L_{n,t,r,0}$ [a] **for lightweight floors C1 and C2** dB	$L_{n,t,r,0}$ [a] **for lightweight floors C3** dB
100	67	78	69
125	67,5	78	72
160	68	78	75
200	68,5	78	78
250	69	78	78
315	69,5	78	78
400	70	76	78
500	70,5	74	78
630	71	72	78
800	71,5	69	76
1 000	72	66	74
1 250	72	63	72
1 600	72	60	69
2 000	72	57	66
2 500	72	54	63
3 150	72	51	60
$L_{n,r,0w}$ or $L_{n,t,r,0w}$ dB	78	72	75
$C_{I,r,0}$ or $C_{I,t,r,0}$ dB	–11	0	–3

[a] The index, t, is used to distinguish results for lightweight floors from those for heavyweight floors; it originates from the word “timber”.



Key

X frequency (Hz)

Y L_n (dB re 20 µPa)

1 heavyweight floor

2 lightweight floors C1 and C2

3 lightweight floor C3

Figure C.5 — Reference curves for standard reference floor elements

C.3.4 Values of $\Delta L_{t,w}$

Values of $\Delta L_{t,w}$ calculated with the lightweight reference floor C1 or C2 shall be designated as $\Delta L_{t,1,w}$ or $\Delta L_{t,2,w}$ respectively; values of $\Delta L_{t,w}$ calculated with the lightweight reference floor C3 shall be designated as $\Delta L_{t,3,w}$.

Annex D
(normative)

Qualification procedure for loudspeakers and loudspeaker positions

D.1 Test procedure to find the number of source positions and the optimal positions

D.1.1 General

The suitability of source positions shall be tested with regard to excitation of room modes in order to find positions that lead to results of sound insulation measurement which are as close as possible to the mean value of a large number of positions equally distributed around the room.

Guidance is given for selecting trial source positions. Procedures are also described for finding the recommended number of positions and for the selection of optimal positions, including a qualification test. Guidance is also given for continuously moving loudspeakers. A recommended test element is described.

When using the selected loudspeaker positions for measurements of sound insulation, the loudspeaker type and orientation shall be the same as for the qualification test. This shall also be carried out for all laboratory features including microphone positions or microphone paths, diffusing elements, absorbing surfaces and, as far as possible (especially when using a test opening in a filler wall), the position of the test element.

Loudspeakers should be used with the speaker units mounted in a closed cabinet. All speaker units in the same cabinet shall radiate in phase.

D.1.2 Requirements for loudspeaker positions in the selection procedure

The distance between different fixed loudspeaker positions shall not be less than 0,7 m. At least two positions shall not be less than 1,4 m apart.

The distance between the room boundaries and the acoustic centre of the source shall not be less than 0,7 m, neglecting small irregularities in the room boundaries. For positions near the boundaries, especially corner positions, see D.1.3.

The loudspeaker positions or paths shall not be symmetrical with respect to the axis or central planes of the source room (in the case of parallel room boundaries). Different loudspeaker positions or paths shall not be located within the same planes parallel to the room boundaries and shall have a minimum displacement distance of 0,1 m.

The orientation of the loudspeaker shall be accurately recorded unless an omnidirectional radiating source is used. It is recommended that its orientation be the same at all positions in order to ensure that the selected positions are reproduced exactly, because turning the loudspeaker can change the position of the acoustic centre.

D.1.3 Guidelines for finding optimal positions and qualification test

The number of loudspeaker positions used and a set of optimal positions are found by the following procedure.

Measure the difference in levels, as specified in ISO 10140-4, using a number of loudspeaker positions, m, which is greater than

$$m = 152 / V^{2/3} \qquad \text{(D.1)}$$

where V is the source room volume, in cubic metres.

Choose positions as specified in D.1.2. If it is necessary for the minimum distance between the positions to be less than 0,8 m, distribute the positions such that the minimum distance is as large as possible and the other requirements given in D.1.2 are fulfilled.

Measure the difference, D, between the source and receiving room levels for each loudspeaker position. Calculate the standard deviation, s_i, of these differences for each one-third octave band, with centre frequency from 100 Hz to 315 Hz, using Equation (D.2):

$$s_i = \left[\frac{1}{m-1} \sum_{j=1}^{m} \left(D_{ji} - \mu_i \right)^2 \right]^{1/2} \tag{D.2}$$

where

$D_{j,i}$ is the level difference for the jth loudspeaker position at the ith one-third octave band;

μ_i is the arithmetic mean of the differences in levels in the ith position one-third octave band;

m is the number of loudspeaker positions examined.

The number, N, of loudspeaker positions used in practice is determined by the conditions given in Equations (D.3), (D.4) and (D.5):

$$N \geqslant 2 \tag{D.3}$$

$$N \geqslant (s_i / \sigma_i)^2 \tag{D.4}$$

$$N \geqslant \left(\sum_i s_i / 4{,}8 \text{ dB} \right)^2 \tag{D.5}$$

where

s_i is the standard deviation of the differences in levels [see Equation (D.2)];

σ_i is the prescribed maximum standard deviation of the mean value for N loudspeaker positions (see Table D.1).

Requirement (D.4) shall be fulfilled in all one-third octave bands listed in Table D.1.

Table D.1 — Prescribed maximum standard deviation for the mean value of measured level difference for N loudspeaker positions

f Hz	σ_i dB
100	1,4
125	1,2
160	1,0
200	0,8
250	0,8
315	0,8

If $2N$ exceeds the number of loudspeaker positions investigated, m, this number shall be increased from m to $2N$. The additional loudspeaker positions shall be chosen such that the requirements given in Equations (D.3), (D.4) and (D.5) are fulfilled for all $2N$ positions.

For each loudspeaker position, j, the sum, S_j, of the squares of the deviations from the mean values at the six one-third octave bands is calculated as given by Equation (D.6):

$$S_j = \sum_{i=1}^{6} (D_{j,i} - \mu_i)^2 \quad \text{(D.6)}$$

The q positions for which values of S_j are smallest are selected from all investigated loudspeaker positions.

Additional loudspeaker positions not satisfying the conditions given in D.1.2 may also be investigated. For example, corner positions can be of advantage for practical use. If S_j for an additional position does not exceed the largest value of the selected q positions, that position may be used in practice.

Finally, choose q positions, with $q \geqslant 2$, by the following procedure.

For each of the combinations of the q positions, calculate the sum, $S_{j,q}$, of the square of the deviations from the mean values at the six one-third octave bands. Select the q positions for which values of $S_{j,q}$ are smallest.

Two or more of the selected positions shall be at least 1,4 m apart.

Positions close to the boundaries are critical for many types of loudspeaker as small displacements can lead to strong variations of the measurement result. If such positions are selected, ensure that they can be reproduced accurately.

D.1.4 Test element

Carry out the test procedure using a test element whose sound reduction index does not exceed the values in Table D.2 and whose size is such that it fits in the small-sized test opening (see 3.2.2, if appropriate).

NOTE 1 Measurement results on small test elements with relative low sound insulation have been found, in general, to be particularly sensitive to variations in the sound source positions.

Table D.2 — Maximum sound reduction index for the test element

f Hz	R dB
100	27
125	28
160	29
200	30
250	31
315	32

A recommended test element is a single-leaf sheet made of a steel sandwich leaf (steel sheet/resin/steel sheet, total thickness 2,2 mm), fixed to a channel section frame by screws in rivets and elastoplastic sealant.

NOTE 2 The recommended test element shows no resonance influence on the sound reduction over the whole frequency range up to 5 000 Hz. It is, therefore, suited for regular repeatability tests as recommended in Clause 1.

NOTE 3 If a laboratory does not normally test elements of this type, the test procedure can be carried out on a test sample which is representative of those normally used.

D.1.5 Use of continuously moving loudspeakers

It is permissible to use a loudspeaker that is moved automatically along a path while the sound level measurements in both rooms are performed. The path length shall be not less than 1,6 m. At least two points on the path shall not be less than 1,4 m apart. The loudspeaker should have omnidirectional radiation; otherwise, the qualification procedure given in D.3 shall be performed for all positions on the path with the shortest distances to the different microphone positions.

Measurements of the sound reduction index of a test element following the procedure given in D.1.4 shall be performed using several paths, including the four diagonals, through that part of the room space satisfying the requirements given in D.1.2. The path with the smallest value for S_j [see Equation (D.6)] shall be used for the measurements in practice.

D.2 Test procedure for loudspeaker radiation directivity

For a test of the directional radiation of a source, measure the sound pressure levels around the source at a distance of about 1,5 m in a free field. The source shall be driven with a noise signal and measurements made in one-third octave bands. Measure the level difference between the energetic mean value for the arc of 360° (L_{360}) and the "gliding" mean values of all arcs of 30° ($L_{30,i}$).

The directivity indices are:

$$\mathrm{DI}_i = L_{360} - L_{30,i} \tag{D.7}$$

Uniform omnidirectional radiation can be assumed if the DI values are within the limits of ± 2 dB in the frequency range of 100 Hz to 630 Hz. In the range of 630 Hz to 1 000 Hz, the limits increase linearly from ± 2 dB to ± 8 dB. They are 8 dB for frequencies of 1 000 Hz to 5 000 Hz.

Carry out the test in the different planes to ensure inclusion of the "worst case" condition. For a polyhedron source, testing in one plane is sufficient.

Mounting loudspeakers on the surfaces of a polyhedron, preferably a dodecahedron, gives an adequate approximation of uniform omnidirectional radiation.

D.3 Test procedure for loudspeaker positions with regard to microphone positions

Ensure that the microphone positions are outside the direct sound field of the source. This can be verified experimentally by recording the sound pressure level while moving a microphone along a line from the surface of the source to the selected microphone positions.

Perform the test for all one-third octave bands with centre frequencies higher than 630 Hz. Each fixed microphone position shall lie outside the region in which levels decrease significantly according to its distance from the source.

For a moving microphone, this is verified if no significant level increase occurs when the path comes close to the source.

Annex E
(normative)

Standard tapping machine

E.1 Requirements

The standard tapping machine shall have five hammers placed in a line. The distance between centrelines of neighbouring hammers shall be (100 ± 3) mm.

The distance between the centre of the supports of the tapping machine and the centrelines of neighbouring hammers shall be at least 100 mm. The supports shall be equipped with vibrational insulating pads.

The momentum of each hammer that strikes the floor shall be that of an effective mass of 500 g which falls freely from a height of 40 mm within tolerance limits for the momentum of ± 5 %. As friction of the hammer guidance shall be taken into account, it shall be ensured that not only the mass of the hammer and the falling height, but also the velocity of the hammer at impact, lie within the following limits: the mass of each hammer shall be (500 ± 12) g from which it follows that the velocity at impact shall be (0,886 ± 0,022) m/s. The tolerance limits of the velocity may be increased to a maximum of ± 0,033 m/s if it is ensured that the hammer mass lies within accordingly reduced limits of (500 ± 6) g.

The falling direction of the hammers shall be perpendicular to the test surface to within ± 0,5°.

The part of the hammer carrying the impact surface shall be cylindrical with a diameter of (30 ± 0,2) mm. The impact surface shall be of hardened steel and shall be spherical with a curvature radius of (500 ± 100) mm. Testing for fulfilment of this requirement may be performed in the following ways.

a) The curvature of the impact surface is considered to comply with the specifications if the measurement results lie within the tolerances given in Figure E.1 when a meter is moved over the surface on at least two lines through the centre point, the lines being perpendicular to each other.

   The curves of Figure E.1 describe a curvature of 500 mm. The distance between the curves is the smallest distance that allows both the 400 mm and 600 mm radius to fall within the tolerance limits. The accuracy of the measurement shall be at least 0,01 mm.

b) The curvature of the hammer heads may be tested by using a spherometer with three feelers lying on a circle with a diameter of 20 mm.

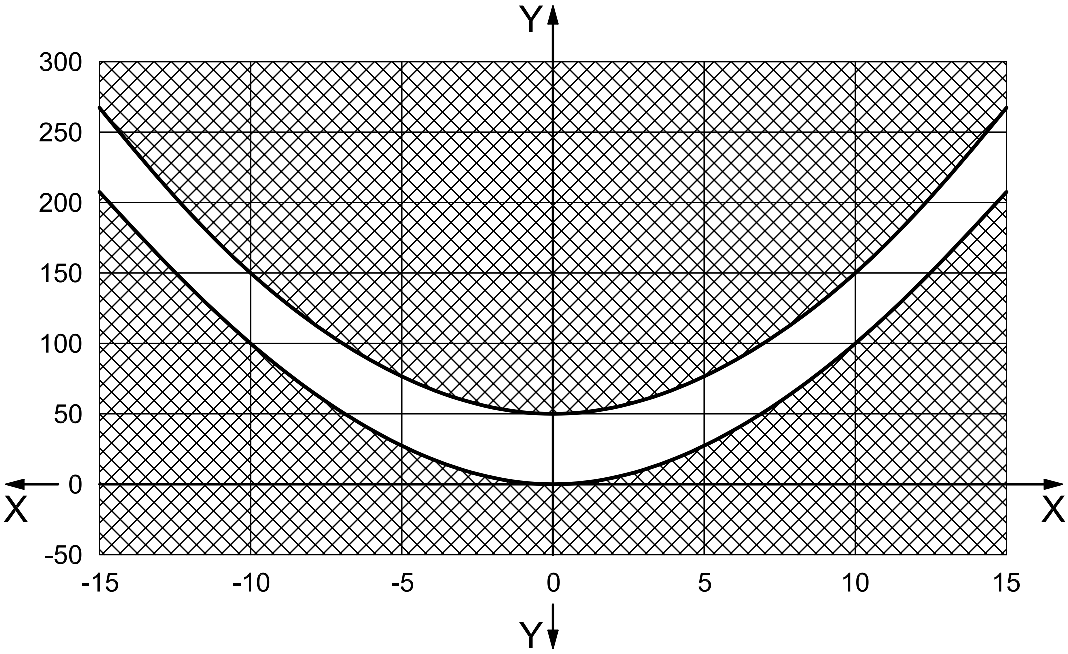
The tapping machine that be self-driven. The mean time between impacts shall be (100 ± 5) ms. The time between successive impacts shall be (100 ± 20) ms.

The time between impact and lift of the hammer shall be less than 80 ms.

For standard tapping machines that are used for testing impact sound insulation of floors with soft coverings or uneven surfaces, it shall be ensured that it is possible for the hammers to fall at least 4 mm below the plane on which the supports of the tapping machine rest.

All adjustments on the standard tapping machine and verification of the fulfilment of the requirements shall be performed on a flat hard surface and the tapping machine shall be used in that condition on any test surface.

The weight of the tapping machine shall be less then 25 kg in order not to load lightweight floors or floor coverings differently.



Key

X distance from centre (mm)

Y relative height (µm)

NOTE The relative height at the centre can be chosen freely within 0 µm to 50 µm to make the curvature of the hammer head fit within the tolerance limit.

Figure E.1 — Tolerance limits for the curvature of hammer heads

E.2 Regular checks of performance

Some of the parameters only need to be measured once, unless the tapping machine has been reconstructed or repaired. This concerns the distance between hammers, supports of the tapping machine, diameter of the hammers, mass of the hammers (unless the hammer heads have been refinished), time between impact and lift, and maximum possible falling height of the hammers.

The velocity of the hammers, diameter and curvature of hammer heads, falling direction of the hammers and time between impacts shall be verified regularly.

The fulfilment of the requirement shall be verified at regular intervals under standard laboratory conditions. The test shall be performed on a test surface that is flat to within ± 0,1 mm and horizontal to within ± 0,1°.

The uncertainty of the verification measurements shall be at maximum 20 % of the values of the tolerances.

Annex F
(normative)

Alternative impact sound sources

F.1 Modified tapping machine

F.1.1 General

In this annex, two methods of creating a modified tapping machine are specified, namely Method A and Method B.

F.1.2 Method A

Springs are fixed to the hammers of the standard tapping machine [see Figure F.1 a)]. The dynamic stiffness, s, of each spring shall be 24 kN/m ± 10 %, the loss factor, η, shall be 0,2 to 0,5. To maintain the same contact area compared with the excitation by an unmodified tapping machine, the springs shall have the same cross-section as the hammers. The modified tapping machine shall be adjusted to keep the same falling height of the hammers as with the standard tapping machine.

F.1.3 Method B

Place a soft layer on the floor under the hammer area of the tapping machine [see Figure F.1 b)]. The dynamic stiffness, s, per unit area of the soft layer shall be 34 MN/m^3 ± 10 %, the loss factor, η, shall be 0,2 to 0,5.

The dynamic stiffness shall be measured in accordance with ISO 9052-1. The loss factor shall be determined from the same measurement by the following relation:

$$\eta = b / f_{\text{res}} \tag{F.1}$$

where

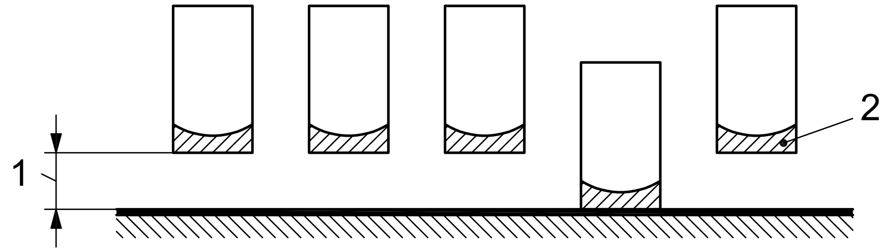
f_{res} is the resonance frequency of the spring-mass-system in accordance with ISO 9052-1:1989, Figure F.1;

b is the 3 dB bandwidth at the resonance.

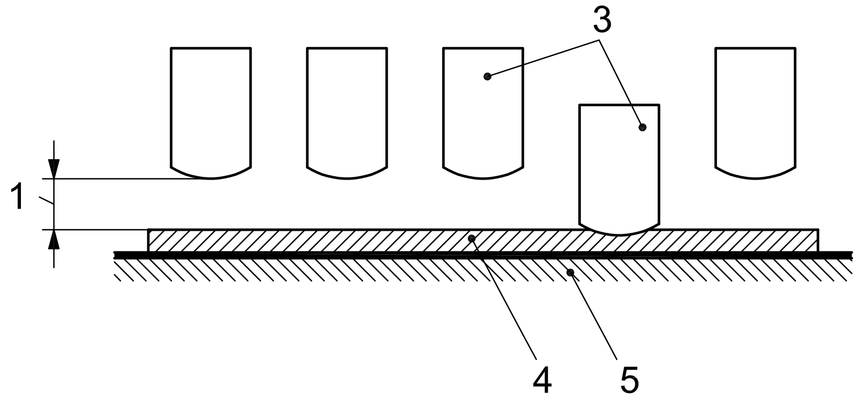
The modified tapping machine shall be adjusted to keep the same falling height of the hammers as with the standard tapping machine, as shown in Figure F.1.

NOTE No single product is recommended as a soft layer. The layer can be made of rubber, cork, plastic material or similar.

It is recommended that the elastic layer be created using a number of thin layers (e.g. 3 mm each) to ensure a low bending stiffness. For the same reason, the thin layers should be fixed to each other only at single points. The area of the soft layer should be as small as possible, preferably a strip of 45 cm length and 5 cm width. The stiffness of the soft layer can be affected by temperature, non-linear behaviour and ageing of the material.



a) Single springs fixed to the hammers



b) Elastic layer under the hammers, laid on the test floor under test

Key

1 falling height (40 mm)

2 spring

3 hammers of the tapping machine

4 elastic layer

5 reference floor

NOTE Only hammers are shown.

Figure F.1 — Modified tapping machine

F.2 Heavy/soft impact source — Rubber ball

F.2.1 General

This clause specifies the impact force characteristics of the heavy/soft impact source for the measurement of impact sound pressure level specified in ISO 10140-3.

F.2.2 Impact force characteristics

The heavy/soft impact source shall generate the impact force exposure level in each octave band shown in Table F.1 and Figure F.2 when it is dropped vertically in a free fall from the height of (100 ± 1) cm (from the bottom of the impact source to the surface of the floor under test).

The impact force exposure level, L_{FE}, is ten times the common logarithm of the ratio of the time-integrated value of the impact force squared to the square of the reference force, as expressed in decibels by Equation (F.2).

$$L_{\mathrm{FE}} = 10 \lg \left[\frac{1}{T_{\mathrm{ref}}} \int_{t_1}^{t_2} \frac{F^2(t)}{F_0{}^2} dt \right] \ \mathrm{dB} \qquad \text{(F.2)}$$

where

$F(t)$ is the instantaneous force acted on the floor under test when the heavy/soft impact source is dropped on the floor, in newton;

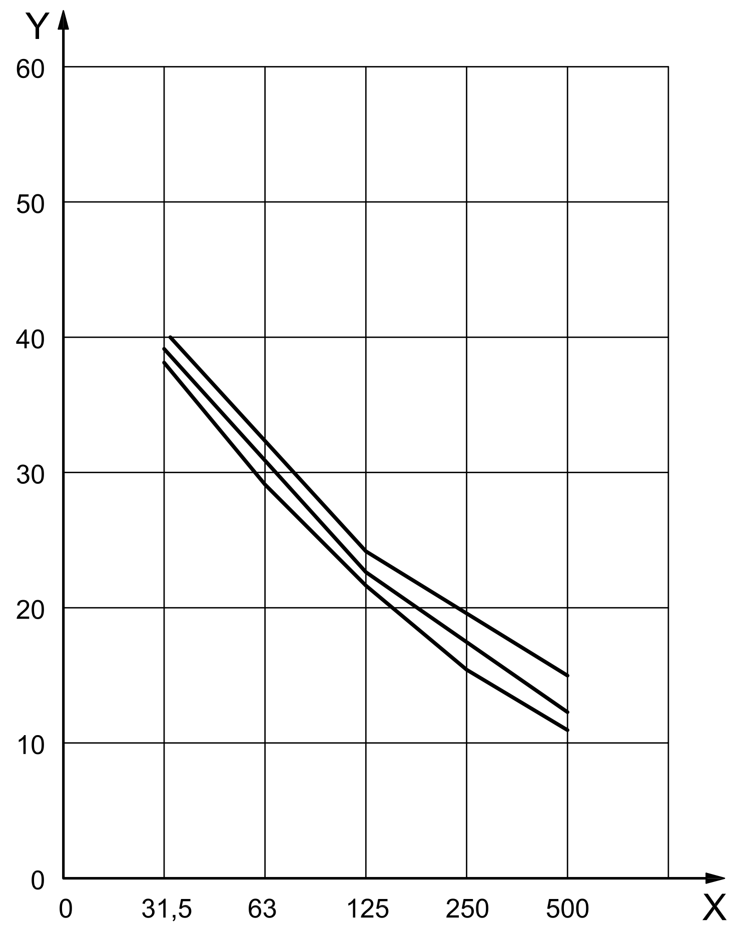
F_0 is the reference force (= 1 N);

$t_2 - t_1$ is the time duration of the impact force, in seconds;

T_{ref} is the reference time interval (= 1 s).

Table F.1 — Impact force exposure level in each octave band of the heavy/soft impact source

Octave band centre frequency Hz	Impact force exposure level L_{FE} dB re 1 N
31,5	39,0 ± 1,0
63	31,0 ± 1,5
125	23,0 ± 1,5
250	17,0 ± 2,0
500	12,5 ± 2,0



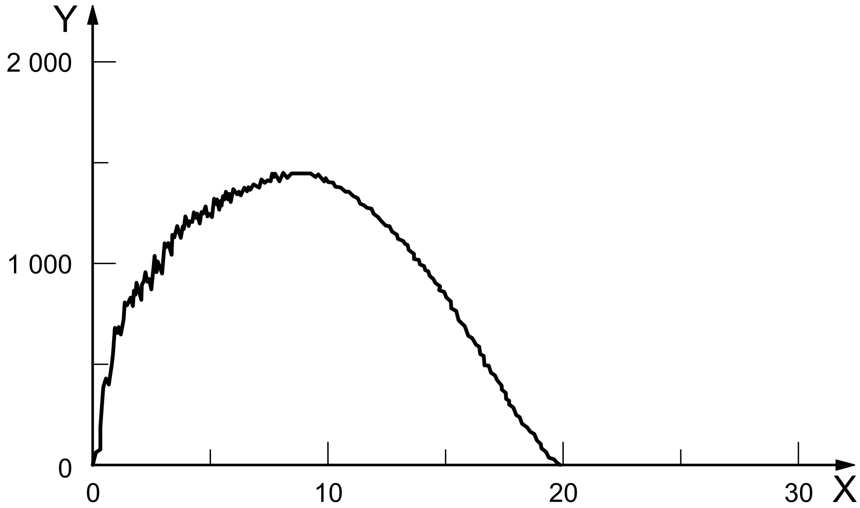
Key

X octave band centre frequency (Hz)

Y impact force exposure level (dB re 1 N)

Figure F.2 — Impact force exposure level in each octave band of the heavy/soft impact source

Figure F.3 shows the impact force waveform of the rubber ball.



Key

X time (ms)

Y impact force (N)

NOTE The rubber ball can either be dropped manually or using an automated set-up.

Figure F.3 — Impact force waveform of the rubber ball measured on a heavy concrete floor

F.2.3 Example of the construction of the heavy/soft impact source

A rubber ball with the following characteristics can realize the conditions specified in F.2.2:

a) shape and size: hollow ball of 180 mm in diameter with 30 mm thickness (see Figure F.4);

b) composition: see Table F.2;

c) effective mass: (2,5 ± 0,1) kg;

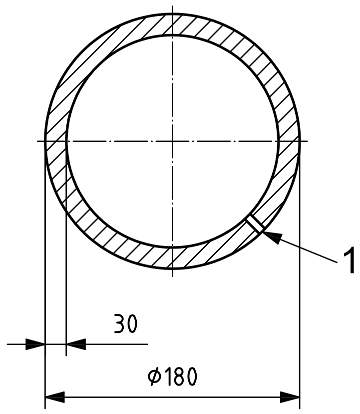
d) coefficient of restitution: 0,8 ± 0,1.

Table F.2 — Composition of the rubber ball

Material	Silicone rubber	Peroxide cross-linking agent	Pigment	Vulcanizing agent
mass fraction, w_l [a]	100	2	2	$<$ 0,1

[a] Parts by mass per hundred parts by mass of rubber.

Dimensions in millimetres



Key

1 pin hole (1 mm in diameter)

Figure F.4 — Section view of the rubber ball — heavy/soft impact source

Annex G
(normative)

Wooden mock-up floor for measuring the improvement of impact sound insulation by floor coverings

G.1 Alternative basic element

For the application of floor coverings on lightweight constructions, the construction described in this annex can be used as an alternative basic element to those specified in Annex C. It consists of a lightweight top floor, described in G.2, mounted on the standard heavyweight reference floor as specified in C.2.

G.2 Lightweight top floor

Unless a specific lightweight floor should be simulated, the standard top floor shall consist of a 22 mm thick floor particleboard mounted on 20 wooden feet c/c 600 mm. The area of the particleboard shall be 2 000 mm × 2 600 mm. If smaller particleboards are used, they shall be glued together using a PVAc glue (polyvinyl acetate). The outermost feet shall be located approximately 100 mm from the edges of the board. The E-modulus of the particleboard shall be 3 000 MPa to 3 500 MPa and the density shall be 700 kg/m^3 to 900 kg/m^3. Each foot shall be made of spruce wood or similar, with an approximate height of 200 mm and a cross-section of 50 mm × 50 mm. The feet shall be screwed and glued on the board.

The top floor shall be mounted on the concrete subfloor on a thin layer of resilient material, for instance plastic padding or similar.

Optionally, the standard top floor described above may be supplemented by other top floors simulating the upper part of arbitrary lightweight floors. This is done by replacing the 22 mm particleboard by other boards or combinations thereof.

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