INTERNATIONAL STANDARD

ISO 10140-1

Second edition
2016-08-15

Acoustics — Laboratory measurement of sound insulation of building elements —

Part 1: **Application rules for specific products**

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

Partie 1: Règles d'application pour produits particuliers

Reference number
ISO 10140-1:2016(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.

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

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

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

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

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

This second edition cancels and replaces the first edition (ISO 10140-1:2010), which has been technically revised.

It also incorporates the Amendments ISO 10140-1:2010/Amd 1:2012 and ISO 10140-1:2010/Amd 2:2014.

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).

This part of ISO 10140 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 ISO 10140-5 where appropriate. For elements and products without a specific application rule described in this part of ISO 10140, it is possible to apply ISO 10140-2 and ISO 10140-3. ISO 10140-4 contains basic measurement techniques and processes. ISO 10140-5 contains the 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 this part of ISO 10140 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 according 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)

Table 1 — (*continued*)

Relevant part of ISO 10140	Main purpose, contents and use	Detailed content
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 1: Application rules for specific products

1 Scope

This part of ISO 10140 specifies test requirements for building elements and products, including detailed requirements for preparation, mounting, operating and test conditions, as well as applicable quantities and additional test information for reporting. The general procedures for airborne and impact sound insulation measurements are given in ISO 10140-2 and ISO 10140-3, respectively.

2 Normative references

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

ISO 717-1:2013, *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 10140-2, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurement of airborne sound insulation*

ISO 10140-3:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 3: Measurement of impact sound insulation*

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

ISO 10140-5:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 5: Requirements for test facilities and equipment*

ISO 10140-5:2010/Amd 1:2014, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 5: Requirements for test facilities and equipment — Amendment 1: Rainfall sound*

ISO 12999-1:2014, *Acoustics — Determination and application of measurement uncertainties in building acoustics — Part 1: Sound insulation*

ISO 16940, *Glass in building — Glazing and airborne sound insulation — Measurement of the mechanical impedance of laminated glass*

EN 572-1, *Glass in building — Basic soda lime silicate glass products — Part 1: Definitions and general physical and mechanical properties*

EN 572-2, *Glass in building — Basic soda lime silicate glass products — Part 2: Float glass*

3 General

General requirements regarding boundary conditions and mounting of the test element in the laboratory are specified in ISO 10140-2, ISO 10140-3 and ISO 10140-5. Additional and more detailed requirements regarding preparation, mounting and operating conditions, and conditioning are given in Annexes A, B, C, D, E, F, G, H, I, J and K.

NOTE For products which are not covered by Annexes A, B, C, D, E, F, G, H, I, J or K, a new annex can be added, based on available knowledge and practice. The preferred structure of annexes is specified in Clause 4.

When testing in accordance with ISO 10140 (all parts), this part of ISO 10140 shall always be checked for requirements relating to specific elements and products. The basic conditions specified in ISO 10140-2 or ISO 10140-3 shall always be followed.

4 Structure of application rules for specific products

To extend or update the Annexes A, B, C, D, E, F, G, H, I, J and K, or to prepare a new annex with application rules for specific products, the required contents are listed below. For some elements or products, certain items might not be relevant. The purpose is to describe boundary, mounting and operating conditions for specific elements, products or groups of products.

a) Application:

  1) definition of the element/product it applies to;

  2) quantities measured (if needed);

  3) reference to test method(s).

b) Test element:

  1) size of the test opening and the test element;

  2) number of test elements.

c) Boundary and mounting conditions (should be applied before installation):

  1) boundary conditions, e.g. filler wall, element boundaries;

  2) mounting positions;

  3) installation of the test element in the test opening.

d) Test and operating conditions (should be applied after installation):

  1) operating conditions, e.g. open/close before test;

  2) conditioning/curing/drying;

  3) loading;

  4) environmental conditions.

e) Test report.

f) Additional information: if necessary, any information additional to the information that is required in basic ISO 10140-2 and ISO 10140-3.

Annex A
(normative)

Walls — Airborne sound insulation

A.1 General

For walls and other partitions, ISO 10140-2 is applicable. This annex is applicable to lightweight twin leaf partitions, such as those constructed of gypsum boards.

The quantity determined is the sound reduction index, R, as a function of frequency. The definition of R is given in ISO 10140-2.

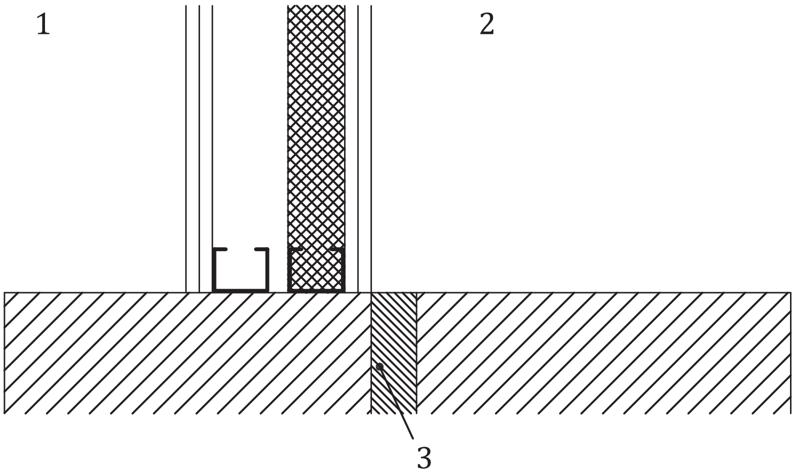
The general guidelines in the relevant clauses of the basic ISO 10140-2 shall always be followed.

A.2 Test element

The test opening for walls should be approximately 10 m².

A.3 Boundary and mounting conditions

The sound reduction index of lightweight twin leaf partitions (e.g. twin leaf gypsum board walls) is influenced by the mounting conditions in the test opening of the laboratory. Important installation parameters include the niche depth and the position of the partition in relation to the acoustic break in the test aperture.



Key

1 source room

2 receiving room

3 acoustic break of the laboratory

Figure A.1 — Example of the position of the test element relative to the acoustic break of the laboratory

To improve the reproducibility between laboratories and facilitate comparison of sound reduction indices for different lightweight double walls, the twin leaf partition shall not be mounted across the acoustic break of the laboratory, but on the same side of the break, as indicated in Figure A.1. The aperture should meet the requirements in ISO 10140-2.

Other mounting conditions may be used but shall be fully described in the test report.

NOTE 1 Mounting the lightweight partition with one leaf on one side and the other leaf on the other side of the acoustic break can result in higher values for the sound reduction index.

NOTE 2 Other mounting conditions can be suitable for certain types of twin leaf walls, for example walls for semi-detached houses where the leaves are vibrationally uncoupled (for example on separate foundations). In such cases, the wall leaves can be mounted on each side of the acoustic break.

A.4 Test and operating conditions

The test and operating conditions are given in ISO 10140-2.

A.5 Test report

The test report is given in ISO 10140-2.

Annex B
(normative)

Doors — Airborne sound insulation

B.1 General

This annex is applicable to internal and external doors (including door sets).

The quantity determined is the sound reduction index, *R*, as a function of frequency. The definition of *R* is given in ISO 10140-2.

The general guidelines in the relevant clauses of the basic ISO 10140-2 shall always be followed.

NOTE For a definition of door, see ISO 1804 and EN 12519.

B.2 Test element

For most doors, a test opening with an area of less than 10 m^2 is needed. The area of the test element, *S*, is the area of the opening in the filler wall required to accommodate the door.

B.3 Boundary and mounting conditions

The test opening for doors shall be arranged such that the lower edge is situated near to the level of the floor of the test rooms and such that conditions in the building are reproduced. The door shall be installed for test such that it can be opened and closed in a normal manner.

B.4 Test and operating conditions

The door shall be opened and closed at least five times immediately before testing.

B.5 Test report

The test report is given in ISO 10140-2.

Annex C
(normative)

Windows — Airborne sound insulation

C.1 General

This annex is applicable to windows.

The quantity determined is the sound reduction index, R, as a function of frequency. The definition of R is given in ISO 10140-2.

The general guidelines in the relevant clauses of ISO 10140-2 shall always be followed.

NOTE For a definition of window (terminology), see EN 12519.

C.2 Test element

The preferred dimensions of the test opening for a window are 1 250 mm × 1 500 mm as for the specific small-sized test opening described in ISO 10140-5, but variations from this size can be necessary in recognition of national building practice. For windows, the test opening may be staggered as shown in ISO 10140-5:2010, Figure 3. In the case of a window assembly, dimensions may be chosen as representative of the assembly used in practical circumstances. For windows, the area, S, is the area of the opening in the filler wall required to accommodate the test element.

C.3 Boundary and mounting conditions

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

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

If the test element is intended to be readily openable, it shall be installed for the test in such that a way it can be opened and closed in a normal manner.

C.4 Test and operating conditions

C.4.1 Conditioning

The sound insulation of certain glazing systems or elements, especially those incorporating laminated glass, can depend on the room temperature during the measurements. The temperature of both rooms used for measuring the sound insulation should be (20 ± 3) °C. The test elements should be stored for 24 h at the test temperature. In addition, it can be advantageous to make measurements at temperatures similar to those for which the test element is designed.

C.4.2 Operation

If the test element is intended to be openable, it shall be opened and closed at least five times immediately before testing.

C.5 Test report

The test report is given in ISO 10140-2.

Annex D
(normative)

Glazing — Airborne sound insulation

D.1 General

This annex is applicable to glazing.

The quantity determined is the sound reduction index, R, as a function of frequency. The definition of R is given in ISO 10140-2.

The general guidelines in the relevant clauses of ISO 10140-2 shall always be followed.

NOTE For a definition of glass (terminology), see EN 12758.

D.2 Test element

The dimensions of the test opening for glazing shall be 1 250 mm × 1 500 mm with an allowable tolerance on each dimension of ±50 mm, preferably maintaining the same aspect ratio. For glazing, the test opening shall be staggered on both sides and on the top by a distance of between 60 mm and 65 mm. The glazing shall be mounted in the smaller opening as shown in Figure D.1. For glazing, the area, S, is the area of the opening in the filler wall required to accommodate the test element.

The specific small-sized test opening described in ISO 10140-5:2010, Figure 3, fulfils these criteria, and a test opening in accordance with ISO 10140-5:2010, 3.3.2, shall be used.

NOTE Details of the measurement conditions for glazing are prescribed in order to ensure the best possible comparison between results obtained by different laboratories.

D.3 Boundary and mounting conditions

The glazing shall be installed into the test opening such that the niches on both sides of the pane have different depths with a ratio of 2:1. A gap of about 10 mm shall remain between the pane and the reveal of the test opening. This gap shall be filled with a type of putty, which shall be tested as described below. To fix the glazing, two wooden beads (25 mm × 25 mm) shall be used (see Figure D.1). The space between the glazing and the wooden beads shall be filled with putty about 5 mm thick. The beads shall cover not more than 15 mm and not less than 12 mm of the glass[1)].

The putty used for filling the 10 mm gap between the perimeter of the glazing and the reveal of the test opening, and the 5 mm gap between the glazing and the wooden beads shall be qualified by the following test method. A single soda-lime/silica glass pane (float, density 2 500 kg/m^3, modulus of elasticity $E = 7 \times 10^4$ MPa) with a thickness of (10 ± 0,3) mm and dimensions of 1 230 mm × 1 480 mm shall be mounted with this putty in accordance with Figure D.1. The airborne sound reduction index shall be determined in one-third octave bands in the frequency range from 1 600 Hz to 3 150 Hz. The first measurement shall begin not later than 1 h after mounting. The results shall be as follows, to within ±2,0 dB:

— 1 600 Hz: R = 31,3 dB;

— 2 000 Hz: R = 35,6 dB;

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

— 2 500 Hz: R = 39,2 dB;

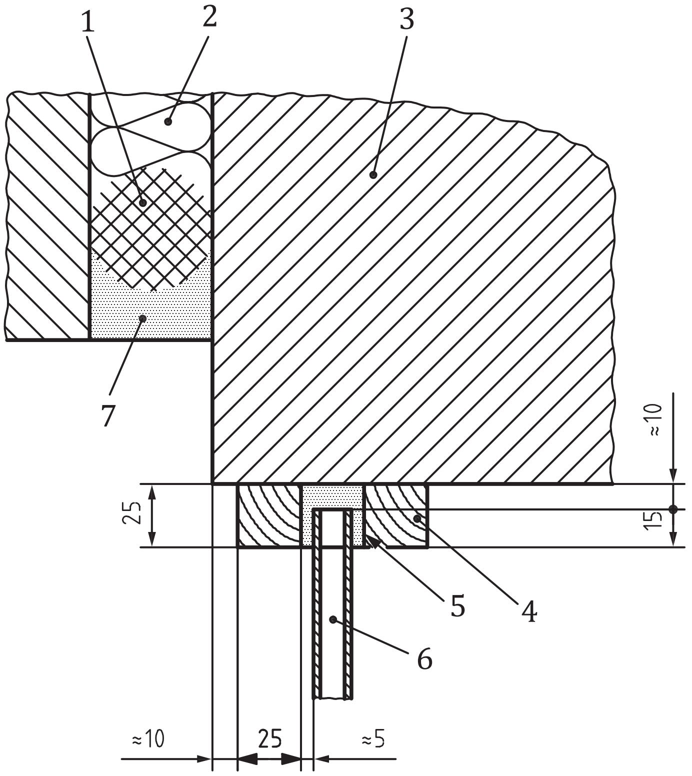
— 3 150 Hz: R = 42,9 dB.

A second measurement shall be taken about 24 h later in order to make sure that no hardening process is influencing the measurement. No systematic deviation average, ΔR (mean of the four ΔR values), greater than 0,5 dB is permitted.

NOTE Perennator TX 2001 S[2)] has been shown to fulfil these conditions.

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

Dimensions in millimetres



Key

1 compressible seal

2 mineral wool

3 wall

4 wooden beading

5 putty

6 glass pane

7 resilient material (acoustically reflective)

NOTE This figure shows (as an example) a double-glazed pane installed directly into the (smaller) aperture of a double-filler wall (for more details, see ISO 10140-5:2010, 3.3.2).

Figure D.1 — Example of installation of glass pane

2) Perennator TX 2001 S is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

D.4 Test methods

D.4.1 General

Acoustic performance data shall be obtained under the conditions specified by ISO 10140-1 and ISO 717-1. For laminated glasses, owing to temperature dependency, it is recommended that the specimen temperature should be (20 ± 3) °C.

For best reproducibility, it is recommended that the test opening for glass panes, as described in this part of ISO 10140, be adopted.

Some variation in panel size, etc., to those in ISO 10140 (all parts), may be necessary for the testing of glazed assemblies, i.e. glass blocks, paver units, channel-shaped glass, structural sealant glazing and structural assemblies, in order to include a valid representation of all their features. Acoustic measurements of the performance of these products shall be made on assemblies or arrays of them and not of individual elements. Factors which influence testing are size, jointing, etc.

Test reports on the sound insulation of glazing shall be obtained from measurements made under the conditions specified in ISO 10140 (all parts) or, as closely as possible, for some unconventional glass products or assemblies, as acknowledged above. In all cases, constructional details shall be included, with statements, where appropriate, of:

a) type of glass;

b) glass thickness(es);

c) airspace(s)/cavity width(s);

d) gas filling - type and concentration;

e) edge seal profile, edge seal materials and edge seal components;

f) for laminated glass, glass/plastics sheet material/interlayer build up - type, thickness(es) and number;

g) for laminated glass, the specimen temperature;

h) description of the particular mounting conditions for assemblies of glass blocks, pavers units, channel-shaped glass, structural sealant glazing and structural assemblies due to the necessary deviation from the prescribed conditions of ISO 10140 (all parts).

D.4.2 Reference curves

D.4.2.1 General

These shall be determined by measuring two reference insulating glass units (IGU) as defined in D.4.2.2 and D.4.2.3. Reference curves shall be determined when the test equipment is set up and then checked at least once a year or before each new glazing measurement.

In case of doubt concerning the results obtained using the reference IGUs, then a specimen of single glass, i.e. 10 mm float glass in accordance with EN 572-1 and EN 572-2, shall be measured to check repeatability.

D.4.2.2 Reference IGU 6(16)6

The sound reduction index (SRI) of a reference 6(16)6 IGU, as described in Figure D.2, shall be in the range as given in Table D.1.

Table D.1 — Sound reduction index of the reference IGU 6(16)6

Frequency Hz	**Min. value** $R_{\mathrm{min},i}$ dB	**Max. value** $R_{\mathrm{max},i}$ dB
100	20,0	25,3
125	15,9	21,5
160	17,9	21,1
200	17,3	19,7
250	19,7	22,9
315	23,5	26,4
400	27,2	29,3
500	30,4	32,7
630	33,5	35,6
800	36,9	38,6
1 000	38,4	39,9
1 250	37,8	39,7
1 600	36,6	38,4
2 000	31,7	33,7
2 500	31,5	33,0
3 150	34,9	37,4

When the absolute deviations between the numbers in Table D.1 and the measured values, R_i, are summed, then the total deviation cannot exceed 6,0 dB. All calculations shall be undertaken with an accuracy of ±0,1. Formula (D.1) shall be used:

$$\sum_{i=1}^{16} R_{i,\Delta} \leq 6,0\,\mathrm{dB} \quad \text{with} \quad R_{i,\Delta} = \begin{Bmatrix} 0 \quad \text{if} \quad R_{\mathrm{min},i} \leq R_i \leq R_{\mathrm{max},i} \\ R_{\mathrm{min},i} - R_{i}, \quad \text{if} \quad R_i < R_{\mathrm{min},i} \\ R_i - R_{\mathrm{max},i} \quad \text{if} \quad R_i > R_{\mathrm{max},i} \end{Bmatrix} \tag{D.1}$$

D.4.2.3 Reference IGU 10(16)44-2 laminated glass with acoustic interlayer *S*

The SRI of a reference IGU made up of 10(16)44-2 shall be in the range as given in Table D.2.

The laminated glass being manufactured with an acoustic interlayer *S*. The IGU is described in Figure D.3.

NOTE 1 A laminated glass make up designated 44-2 means 2 × 4 mm glass and 0,76 mm interlayer.

Table D.2 — Sound reduction index of the reference IGU 10(16)44–2 laminated glass with acoustic interlayer *S*

Frequency Hz	**Min. value** $R_{\min,i}$ dB	**Max. value** $R_{\max,i}$ dB
100	25,4	31,5
125	21,2	27,9
160	25,7	29,4
200	27,5	30,4
250	32,4	36,4
315	32,6	35,8
400	37,3	40,4
500	39,7	42,8
630	42,3	45,0
800	43,9	46,4
1 000	43,6	45,8
1 250	43,3	46,2
1 600	45,7	48,1
2 000	47,9	51,0
2 500	48,9	51,9
3 150	49,4	52,0

When the absolute deviations between the numbers in Table D.2 and the measured values, R_i, are summed, then the total deviation cannot exceed 6,0 dB. All calculations shall be undertaken with an accuracy of ±0,1. Formula (D.1) shall be used.

Criteria shall be fulfilled for both reference IGUs.

NOTE 2 These data are issued from a round robin concerning 22 laboratories. The values have been obtained by taking the average value ± one standard deviation.

In accordance with ISO 12999-1:2014, Clause 7, single number uncertainties may be taken from a dedicated round robin. For declaration of glass products $k = 2$, two sided shall be used.

Expanded uncertainties for declaration of performance of glass products defined that way are the following:

R_w	1,2
$R_w + C$	1,2
$R_w + C_{tr}$	1,5

EXAMPLE The airborne sound insulation of a glass product will be designated as:

R_w (C; C_{tr}) = 33(−2; −5) dB;

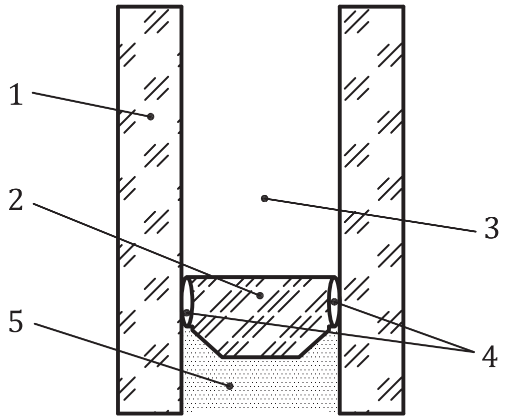
R_w = (33,2 ± 1,2) dB (k = 2, two-sided);

$R_w + C$ = (31,3 ± 1,2) dB (k = 2, two-sided);

$R_w + C_{tr}$ = (28,3 ± 1,5) dB (k = 2, two sided).

D.4.2.4 Maximum standard deviation of repeatability

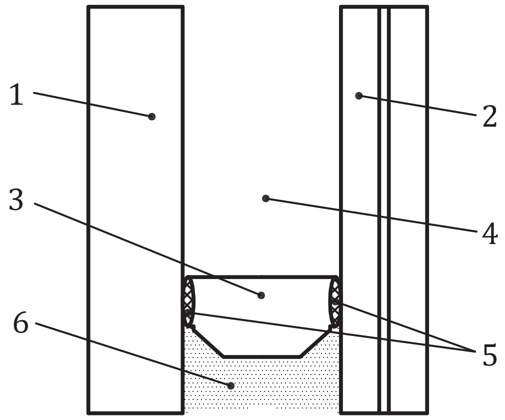
Maximum repeatability will be in accordance with ISO 12999-1.



Key

1 glass pane: float of nominal thickness of 6 mm
2 spacer bar: aluminium of nominal thickness of 16 mm
3 air space of nominal thickness of 16 mm
4 inner seals: butyl
5 outer seal: polysulfide

Figure D.2 — Description of reference insulating glass unit, type IGU 6(16)6, air filled



Key

1 glass pane: float of nominal thickness of 10 mm
2 laminated glass pane: nominal thickness of 2 × 4 mm float assembled with acoustic interlayer *S*, nominal thickness of 0,76 mm
3 spacer bar: aluminium of nominal thickness of 16 mm
4 air space of nominal thickness of 16 mm
5 inner seals: butyl
6 outer seal: polysulfide

Figure D.3 — Description of reference insulating glass unit IGU 10(16)44-2, laminated glass with acoustic interlayer *S*, air filled

The acoustic interlayer *S* mentioned in Figure D.3 shall have a measured loss factor of the first mode of the beam above or equal to 0,25 when evaluated in accordance with ISO 16940.

NOTE For detailed description of glass products and glass components, see ISO 20492 (all parts), ISO 12543-1 and ISO 16293-2.

D.5 Test report

The test report given in ISO 10140-2 shall be used.

Annex E
(normative)

Small technical elements — Airborne sound insulation

E.1 General

This annex is applicable to small technical elements, for instance air intakes and other elements smaller than 1 m^2, such as profiles and shutter boxes.

The acoustic performance of the element is expressed in the element-normalized level difference, $D_{n,e}$ per unit, as defined in ISO 10140-2.

The general guidelines in the relevant clauses of the basic ISO 10140-2 shall always be followed.

For small technical elements, the sound reduction index is less suitable as a descriptor because the area of the test element is not normally well defined and the performance is not necessarily proportional to the area of the test element. Therefore, the performance is expressed as a normalized level difference for a specific unit. Furthermore, due to the small dimensions and mounting conditions, the direct environment around the test element and nearby objects can have a large influence on the results and should therefore be carefully specified.

E.2 Test element

E.2.1 General

Ensure that the test element is installed in a manner representative of field practice using normal connections and sealing conditions at the perimeter and at joints within the unit.

The building elements are small and, in combination with the spatial variations of the sound fields, this leads to significant dependency on their position; it is therefore recommended more than one position of the test element be used (see E.2.2).

In order to achieve a realistic wall thickness around the element, it may be practical or necessary to either increase or decrease the thickness of the partition wall in the area around the element (see E.2.3 and E.2.4).

When a small building unit is mounted near one or more reflecting planes, the sound transmission can differ appreciably from that obtained when the unit is mounted through a partition, but away from any adjoining room surface. Therefore, mount the equipment selected for testing through the partition in positions representative of normal usage. If natural corners or edges are not available in the test opening, it is essential to simulate such mounting conditions by attaching reflective panels at right angles to the partition wall, as described in E.2.5.

E.2.2 Number of positions

Three positions should be used for the mounting of the test element in the partition wall. These positions shall either be simulated, as described in E.2.5, or they shall be located at least 1,2 m from each other.

A dependency on position also occurs for apparently equivalent corners; this makes it necessary to use more than one corner.

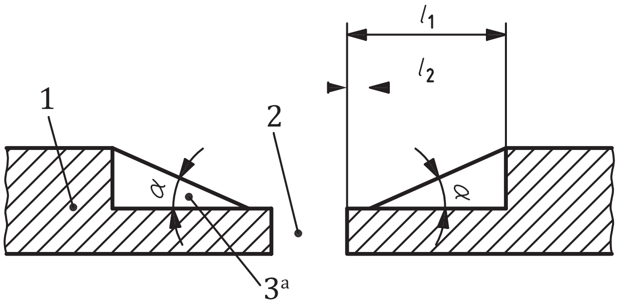
NOTE When simulating corner or edge positions by attaching reflective panels, it is possible to achieve the necessary position averaging by changing the locations and orientations of the reflective panels while the test element stays in the same position.

E.2.3 Local increase of wall thickness

Instead of changing the thickness of the complete partition wall, simulate various wall thicknesses by adding extra panels with a mass per unit area of more than 10 kg/m^2 to the original partition construction. The edges of such additional panels shall be at least 0,5 m from any part of the test element.

E.2.4 Local decrease of wall thickness

If a thick partition wall is needed to achieve a sufficiently high flanking transmission loss, create a realistic wall thickness around the test device by locally reducing the thickness using panels. This shall be done in accordance with Figure E.1.



Key

1 partition between test rooms

2 test element

3 auxiliary transition panels

a The panels shall be sealed with tape along the edges.

Figure E.1 — Local decrease of wall thickness

The following relations shall hold:

a) $l_1 > 0,6$ m;

b) $l_2 > 0,1$ m; if $l_2 > 0,5$ m in every direction, no smooth transition of thickness is necessary;

c) $\alpha < 30°$.

E.2.5 Central, corner and edge positions

E.2.5.1 Equipment used away from walls

Install equipment mounted through a partition but normally located away from an adjoining wall, floor or ceiling in such a manner that no part is within 1,00 m of a surface at right angles to the mounting surface; 0,85 m is sufficient, if several elements are tested at the same time.

E.2.5.2 Equipment used near an edge

Locate equipment mounted through a partition, and normally located near an adjoining wall, floor or ceiling, and away from a corner, at least 1,00 m (0,85 m if several elements are tested at the same time) from the nearest wall not being a part of the edge. Unless otherwise specified by the manufacturer, locate the edge of the equipment 0,1 m from the edge of the wall.

E.2.5.3 Equipment used near a corner

Locate equipment mounted through a partition and normally located near a corner at a distance from the corner which should be representative of typical use, as recommended by the manufacturer.

E.2.5.4 Simulation of corner or edge positions

The simulation of a corner is shown in Figure E.2. To simulate an edge, it is sufficient to use only one panel, the dimensions of which shall be at least 1,2 m × 2,4 m. The panels shall not be mounted parallel to the boundary surfaces of the room. If it is necessary to use additional panels in both the source room and the receiving room, ensure that the locations and orientations of the panels are the same in both rooms.

The mass per unit area of the panels shall exceed 7 kg/m^2. Above 100 Hz, the sound absorption coefficient shall be less than 0,1.

Seal the connections between the panels and the partition wall with, for example, a heavy adhesive tape. As the mounting of additional panels to the partition wall can influence its transmission characteristics, include the various panel arrangements in the measurements of the flanking transmission.

Dimensions in metres

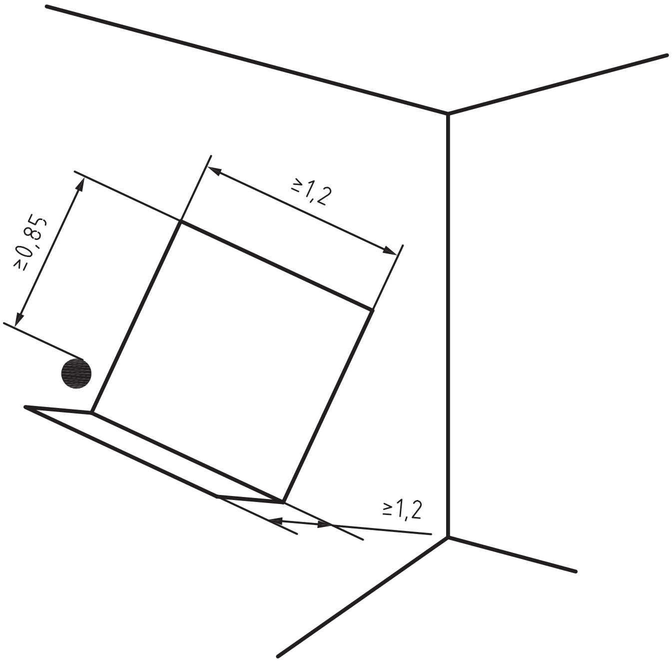


Figure E.2 — Drawing indicating simulation of a corner position by attaching reflective panels at right angles to the partition wall mounted in the test opening

E.3 Boundary and mounting conditions

E.3.1 Transfer air devices

Install the test elements in a manner representative of field practice and in typical locations with respect to the room surfaces, as given in the installation rules above. Mount transfer air devices which are normally mounted near an adjoining ceiling in a position close to a reflective surface at right angles to the partition, but at least 1,00 m (0,85 m if several elements are tested at the same time) from any corner. The distance between the closest part of the device and the adjoining surface shall be 0,1 m. Accessories that are normally used shall be included. Position and fix these accessories in accordance with the manufacturer's instructions.

For devices which can be used in several different positions, carry out measurements with at least an edge present in both rooms.

If the device is continuously adjustable to various wall thicknesses, ensure that the tests comprise at least the two extreme wall thicknesses for which the device is stated to be suitable.

E.3.2 Electrical raceways

Install the test element in a manner representative of field practice and in typical locations with respect to the room surfaces. Mount raceways which are normally mounted directly on walls on a reflective surface at right angles to the partition and according to the manufacturer’s directions. Include accessories normally used. Install these accessories according to the manufacturer’s instructions.

Install the test element with an exposed continuous duct length of at least 2 m, both in the source and in the receiver room. Provide the exposed duct ends with standard end covers.

Soundproofing accessories used in installations through partition walls are often available in raceways. To test practical sealing and insulating properties of such soundproofing accessories, it is recommended that the raceway be filled to its rated capacity with cables.

NOTE The acoustic performance can vary with the number of cables.

If the edge mounting is simulated with additional panels, ensure that the panel length is at least as long as the duct length.

E.4 Test and operating conditions

For transfer air devices, if the device is provided with some air-flow control, ensure that the equipment is operated in a specified manner typical of normal usage. The fully open condition should be included among the tests.

E.5 Test report

The test report is given in ISO 10140-2. The following additional information shall also be reported:

a) a detailed description of the corners or edges used, being normally available or simulated;

b) a detailed description of the methods used to increase or decrease the wall thickness in order to install the test element.

Annex F
(normative)

Floors — Airborne and impact sound insulation

F.1 General

This annex is applicable to floors.

The quantity determined is the sound reduction index, R, as a function of frequency or the normalized impact sound pressure level, L_n, as a function of frequency. The definitions of R and L_n are given in ISO 10140-2 and ISO 10140-3, respectively.

The general guidelines in the relevant clauses of ISO 10140-2 and ISO 10140-3 shall always be followed.

F.2 Test element

The test opening for floors should be between 10 m^2 and 20 m^2.

F.3 Boundary and mounting conditions

Follow the guidelines given in ISO 10140-2 and ISO 10140-3.

F.4 Test and operating conditions

Follow the guidelines given in ISO 10140-2 and ISO 10140-3.

F.5 Test report

The test report is given in ISO 10140-2 and ISO 10140-3.

Annex G
(normative)

Acoustical linings — Improvement of airborne sound insulation

G.1 General

This annex is applicable to acoustical linings on walls and floors.

The quantity determined is the sound reduction improvement index, ΔR, in decibels, which is defined as the difference between the sound reduction indices of the basic element with and without the lining for each one-third octave band:

$$\Delta R = R_{\text{with}} - R_{\text{without}}$$

The general guidelines in the relevant clauses of the basic ISO 10140-2 shall always be followed.

NOTE 1 The sound reduction improvement of a lining can be different for direct and flanking sound transmission, as well as for airborne and impact sound excitation. The method described in this part of ISO 10140 yields the sound reduction improvement for direct airborne sound transmission.

NOTE 2 This annex does not deal with the sound reduction improvement by linings on flexible lightweight structures, such as timber frame floors or double-leaf gypsum board walls.

NOTE 3 The sound reduction index of walls/floors and acoustical linings are characterized separately for the comparison of products. In addition, the European calculation model for the acoustic performance of buildings from the performance of elements distinguishes the sound reduction index of a wall (or floor) and the improvement of the sound reduction index by an additional lining. The laboratory measurement of this sound reduction improvement is the subject of this annex.

G.2 Test element

The test element (i.e. the acoustical lining) and the basic structure shall cover the whole test opening.

Corresponding to the application of the lining, the constructions specified in ISO 10140-5:2010, Annex B, shall be used as standard basic elements. The basic element is defined as the wall or ceiling (floor) to which an additional lining is fixed (see ISO 10140-5:2010, Annex B).

Characterizing a lining alone requires that its acoustic performance be independent from the basic structure to which it is fixed. This is fulfilled when the mass per unit area of the basic structure is much larger than the surface mass of the lining, when the critical frequency of the basic structure is below the measured frequency range and the structural coupling between the lining and the basic structure is weak. If the actual situation differs from these conditions, the effect of the lining is to some extent dependent on the properties of the basic structure. The independent characterization of the acoustic performance of a lining thus requires heavyweight elements. However, a lot of practical applications involve various lightweight elements. As a practical compromise, the following are descriptions of different types of test.

a) In all cases, the lining shall be applied to either a heavy massive wall of about 350 kg/m^2 with its critical frequency around 125 Hz or to the standard concrete floor in accordance with ISO 10140-5:2010, Annex B, depending on the use of the lining. The measured improvement due to the lining is given as a frequency spectrum and as a single-number improvement value according to this annex. As it is based on mean basic element characteristics, the results are largely independent of the particular features of the test facility and of the basic element used, and thus characterize the lining in the most general way.

b) If the performance of a lining on a lightweight solid wall is of interest, a standard lightweight wall of about 70 kg/m^2 with a critical frequency around 500 Hz shall be used in accordance with ISO 10140-5:2010, Annex B. The results shall be given as a frequency spectrum and as a single-number improvement value according to this annex. The critical frequency can strongly influence the improvement by the lining, hence the results are not likely to be transferable to other basic constructions. However, using the weighting procedure in this annex, the influences of the particular test facility and basic construction on the single-number ratings are minimized, thus making the results comparable between different laboratories.

c) In order to specify the effect of linings in specific situations, other basic structures can be used in addition to those specified for the general characterization of the product. As no average properties of the basic element are available in this case, single-number results can only be given in terms of the direct difference between the weighted sound reduction indices with and without lining (subsequently called "direct difference of the weighted sound reduction indices"). These improvement values include the particular features of the laboratory and the basic element, thus allowing a comparison of different linings under these particular conditions.

G.3 Boundary and mounting conditions

The lining shall be mounted to the basic element as in practice. The lining shall be linked to the flanking parts of the laboratory as in practice, but there shall be no strong coupling between the basic element and the lining via the edges of the laboratory flanking elements. Either the flanking parts of the laboratory shall be sufficiently heavy (for details, see ISO 10140-5) or there shall be a structural break in the flanking elements, positioned between the basic element and the lining, or the lining, shall not be rigidly fixed along its edges to the flanking elements (i.e. use a flexible sealant where necessary).

G.4 Test and operating conditions

The curing period of the lining and its fixing shall be long enough to reach final conditions. The sound reduction index of the basic element shall not change during the two measurements, hence it shall either be at its final condition or the two measurements shall be carried out within a sufficiently short time interval. For masonry and concrete, this requires a curing period of not less than two weeks. Alternatively, the time lag between the two sound reduction measurements shall not exceed one-third of the curing time elapsed before the first measurement.

For example, when the two measurements are carried out within 1 d, they can be started not less than 3 d after the end of construction of the concrete or masonry basic element.

G.5 Test report

The test report is given in ISO 10140-2. The following additional information shall also be reported:

a) a detailed description of the basic element (dimensions, mass per unit area, materials), details of fixing into the test facility (boundary conditions of the element) and a reference to the corresponding standard basic element from ISO 10140-5:2010, Annex B, or a statement that it is not one of the standard basic elements;

b) a detailed description of the lining and its fixing to the basic element;

c) R_{with}, R_{without} and ΔR as specified in G.6. For standard basic elements in accordance with ISO 10140-5:2010, B.2, B.3 and B.4: ΔR_{w}, $\Delta(R_{\text{w}} + C)$ and $\Delta(R_{\text{w}} + C_{\text{tr}})$ as specified in G.6, with an index in accordance with G.6.1.2 and G.6.1.3, indicating the basic element used. For other basic elements: $\Delta R_{\text{w,direct}}$, $\Delta(R_{\text{w}} + C)_{\text{direct}}$ and $\Delta(R_{\text{w}} + C_{\text{tr}})_{\text{direct}}$ in accordance with G.6.1.3, without any further index for the type of basic element;

d) the total loss factor of the basic element with lining, if measured, as a table of one-third octave band values.

G.6 Additional information

G.6.1 Single-number rating for improvement of sound reduction index by linings

G.6.1.1 General

All results of R_{with}, R_{without} and ΔR shall be given as one-third octave band levels to one decimal place. If required, octave band values ΔR_{oct}, in decibels, shall be calculated from the corresponding one-third octave band values, ΔR_n, using Formula (G.1):

$$\Delta R_{\text{oct}} = -10\lg\left(\sum_{n=1}^{3}\frac{10^{\left(-\Delta R_n/10\right)}}{3}\right) \tag{G.1}$$

R_{with}, R_{without} and ΔR shall be given as frequency spectra in a table as follows:

— R_{with} and R_{without} as one-third octave band level spectra;

— ΔR as one-third octave and as octave band level spectra.

To evaluate the single-number rating, ΔR_{w}, from the one-third octave band ΔR values given to one decimal place, the measured values of the sound reduction improvement are used in conjunction with standard reference curves for the standard basic elements by calculation (see ISO 10140-5:2010, Annex B). The difference between the weighted sound reduction indices of the reference standard basic element with and without lining yields the weighted improvement of sound reduction index, ΔR_{w}, of the lining. A similar procedure is used for the A-weighted improvement of sound reduction indices of the lining, $\Delta(R_{\text{w}} + C)$ and $\Delta(R_{\text{w}} + C_{\text{tr}})$ (see ISO 717-1:2013, 4.5). To calculate the A-weighted sound reduction indices, with and without the lining, sound level spectra in accordance with ISO 717-1:2013, Table 4 or Table B.1 (extended frequency range) shall be used.

NOTE 1 The procedures for determination of single-number quantities are described in ISO 717. However, at the time of publication, ISO 717 has not been revised or amended to include a single-number rating for the improvement of the sound reduction index by linings. G.6.1 will be withdrawn once this takes place.

NOTE 2 To evaluate the single-number rating, ΔR_{w}, from the one-third octave band ΔR values, the same procedure is used as when evaluating the weighted improvement of impact sound insulation ΔL_{w} from the normalized impact sound pressure levels L_{n} according to ISO 717-2.

G.6.1.2 Quantities determined

The single-number ratings determined in accordance with this subclause are as given below.

— The weighted sound reduction improvement index, ΔR_{w}. The single-number rating calculated from the sound reduction improvement index, ΔR. An additional index indicates the standard basic element used: “heavy” for the heavyweight wall or floor and “light” for the lightweight wall in accordance with ISO 10140-5:2010, Annex B. For example, $\Delta R_{\text{w,heavy}}$.

— The direct difference of the weighted sound reduction indices, $\Delta R_{\text{w,direct}}$, in decibels: the difference of the weighted sound reduction indices of the basic element with and without lining under the particular conditions of the measurement (without generalization by means of a reference curve for the sound reduction of the basic element) as given by Formula (G.2):

$$\Delta R_{\text{w,direct}} = R_{\text{w,with}} - R_{\text{w,without}} \tag{G.2}$$

G.6.1.3 Rating procedures

Take the one-third octave band sound reduction improvement index ΔR values, as measured. Add them to the reference values of the sound insulation index, $R_{\text{ref,without}}$, of the matching standard basic element as given in ISO 10140-5:2010, Annex B.

$$R_{\text{ref,with}} = R_{\text{ref,without}} + \Delta R \tag{G.3}$$

Determine the weighted sound reduction indices $R_{\text{w,ref,with}}$ and $R_{w\text{,ref,without}}$ and the corresponding spectrum adaptation terms in accordance with ISO 717-1. The weighted improvement of sound reduction index is then given by Formula (G.4):

$$\Delta R_{\text{w}} = R_{\text{w,ref,with}} - R_{\text{w,ref,without}} \tag{G.4}$$

The A-weighted improvement of sound reduction indices $\Delta(R_{\text{w}} + C)$, respectively, $\Delta(R_{\text{w}} + C_{\text{tr}})$, are calculated in an equivalent way.

An additional index indicates the reference basic element used: “heavy” for the heavyweight wall and floor and “light” for the lightweight wall in accordance with ISO 10140-5:2010, Annex B. For example, $\Delta(R_{\text{w}} + C)_{\text{heavy}}$.

If basic elements besides the standard basic elements are used, the single-number ratings follow directly from the single-number ratings for that basic element with and without the tested acoustical lining according to the definition in G.6.1.2.

Annex H
(normative)

Floor coverings — Improvement of impact sound insulation

H.1 General

This annex is applicable to floor coverings intended to improve the impact sound insulation of floors.

The quantity determined is the improvement of impact sound insulation, ΔL, in decibels, as a function of frequency. ΔL is defined as the reduction in normalized impact sound pressure level resulting from the installation of the test floor covering on a specific reference floor, as given by Formula (H.1):

$$\Delta L = L_{n0} - L_n \tag{H.1}$$

where

L_{n0} is the normalized impact sound pressure level of the reference floor without the floor covering;

L_n is the normalized impact sound pressure level of the reference floor with the floor covering.

If the reduction of impact sound pressure level is needed in octave bands, these values shall be calculated from the three one-third octave band values in each octave band using Formula (H.2):

$$\Delta L_{oct} = -10\lg\left(\sum_{n=1}^{3}\frac{10^{-\Delta L_{1/3oct,n}/10}}{3}\right)\text{dB} \tag{H.2}$$

The reference floors are specified in ISO 10140-5:2010, Annex C; there is one heavyweight reference floor and three types of lightweight reference floors.

The general guidelines in the relevant clauses of the basic ISO 10140-3 shall always be followed.

When it is necessary to specify the reference floor used in the measurement, ΔL_w, $\Delta L_{t,1,w}$, $\Delta L_{t,2,w}$ and $\Delta L_{t,3,w}$ should be used for the heavyweight reference floor and lightweight reference floors No. 1, No. 2 and No. 3, respectively.

NOTE If the receiving room absorption is unchanged during the test, it is assumed that the reduction in impact sound pressure level is equivalent to the reduction in normalized impact sound pressure level.

H.2 Test element

H.2.1 General

The reference floor on which the floor covering is installed shall be chosen from the heavyweight and lightweight reference floors specified in ISO 10140-5:2010, Annex C, and shall be installed in accordance with ISO 10140-3:2010, 6.2.1.

NOTE 1 An alternative test arrangement using a wooden mock-up floor assembly installed over the standard heavyweight reference floor can provide estimates of the impact sound improvement of floor coverings mounted on lightweight floor constructions in circumstances where it is not feasible to install the lightweight reference floor as specified in ISO 10140-5:2010, Annex G. Specific guidance for measurements using this wooden mock-up floor is given in H.6.2.

NOTE 2 In ISO 10140-3:2010, Annex A, an alternative method using a heavy/soft source suitable for simulation of sounds generated by such heavy and soft impacts as human footsteps or children jumping is specified.

Three categories of floor coverings are defined, for which different installation and testing procedures apply. These depend on both the category of floor covering and the type of reference floor on which it is tested.

Depending upon the type of floor covering, the test elements shall be either slightly larger than the tapping machine with supports or equal to the floor area.

When soft coverings are under test, the standard tapping machine shall fulfil special requirements given in ISO 10140-5:2010, E.1. Advice regarding the mounting of the standard tapping machine on soft floor coverings is given in ISO 10140-5:2010, 5.1 and E.1.

H.2.2 Classification of floor coverings

H.2.2.1 Category I — Small specimens

This category includes flexible coverings (plastics, rubber, cork, matting, or combinations thereof), which may be installed loosely or by adhesion to the floor surface.

Install three or more samples, preferably of different production runs but from the same source. Each sample shall be large enough to support the whole tapping machine.

H.2.2.2 Category II — Large specimens

This category includes rigid homogeneous surface materials or complex floor coverings of which at least one constituent is rigid.

The specimen shall cover the whole surface from wall to wall, or at least 10 m^2 with a smaller dimension of at least 2,3 m.

H.2.2.3 Category III — Stretched materials

This category includes flexible coverings which cover the floor from wall to wall. Large specimens should be tested.

The specimen shall cover the whole surface from wall to wall, or at least 10 m^2 with a smaller dimension of at least 2,3 m.

H.2.2.4 Materials of uncertain classification

In the case of uncertainty, as to the appropriate category for a material, the testing laboratory decides whether small or large specimens should be tested.

H.3 Boundary and mounting conditions

See ISO 10140-3.

H.4 Test and operating conditions

H.4.1 Load

The assembled floor covering (category II materials) may be tested under load. A normal furnishing should be simulated with a uniformly distributed load of 20 kg/m^2 to 25 kg/m^2. The distributed load should be arranged with at least one weight per square metre of the flooring area.

For category III materials (stretched materials, including flexible coverings which cover the floor from wall to wall), large specimens should be tested, but loading is not required.

H.4.2 Installation

Follow the manufacturer's installation instructions with careful attention to the edges of the test specimen.

H.4.3 Adhesive mounting

Floor coverings mounted with adhesive normally require adhesive over the entire surface. If the adhesive is applied in isolated patches, describe the exact procedure in the test report. Follow the manufacturer's instructions for use of the adhesive, particularly concerning the amount of adhesive and the bonding-time. The test report shall describe the type of adhesive and the bonding-time.

H.4.4 Curing

Do not test coverings such as cast *in situ* concrete floating slabs before the required curing period has passed. For example, three weeks are recommended for ordinary concrete.

H.4.5 Environmental conditions

For many floor coverings, the acoustic properties depend on temperature and humidity. The test report shall state the temperature at the centre of the upper floor surface and the humidity of the air in the same room as the covering. The floor temperature should lie within the range of 18 °C to 25 °C.

H.4.6 Position of the tapping machine

Guidance on adjustment of the falling height of the hammers of the tapping machine is given in ISO 10140-5:2010, Annex E. When situated on a specimen that does not cover the whole floor, the hammers shall touch the specimen at least 100 mm from the edges.

Each set of measurements on the bare floor and covered floor shall be made with as many tapping machine positions as necessary to yield a reliable mean value.

H.4.6.1 Floor coverings on a heavyweight reference floor

H.4.6.1.1 Testing floor coverings of category I

If the floor coverings are installed as small specimens on the reference floor, at least three specimens shall be used. The minimum size of each specimen shall be 650 mm × 350 mm. The number of tapping machine positions shall be the same as the number of specimens. The hammers shall impact the test specimen at least 100 mm from its edges. Place the tapping machine with its feet successively on each specimen of floor covering with all hammers impacting on the specimen in each case. Determine the normalized impact sound pressure level with floor covering, L_n (see ISO 10140-4:2010, 5.3). Repeat with the tapping machine on the uncovered floor using the same positions. Determine the normalized impact sound pressure level without floor covering, L_{n0} (see ISO 10140-4:2010, 5.3).

Calculate the reduction of impact sound pressure level (improvement of impact sound insulation) (see H.1).

Alternatively, the tapping machine can be placed on either side of each specimen and as close to it as possible, in which case the line of hammers shall be parallel to the long dimension of the specimen (see Figure H.3). For each specimen of floor covering, the impact sound pressure level corresponding to the uncovered floor is the arithmetic mean of the level determined for the two machine positions on either side of the specimen.

H.4.6.1.2 Testing floor coverings of category II or III

At least four tapping machine positions shall be used when measuring the reduction of transmitted impact noise by floor coverings on a heavyweight reference floor (see Figure H.1).

Determine the normalized impact sound pressure level with floor covering, L_n, and without the floor covering, L_{n0}, using the same positions for the tapping machine (see ISO 10140-4:2010, 5.3).

Calculate the reduction of impact sound pressure level (improvement of impact sound insulation) (see H.1).

H.4.6.2 Testing floor coverings on a lightweight reference floor

H.4.6.2.1 Testing floor coverings of category I

If installed as small specimens on the reference floor, there shall be at least three test specimens. The minimum size of each specimen is 650 mm × 350 mm. The number of tapping machine positions shall be the same as the number of specimens. The hammers shall impact the test specimen at least 100 mm from its edges. The line of hammers should be oriented at 45° to the direction of the beams, ribs or joists. The tapping machine shall be positioned so that at least one hammer is directly above a joist as shown in Figure H.2. Place the tapping machine with its feet successively on each specimen of floor covering with all hammers impacting on the test specimen in each case. Determine the normalized impact sound pressure level with floor covering, L_n (see ISO 10140-4:2010, 5.3). Repeat with the tapping machine on the uncovered floor using the same positions. Determine the normalized impact sound pressure level without floor covering, L_{n0} (see ISO 10140-4:2010, 5.3).

Alternatively, the tapping machine can be placed on either side of each specimen and as close to it as possible, in which case the line of hammers shall be parallel to the long dimension of the specimen (see Figure H.3). For each specimen of floor covering, the impact sound pressure level corresponding to the uncovered floor is the arithmetic mean of the level determined for the two machine positions on either side of the specimen.

Calculate the reduction of impact sound pressure level (improvement of impact sound insulation) (see H.1).

H.4.6.2.2 Testing floor coverings of category II or III

At least six tapping machine positions shall be used when measuring the reduction of transmitted impact noise by floor coverings on lightweight reference floors. The positions shall be randomly distributed on the floor under test. The line of hammers should be oriented at 45° to the direction of the beams, ribs or joists.

Determine the normalized impact sound pressure level with floor covering, L_n, and without floor covering, L_{n0}, using the same positions for the tapping machine (see ISO 10140-4:2010, 5.3).

Calculate the reduction of impact sound pressure level (improvement of impact sound insulation) (see H.1).

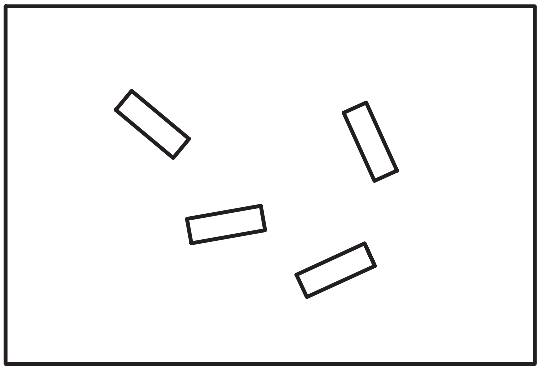


Figure H.1 — Typical locations for tapping machine for category II and III floor coverings on heavyweight reference floor

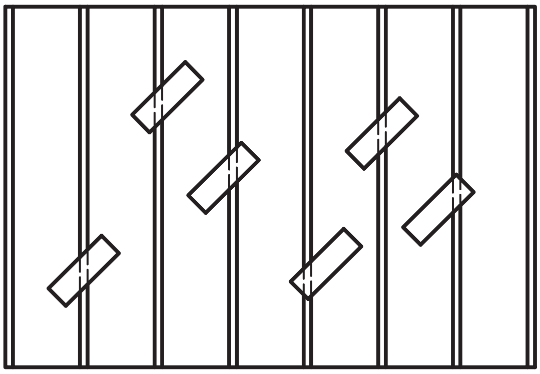
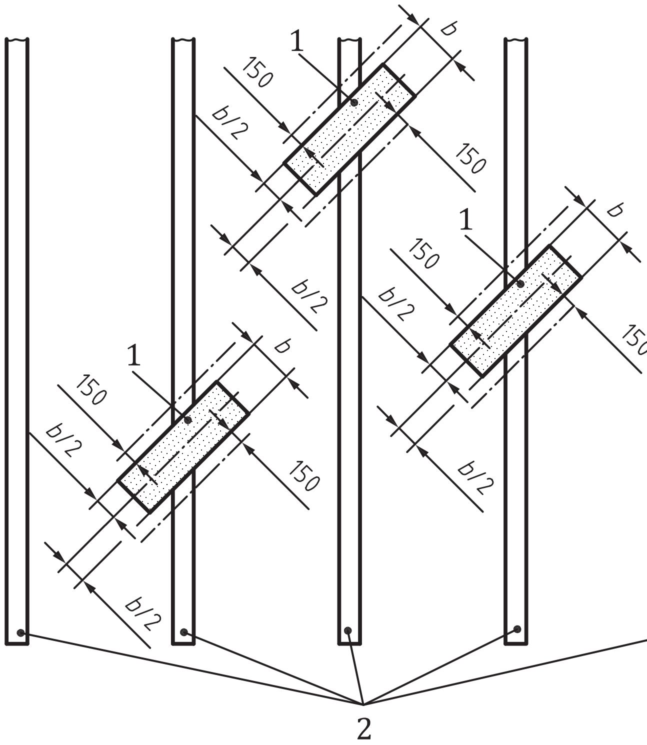


Figure H.2 — Typical locations for tapping machine for floor coverings on lightweight reference floor

Dimensions in millimetres



Key

1 test specimen (category I)

2 joist

b width of the test specimen

NOTE The shaded rectangles mark the test specimen positions and the set of small circles mark the position where the hammers of the tapping machine should strike the lightweight reference floor or the test specimens, respectively.

Figure H.3 — Alternative arrangement for tapping machine with small specimens of category I floor coverings on a lightweight reference floor

H.5 Test report

See ISO 10140-3. The following additional information shall also be reported.

For laboratory measurement of the change of impact sound insulation due to floor covering, the test report shall also include the following:

a) descriptions of the reference floor including type (heavyweight or lightweight type 1, 2 or 3), including dimensions, materials, surface mass, etc.;

b) for the floor covering, the layers of multi-layered coverings and the adhesive, the names and addresses of the manufacturers, the commercial designation and the source of supply of the test specimen;

c) detailed description, including the type, mass, surface dimensions and thickness of the test specimens (under load where specified), with appropriate drawings where necessary;

d) method of mounting, with particular reference to the adhesive, its mass per unit area and bonding time, and, in the case of floating slab floors, the curing time for the concrete;

e) number, location and installation time of the loads, where used;

f) material and dimensions and number of supports of the tapping machine;

g) a statement as to whether the test specimen suffered visible damage during the test (for example compaction);

NOTE It is desirable that the tested specimen is retained in the laboratory for subsequent inspection.

h) reduction in impact sound pressure level due to the floor covering under test, as a function of frequency, the weighted reduction of impact sound pressure level, ΔL_w, and the spectrum adaptation term;

i) normalized impact sound pressure level of the bare reference floor used in the test, as a function of frequency, the weighted normalized impact sound pressure level and the related spectrum adaptation term of the reference floor with and without the floor covering under test: $L_{nw,r}$ and $C_{l,r}$ or $L_{nw,0}$ and $C_{l,0}$.

H.6 Additional information

H.6.1 Improvement with heavy/soft impact

Install the floor covering, in accordance with requirements of H.3, on a reference floor specified in ISO 10140-5:2010, Annex C.

Measure the maximum impact sound pressure level, $L_{i,Fmax,\,j}$, with and without the test floor covering.

NOTE The maximum impact sound pressure level, $L_{i,Fmax,\,j}$, is defined in ISO 10140-3:2010, Annex A.

From the results of measurements with and without floor covering under test, the reduction of impact sound pressure level (improvement of impact sound insulation), ΔL_r, in decibels shall be calculated as given by Formula (H.3):

$$\Delta L_r = L_{i,Fmax,0} - L_{i,Fmax} \tag{H.3}$$

where

$L_{i,Fmax,0}$ is the impact sound pressure level of the reference floor without floor covering;

$L_{i,Fmax}$ is the impact sound pressure level of the reference floor with floor covering.

H.6.2 Procedures using a wooden mock-up floor to determine the impact sound improvement of floor coverings when mounted on lightweight floor constructions

H.6.2.1 General

This method applies to all kinds of floor coverings. The results are only applicable to mounting conditions similar to those used in the test. To ensure that the results are applicable to the actual lightweight floor, the board material and thickness used in the mock-up floor should be similar to that of the actual lightweight floor. It is possible that when a different board material and thickness are used, the results only give an estimate of the improvement on the actual lightweight floor.

NOTE 1 There are two sound transmission paths to the receiving room. One is structure-borne sound via the feet of the top floor and the other is airborne sound from the source room through the concrete slab to the receiving room. In general, the structure-borne sound dominates, but, in some cases, particularly at high frequencies, the airborne path influences the result and causes an underestimate of the impact sound improvement of the structure-borne path. Some lightweight floors have very weak transmission via the structure-borne path, e.g. floors with independent ceilings or with ceilings suspended on resilient hangers and, in such cases, the results obtained using this annex can be misleading.

NOTE 2 The effect of a resilient floor covering depends on the resilience of the floor on which the covering is mounted. The stiffer the floor, the greater the improvement in impact sound insulation due to the floor covering. According to H.4.6.1, the floor covering can be mounted on a thick concrete slab, which can be considered as being infinitely stiff. The results are different if the floor covering is mounted on a lightweight floor. The purpose of this method is to provide an alternative to H.4.6.2 (for a laboratory where it is not feasible to install a lightweight reference floor) to simulate the effect of lightweight floor constructions by mounting the floor covering on a wooden assembly representative of the upper part of a typical lightweight floor construction. This resilient board is mounted on feet, which in turn rest on a subfloor identical to the heavyweight reference floor. The resilient board on its feet is designated “top floor” and together with the heavyweight reference floor, designated “subfloor”, they constitute the “test floor”.

H.6.2.2 Test arrangement

Requirements for the wooden mock-up floor and its installation are given in ISO 10140-5:2010, Annex G.

Optionally, the standard top floor described in H.6.2.1 may be supplemented by other top floors simulating the upper part of arbitrary lightweight floors. This is done by replacing the 22 mm chipboard (particle board) by other boards or combinations thereof.

H.6.2.3 Preparation and installation of test specimen

During the test, the top floor shall be loaded with five weights of 20 kg to 25 kg each, plus the tapping machine. The positions should be fixed with one weight in the middle of the top floor, and the remaining four at corners 40 cm from the edges of the top floor. The loads shall be applied when measuring both with and without floor covering.

Parquet floors shall cover the whole top floor. Soft floor coverings shall be laid loosely on the top floor.

H.6.2.4 Test procedure

Follow the test procedure laid down in the main body of this annex, but use at least six positions for the tapping machine. The six positions shall be fixed. The same positions are used with and without the floor covering. Minimum distance to loads should be approximately 300 mm.

H.6.3 Expression of results

An example of the form for the expression of results obtained by laboratory measurements of the reduction of impact sound level by a floor covering according to this annex is given in Figure H.4. The user is allowed to copy this form.

Reduction of impact sound pressure level in accordance with ISO 10140 (all parts)

Laboratory measurements of the reduction of transmitted impact sound by floor coverings on a heavyweight or lightweight reference floor

Manufacturer:

Client:

Test specimen mounted by:

Description of test facility, test specimen and test arrangement:

Type of reference floor:

Mass of test specimen per unit area: kg/m²

Curing time: h

Air temp. in the source room: °C

Air humidity in the source room: %

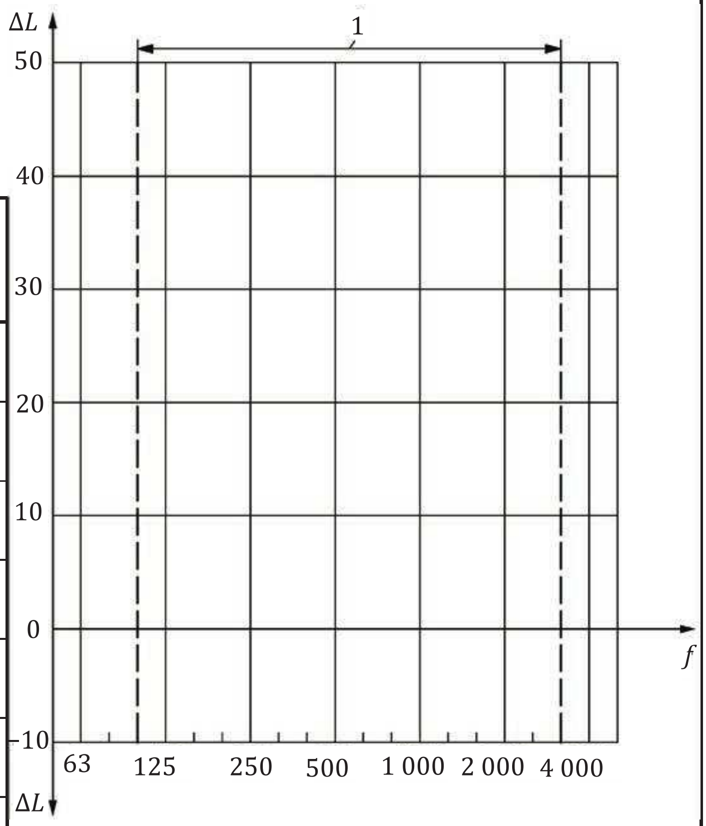
Receiving room volume: m³

Product identification:

Test room identification:

Date of test:

Frequency f Hz	$L_{n,0}$ one-third octave dB	ΔL one-third octave dB
50 63 80		
100 125 160		
200 250 315		
400 500 630		
800 1 000 1 250		
1 600 2 000 2 500		
3 150 4 000 5 000		



Key

ΔL reduction of impact sound pressure level, in dB

f frequency, in Hz

1 frequency range for rating in accordance with ISO 717-2

Rating in accordance with ISO 717-2:

ΔL_{w} = ( ) dB; $C_{I,\Delta}$ = dB; $C_{I,r}$ = dB; $C_{I,r,50\text{-}2\,500}$ = dB

These results are based on a test performed with an artificial source under laboratory conditions (engineering method) with the specified reference floor.

No. of test report:

Date:

Name of test institute:

Signature:

Figure H.4 — Example of form for expression of results

Annex I
(normative)

Shutters — Airborne sound insulation

I.1 General

This annex is applicable to windows with shutters.

The quantity determined is the sound reduction index, R, as a function of frequency, for the shutter in two conditions: shutter retracted and shutter extended. The definition of R is given in ISO 10140-2.

The general guidelines in the relevant clauses of ISO 10140-2 shall always be followed.

NOTE 1 The contents of this annex are from EN 14759.

NOTE 2 For a definition of shutter (terminology), see EN 12216.

I.2 Test element

The additional acoustic performance of the shutter depends on the acoustic performance of the window fitted, on the distance, d, and on the quality of the installation. The test should be carried out on a complete element with shutter and window.

The test should be carried out in the specific small-sized test opening given in ISO 10140-5, with an element size of 1,23 m × 1,48 m for the total element of window and shutter. Built-in shutters of types 2, 5 and 6 can be tested in this opening, assuming that the distance, d, fits the opening. For explanations of shutter types, see I.3.

In cases where this procedure is not relevant, such as for built-in shutters of type 1, 3 and 4, where the type and size of the surrounding wall can influence the test result and are therefore part of the test element, a test arrangement including the surrounding wall should be found. In such cases, a test arrangement should simulate the situation in field.

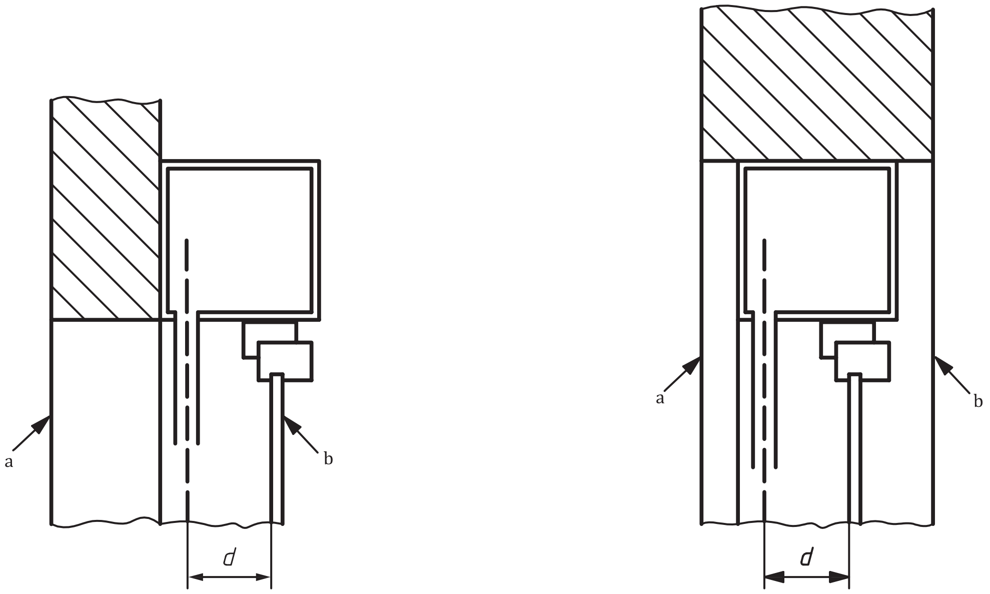
I.3 Boundary and mounting conditions

The acoustic performance also depends on the type of mounting of the shutter or the built-in shutter with window in the opening. The following six types of mounting are defined.

a) For a built-in shutter with window (see Figure I.1):

   1) Type 1: the box is behind the lintel;

   2) Type 2: the box is inside the opening.



a) Type 1 **b) Type 2**

Key

a Exterior side.

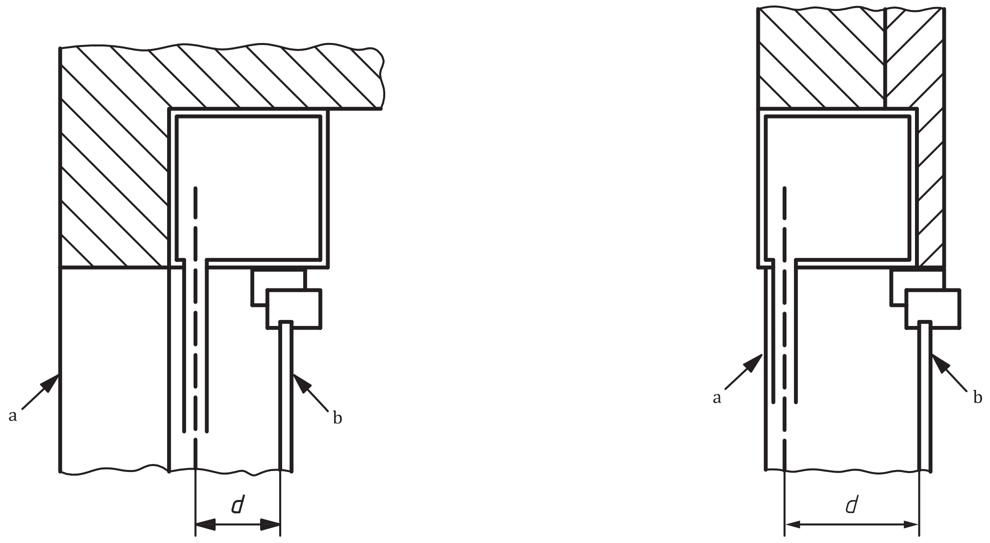
b Interior side.

Figure I.1 — Built-in shutter with window

b) For a built-in shutter (see Figure I.2):

   1) Type 3: the box is fabricated behind the lintel;

   2) Type 4: the box is a prefabricated box.



a) Type 3 b) Type 4

Key

a Exterior side.

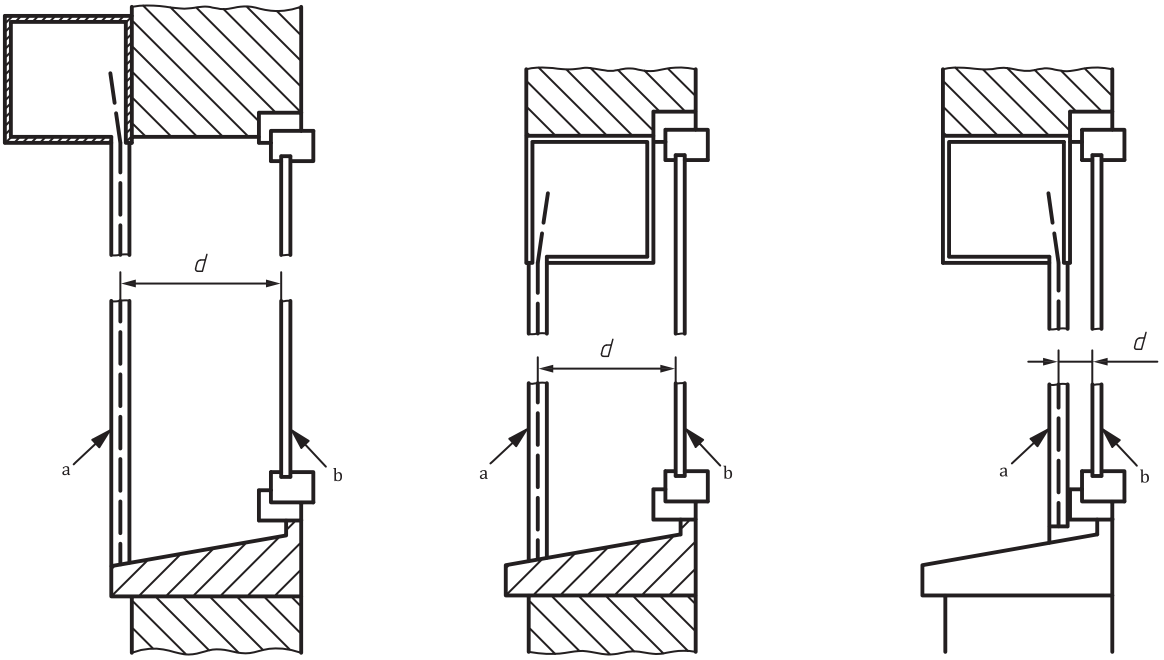
b Interior side.

Figure I.2 — Built-in shutter

c) For a built-on shutter (see Figure I.3):

1) Type 5: the box is outside the opening;

2) Type 6: the box is inside the opening.



a) Type 5 **b) Type 6 — Internal roll-up** **c) Type 6 — External roll-up**

Key

a Exterior side.

b Interior side.

Figure I.3 — Built-on shutter

I.4 Test and operating conditions

I.4.1 Conditioning

The sound insulation of certain glazing systems or elements, especially those incorporating laminated glass, can be dependent on the room temperature during the measurements. The temperature of both rooms used for measuring the sound insulation should be (20 ± 3) °C. The test elements should be stored for 24 h at the test temperature. In addition, it can be advantageous to make measurements at temperatures similar to those for which the test element is designed.

I.4.2 Operation

If the test element is intended to be readily openable, it shall be opened and closed at least five times immediately before testing.

I.5 Test report

The test report is given in ISO 10140-2. The following additional information shall also be reported:

a) values of $R_w(C; C_{tr})_{(\text{shutter retracted})}$ and $R_w(C; C_{tr})_{(\text{shutter extended})}$;

b) type of shutter (built-in shutter with window, built-in shutter, built-on shutter);

c) type of mounting (type 1, 2, 3, 4, 5 or 6);

d) distance, *d;*

e) dimensions of the window for which the test has been performed.

Annex J
(normative)

Joints filled with fillers or seals — Sound reduction index

J.1 General

This annex is applicable to acoustic sealing of slits (with or without fillers) and of gaps or joints between parts of windows or doors. Fillers are materials to fill in joints, e.g. foam or sealing tape, gaskets (or seals) are elements to close openable joints, e.g. retractable floor seals or rebate seals for doors and windows.

The general guidelines in the relevant clauses of ISO 10140-2 shall always be followed. The quantity to be determined is the sound reduction index of joints, R_s, per metre of a sealed gap or joint, in decibels as a function of frequency.

The sound reduction index of joints (of the slit, s) with sound transmission only through the joint or the slit is evaluated from Formula (J.1):

$$R_s = L_1 - L_2 + 10\lg\frac{S_n l}{A l_n} \quad \text{(J.1)}$$

where

L_1 is the energy average sound pressure level in the source room, in decibels (see ISO 10140-2);

L_2 is the energy average sound pressure level in the receiving room, in decibels (see ISO 10140-2);

l is the length of the joint, in metres;

S_n is the reference area, in square metres (S_n = 1 m^2);

l_n is the reference length, in metres (l_n = 1 m);

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

To achieve a better signal-to-noise ratio, simultaneous measurements can be performed on an element with enlarged length of the joint.

For this type of measurement, the influence of flanking transmission through the object in which the slits are present can be very important, so the maximum sound insulation of the test arrangement requires measurement, e.g. by sealing the test joint on both sides with elastic sealant, leading to $R_{s,max}$. Unless this value is 10 dB higher than the measured value, the measurement results require correction for this flanking transmission.

Test $R_{s,max}$ when the test arrangement is prepared.

The sound reduction index of joints (of the slit) R_s shall be calculated according to the rules of ISO 10140-2:2010, A.3, using Formula (J.2):

$$R_s = -10\lg\left[10^{-R'_s/10} - 10^{-R_{s,max}/10}\right] \quad (J.2)$$

where R'_s is the sound reduction index measured with the test element in the test opening, in decibels.

If the difference $R_{s,max} - R'_s$ is less than 6 dB in any of the frequency bands, the correction shall be 1,3 dB.

If R'_s is larger than $R_{s,max}$ − 3 dB, the lower limit of the sound reduction index R_s may be set as $R_{s,max}$. The resulting number shall be presented in brackets and expressed as a minimum value, e.g. ($R_s \geq 50,4$ dB).

The single number ratings are determined in accordance with ISO 717-1. If for one or more frequency bands the result is larger than $R_{s,max}$ − 3 dB, the single number rating is also determined with an infinitely high sound reduction index for those indicative bands. If that result differs by more than 1 dB from that first directly determined, the single number ratings shall also be presented in brackets.

The values which are evaluated can be used directly to compare products (e.g. fillers or sealings) or for the determination of the sound insulation of composite elements, taking into account the appropriate length of joints.

Besides the measurement results for well-described situations, this annex also presents a method to summarize results in a more global way, suitable for use as input data for prediction methods.

J.2 Test element

J.2.1 General

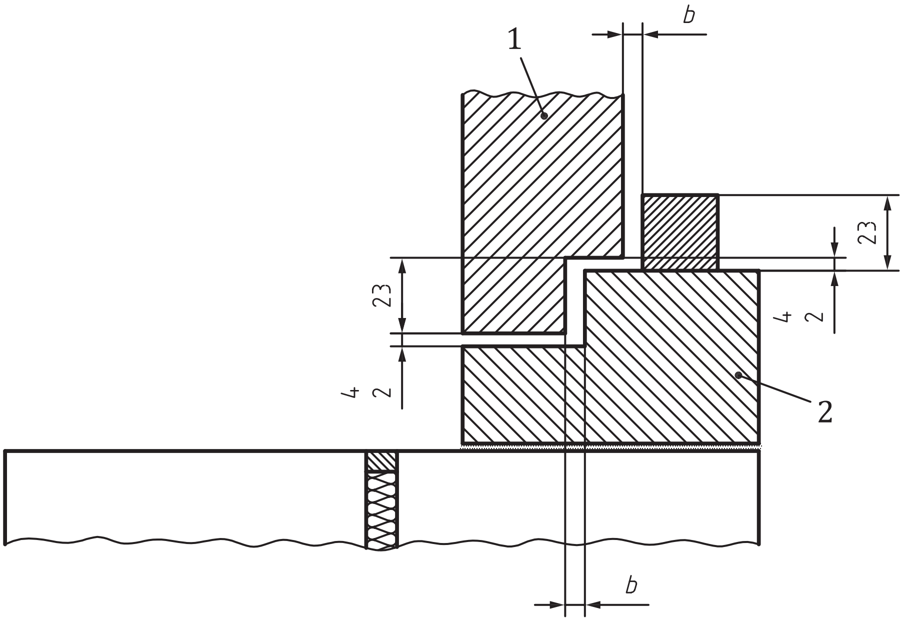
The design of the joint to be tested should be similar to the application because the geometry of the joint is an important parameter for the sound insulation of joints. For this, the design of the environment around the test element (filler or sealing) strongly depends on the application and this clause can only give advice with the description of examples for test elements.

The length of the joint shall be greater than 1 m and the width of the joint shall be no greater than 50 mm.

J.2.2 Illustration 1 — Gaps between windows and doors

The test element shall have a high sound reduction index $R_{s,max}$ in order to be able to get reliable measurement results in the relevant part of the frequency range. The gap or joint under test shall have a length of at least 5,0 m with a uniform cross-section; this total length may be the sum of several gaps or joints. For comparisons, the cross-section shall comply with Figure J.1 where the relevant gap width, *b*, is also defined. Additionally, other shapes can be applied, if relevant. These requirements can normally be fulfilled by using the specific small test opening as defined in this part of ISO 10140, with a panel as given in Figure J.2.

Dimensions in millimetres



Key

1 movable panel

2 frame

b variable gap width

Figure J.1 — Cross-section of gap with definition of gap width

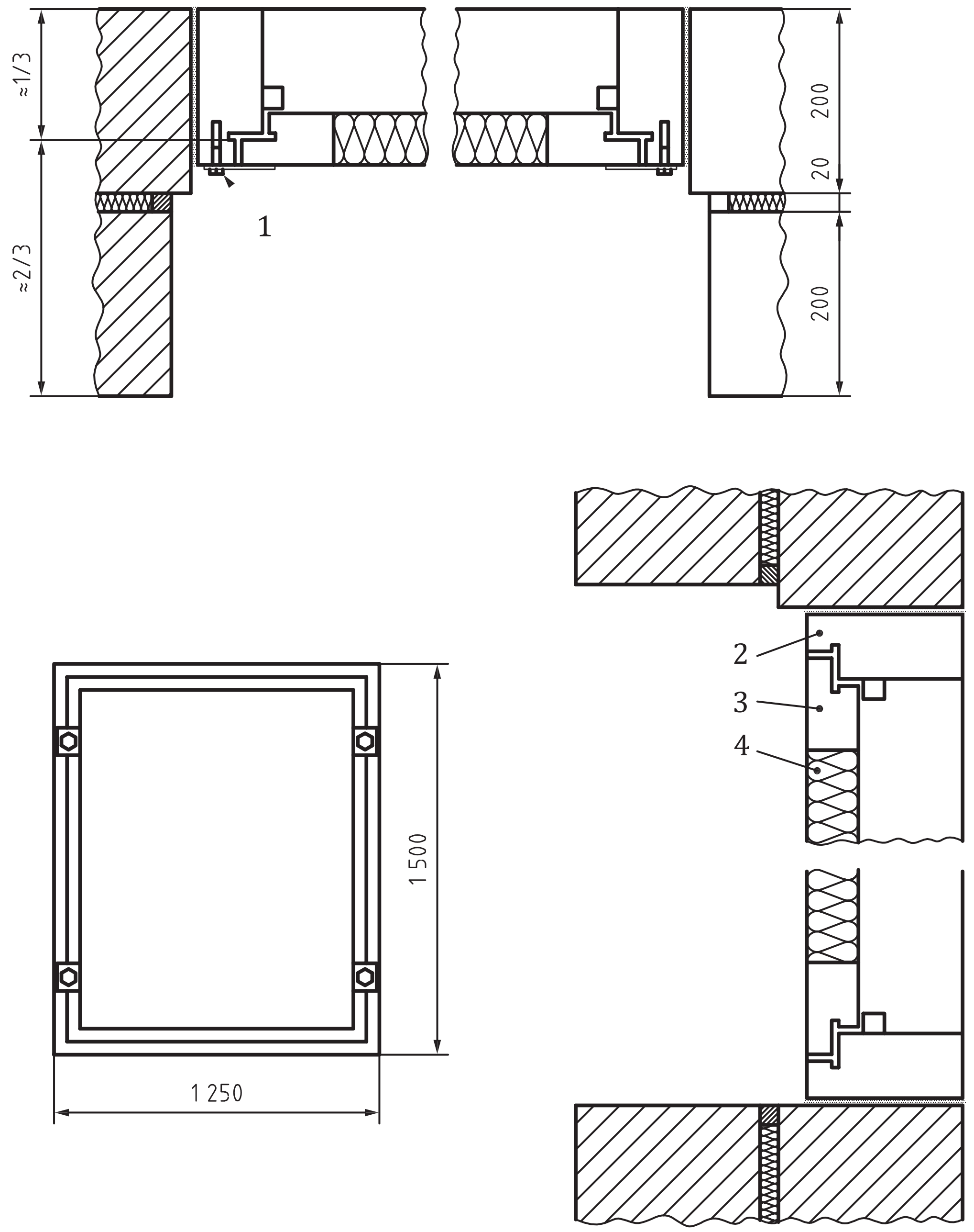
With additional wood strips of identical dimensions (23 mm × 23 mm, with gap tolerances between 2 mm and 4 mm), this profile can also be adapted to double sealing systems (see Figure J.2).

As an example, Figure J.2 gives a test element in the specific small test opening, where the panel in the casement consists of steel sandwich plates of thickness 2 mm and a rectangular wooden frame of cross-section 54 mm × 90 mm, the cavity being filled with mineral wool of surface density 40 kg/m^2.

Determine the gap width at a minimum of four positions, evenly distributed over the total length of sealing. The results shall not deviate by more than 0,3 mm, otherwise readjust the mounting. The average value is denoted as gap width, *b*.

NOTE With this construction, a maximum sound reduction index of $R_{s,max,w}(C; C_{tr})$ = 60(−5; −10) dB can be achieved.

Dimensions in millimetres



Key

1 adjustable closing mechanism, e.g. a steel plate with hole, screw and thumb-nut

2 frame 67 mm × 139 mm

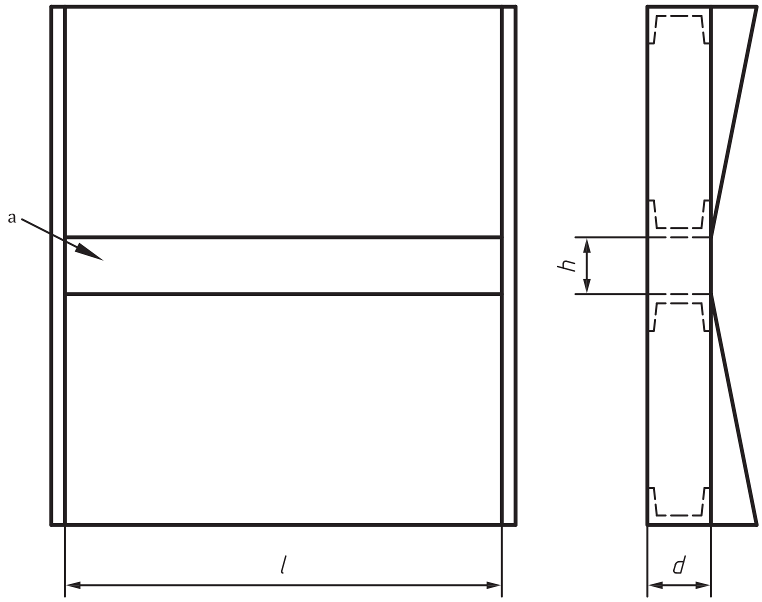
3 frame 54 mm × 90 mm

4 sandwich panel

Figure J.2 — Illustration of a test element in the specific small test opening

J.2.3 Illustration 2 — Test element for slits and gaps

For determination of the sound insulation of joints, a test opening according to the procedure for small elements in Annex E is required. A convenient way to carry out tests of the sound insulation of joints is to use the test opening for glass tests in accordance with ISO 10140-5:2010, 3.3.3. For this purpose, a highly sound-insulating element should be prepared, leaving a small opening of, for example, 1 200 mm × 120 mm (see Figure J.3). In this opening, the geometry of the joint to be tested can be designed.



Key

d depth

h height

l length

a Opening for test element.

Figure J.3 — Illustration of preparation of a test opening for joints in an element with high sound insulation

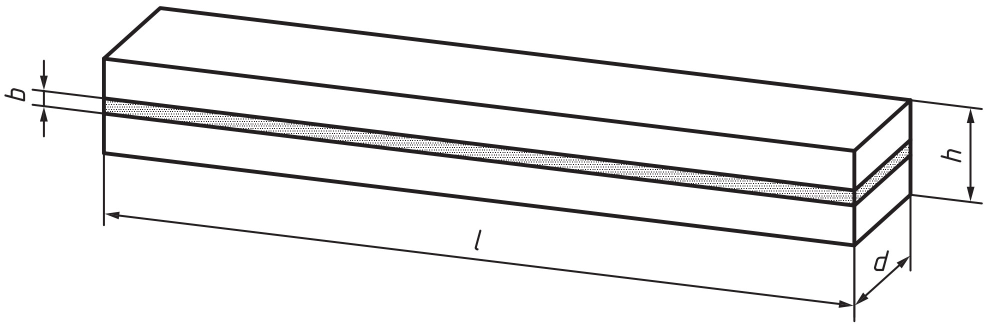
J.3 Boundary and mounting conditions (to be applied before installation)

J.3.1 General

Because the geometry of the joint is an important parameter for the sound insulation of joints and the boundary and mounting conditions depend on the application, this subclause can only discuss and advise on typical examples of test elements.

J.3.2 Illustration 1 — Geometry of a joint to test fillers in a cassette

For the measurement of the sound insulation of joints from fillers, two elements can be arranged one upon the other. The width and the geometric details of the joint shall be adapted to the requirements of the construction to be tested, e.g. width of the joint, b = 10 mm or b = 20 mm; depth of the joint, d = 50 mm or d = 100 mm. The filler to be tested is applied in the joint between the two elements. The overall dimensions should allow the cassettes to fit into the opening of the highly sound-insulating element (see Figure J.4).



Key

b width of the joint

d depth of the joint

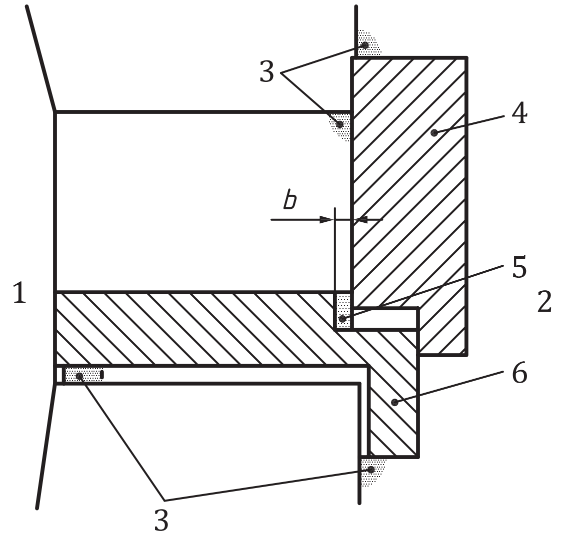
h height of both elements and filler

l length of the joint

Figure J.4 — Example of a designed joint element for fillers

J.3.3 Illustration 2 — Geometry of a joint to test gaskets

For the measurement of the sound insulation of joints closed with sealings or gaskets, it is necessary to replicate the usual construction of the seal mounting, e.g. a rebate of doors. Within such measurements, single parameters of the joint (e.g. width) can be varied (see Figures J.5 and J.6).



Key

1 receiving room

2 source room

3 sealing to the test rig

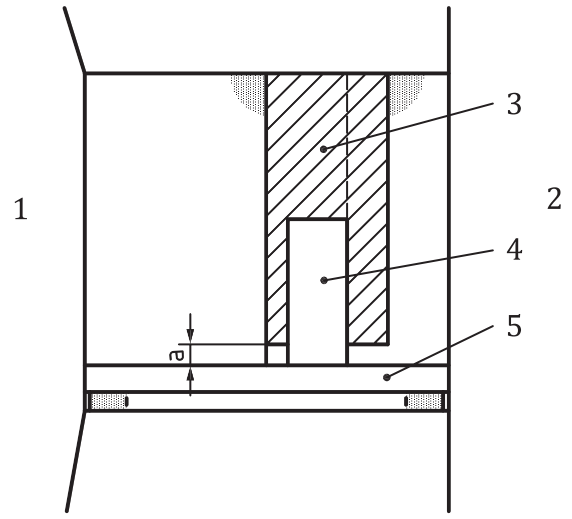
4 lead-covered door leaf section

5 sealing (test element)

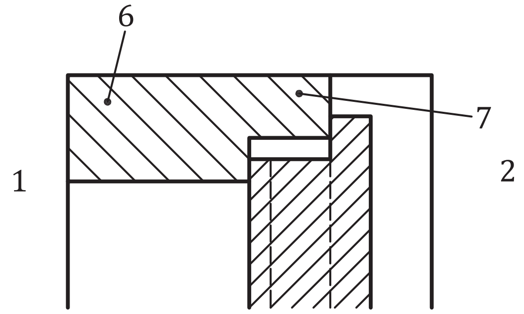
6 door frame, lead-covered

b gap width

Figure J.5 — Illustration of a test arrangement for rebate seals for doors (vertical section)



a) Vertical section



b) Horizontal section

Key

1 receiving room
2 source room
3 lead-covered door leaf section, with mounted floor seal
4 floor seal, the test element
5 floor covering
6 rebate
7 lead bonding door frame

Figure J.6 — Illustration of a test arrangement for floor seal in horizontal and vertical section

J.4 Test and operating conditions (to be applied after installation)

The test can be performed for specific slits, gaps or joints, with or without fillers.

For variable slits, as with openable windows or doors, the test shall be repeated for the following gap width:

a) b_n, the nominal gap width as given by the manufacturer — if unknown b_n = 5 mm is to be taken;

b) b_{min}, the minimal gap width, at maximal pressure of which the applied force, $F_{b,min}$, is to be noted — normally $F_{b,min}$ = 100 N/m sealing length is taken;

c) b_n + 3, i.e. a gap width 3 mm more than nominal, $b_{n+3} = b_n + 3$.

NOTE 1 To characterize the sealing completely, it can be useful to determine the sound reduction index with gap width in steps of 1 mm from maximum compression until a gap is present.

NOTE 2 The results from this test only apply to joints with comparable geometry and cross-section.

Some fillers, e.g. sealing bands, need time to expand. The elements shall be expanded in the way they are used in field.

J.5 Expression of results

Figure J.7 is a sample form for expression of results.

Sound reduction index of joints according to ISO 10140

Determination of sound reduction index of joints

Client:

Description of the test specimen:

Date of test:

Test length *l*:

Separation wall:

Test noise:

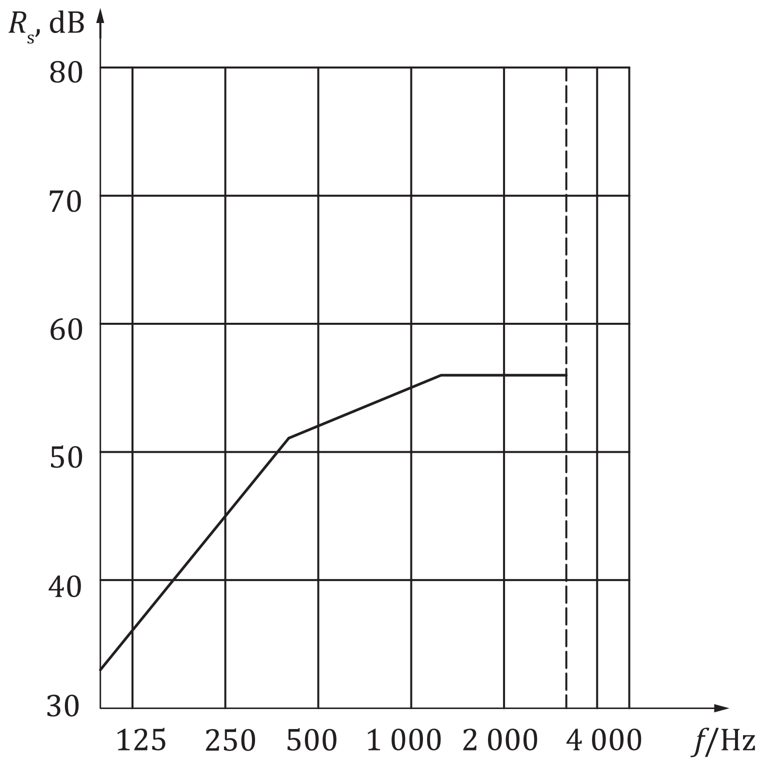
Volumes of the test rooms:

Maximum joint sound reduction index:

Mounting conditions: .... frequency range of weighing curve

Climate in the test rooms: ______________________ test curve

Frequency f Hz	Sound reduction index R_s dB
100 125 160	
200 250 315	
400 500 630	
800 1 000 1 250	
1 600 2 000 2 500	
3 150 4 000 5 000	



Evaluation according to ISO 717-1 (in one-third octave bands):

$R_{s,w}$ (C; C_{tr}) = (;) dB $C_{100–5 000}$ = dB; $C_{tr, 100–5 000}$ = dB;

Test report No:

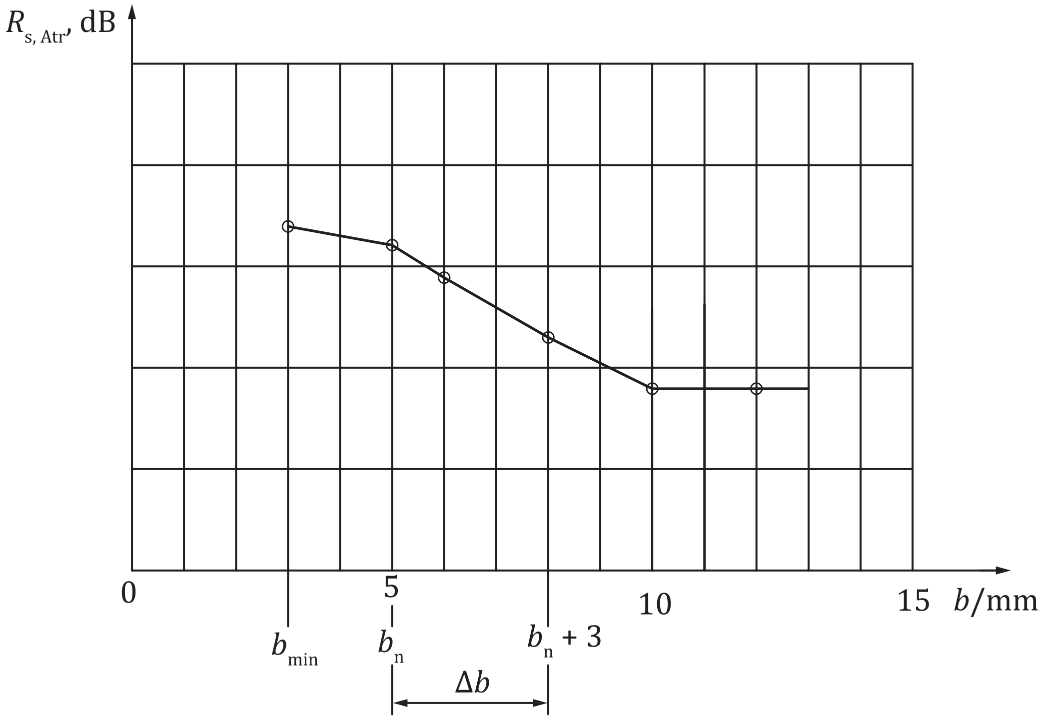
Date: Signature:

Figure J.7 — Sample form for expression of results

Additional sample plots of results appear in Figures J.8 and J.9.

Figure J.8 gives the sound reduction index $R_{s,Atr}$ (= $R_{s,w}$ + C_{tr}) as function of the gap width. Both measurement results (open circles) and interpolations (lines plotted through measurement results) are indicated. Also shown are the nominal gap width and nominal gap width plus 3 mm, indicating the working range of 3 mm.

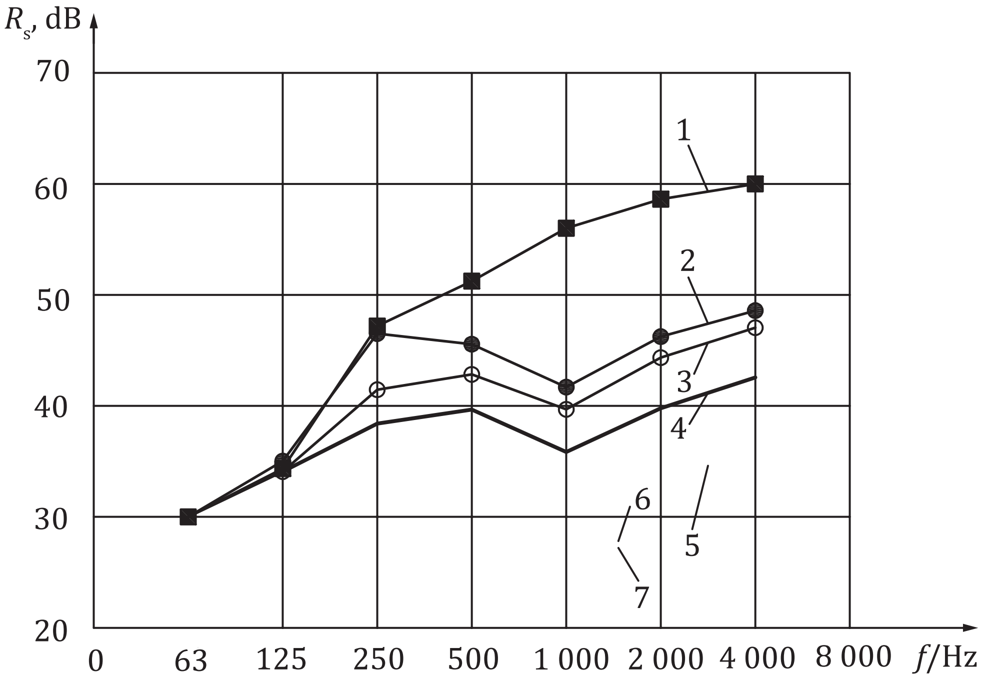
In Figure J.9, measured sound reduction index is plotted against octave band for different gap widths. Also, the result for the closed and sealed test element is given (b = 0) as $R_{s,max}$.



Key

$R_{s,Atr}$	sound reduction index, single number rating for traffic noise
b	gap width
b_{min}	minimum gap width
b_n	nominal gap width
$b_n + 3$	nominal gap width plus 3 mm
Δb_n	working range, 3 mm

Figure J.8 — Sample plot of measurement results; single number rating for traffic noise as function of gap width with nominal gap width and nominal gap width plus 3 mm indicated



Key

R_s	sound reduction index
f	octave band frequency
1, 2, 3, 4, 5, 6, 7	plots at gap widths 1 to 7

Figure J.9 — Sample plot of the results in octave bands at different gap widths

J.6 Test report

The test report shall include the relevant information in accordance with ISO 10140-2 and the following:

a) maximum sound insulation of the test arrangement;

b) data sheet with a diagram which shows the sound insulation of joints as a function of the frequency (see Figure J.7);

c) a schematic drawing of the test set-up;

d) description of the test specimen;

e) mounting or installation manual, if relevant for the test result;

f) detailed description of the test element and gap cross-section, including the definition of the gap width;

g) detailed description of the sealing lining and its fixing to the basic element;

h) sound reduction index for each tested gap width to be presented in accordance with ISO 10140-2 (see Figure J.7); for variable slits, the main results for product comparison are the results for the nominal and the nominal plus 3 mm gap width [unless a gap range other than 3 mm is applicable, the result $R_{s,n+3}$ with $R_{s,n+3,w}(C; C_{tr})$ are the most relevant for comparisons and calculations];

i) for each single number rating ($R_{s,w}$, $R_{s,w} + C$ or $R_{s,w} + C_{tr}$), the sound reduction index as a function of gap width where the nominal gap width is to be clearly marked (where appropriate).

Annex K
(normative)

Roofs, roof/ceiling systems, roof windows and skylights — Rainfall sound

K.1 General

This annex is applicable to the impact sound insulation of roofs, roof/ceiling systems and skylights excited by artificial rainfall. The results obtained can be used for assessing the noise to be produced by rainfall on a given building element in the room or space below. The results can also be used to compare rainfall sound insulation capabilities of building elements and to design building elements with appropriate rainfall sound insulation properties.

Real rain can be classified in terms of rainfall rate, typical drop diameters and fall velocities in accordance with IEC 60721-2-2. These values are given in Table K.1.

Table K.1 — Classification of rain type according to IEC 60721–2–2

Rainfall type	Rainfall rate mm/h	Typical drop diameter mm	Fall velocity m/s
Moderate	up to 4	0,5 to 1,0	1 to 2
Intense	up to 15	1 to 2	2 to 4
Heavy	up to 40	2 to 5	5 to 7
Cloudburst	greater than 100	>3	>6

However, this part of ISO 10140 is based on measurements with artificial raindrops under controlled conditions using a water tank in a laboratory test facility in which flanking sound transmission is suppressed. Water tanks for the two types of rain are specified in ISO 10140-5.

NOTE Measurements using real rain, although a useful means for validation purposes, are not included because of the variable, unpredictable and intermittent nature of real rain. Other mechanical simulation methods under investigation by researchers are not sufficiently well developed at the time of publication to adequately simulate real rain both in terms of sound levels and spectra generated.

The quantity to be determined is the radiated sound intensity level in the test room in one-third octave bands, L_I, the sound power level per unit area referenced to a value of 1×10^{-12} W/m^2. Also, the corresponding A-weighted intensity level, L_{IA}, is to be determined and for comparison purposes, these levels as normalized with the results for a reference object, $L_{I,\text{norm}}$ and $L_{IA,\text{norm}}$.

The general guidelines in the relevant clauses of the basic ISO 10140-3 shall always be followed.

K.2 Test element

K.2.1 Standard element and laboratory configuration

The size of the opening in the roof of the test room shall be between 10 m^2 and 20 m^2, with the length of the shorter edge being not less than 2,3 m. The test element shall be well sealed at the perimeter so no transmission of sound from the outside to the receiving room takes place through the joint between the test element and the test facility. The joints within the test element, if any, shall be sealed in a manner as similar as possible to the actual construction.

For skylights, the preferred dimensions are 1 500 mm × 1 250 mm with limit deviations of ±50 mm. Skylights shall be installed in a filler slab construction of sufficiently high airborne sound insulation and well sealed at the perimeter so that the sound field measured in the test room is only that generated by the impact excitation of the test element and radiated from the test element.

The minimum slope of the test element is 5° for roofs and 30° for skylights. The slope used shall be the lowest that is feasible to ensure water drainage. Unrepresentative niches should be limited as far as is possible in practice for small test elements like skylights, for example by installing the test element in a test opening in a construction having the same slope as the slope of the test element.

The position of a small test opening in the surrounding roof construction shall fulfil the same specifications as for a small test opening in a test wall in accordance with ISO 10140-5.

K.2.2 Other configurations

Elements of surface area less than 1 m^2 are not recommended. The slope of the test element may be the actual slope for specific situations/systems, if known.

K.3 Boundary and mounting conditions

See ISO 10140-3.

K.4 Test and operating conditions

K.4.1 General

The standard rainfall type used for comparison between products shall be the heavy type as specified in ISO 10140-5:2010/Amd 1:2014, Table H.1.

Other types of rainfall are permitted as long as their characteristics as rainfall rate, volume median drop diameter and drop velocity are indicated; however, if a rainfall rate lower than the heavy rain is needed, the intense type described in ISO 10140-5:2010/Amd 1:2014, Table H.1 is recommended.

After impacting on the test specimen, the water shall be drained to eliminate extraneous noise generation. The water supply pump shall either be located well away from the test room or shall be housed in an acoustic enclosure so that its contribution to the background noise does not make rainfall measurements invalid. For smaller test specimens, such as skylights, a single position for the artificial raindrop generation system is sufficient. For larger test specimens (10 m^2 to 20 m^2, see K.2.1), three positions for the artificial raindrop generation system shall be chosen. The location of the impact of artificial raindrops on the test specimen should be slightly off-centre to avoid symmetry. For non-uniform smaller test specimens (size close to 1,25 m × 1,5 m, see K.2.1), the whole surface shall be excited.

Prior to the commencement of acoustic measurements, a steady artificial rainfall rate shall be maintained over the test specimen for at least 5 min.

K.4.2 Determination of the sound intensity level (indirect method)

While maintaining the steady artificial rainfall rate, the average sound-pressure level in the test room shall be determined and corrected for background noise following ISO 10140-3. When using three positions of the rain generation system (i.e. for large test specimen), the three corresponding sound pressure levels shall be added energetically. Also, the reverberation time of the test room follows from ISO 10140-3.

The sound intensity level, L_I, is determined from the average sound pressure level for each one-third octave band by Formula (K.1):

$$L_I = L_{pr} - 10\lg\left(T / T_0\right) + 10\lg\left(V / V_0\right) - 14 - 10\lg\left(S_e / S_0\right)\text{dB} \quad (K.1)$$

where

L_{pr} is the averaged sound-pressure level in the test room, in decibels;

T is the reverberation time of the test room, in seconds;

T_0 is the reference time (= 1 s);

V is the volume of the test room, in cubic metres (m^3);

V_0 is the reference volume (= 1 m^3);

S_e is the area of the test specimen directly excited by the rainfall, in square metres; it corresponds to the specimen size for smaller test specimens and to three times the perforated area of the tank (see ISO 10140-5:2010/Amd 1:2014, Figure H.1) for larger test specimens;

S_0 is the reference area (= 1 m^2).

The one-third octave band levels, L_I, can be combined and converted to yield the A-weighted sound intensity level, L_{IA}, by applying the standardized A-weighting factors as given in Formula (K.2):

$$L_{IA} = 10\lg\sum_{j=1}^{j\max} 10^{0,1\left(L_{Ij}+C_j\right)}\text{dB} \quad (K.2)$$

where

L_{Ij} is the level in the jth one-third octave band;

j_{max} = 18

C_j are the values for one-third octave band centre frequencies between 100 Hz and 5 000 Hz, which are given in Table K.2.

NOTE The sound power level radiated by the whole test specimen (of area S) could then be calculated as:

$$L_w = L_I + 10\lg\left(S / S_0\right)\text{dB}$$

If octave band levels, L_{Ioct}, are to be determined, these values shall calculated for each octave band based on the three values of the corresponding third octave bands, as follows:

$$L_{Ioct} = 10\lg\left[\sum_{j=1}^{3} 10^{0,1\times\left(L_{I1/3oct\,j}\right)}\right]\text{dB} \quad (K.3)$$

Table K.2 — Values of j and C_j for one-third octave bands

j	One-third octave band centre frequency Hz	C_j dB
1	100	−19,1
2	125	−16,1
3	160	−13,4
4	200	−10,9
5	250	−8,6
6	315	−6,6
7	400	−4,8
8	500	−3,2
9	630	−1,9
10	800	−0,8
11	1 000	0
12	1 250	0,6
13	1 600	1
14	2 000	1,2
15	2 500	1,3
16	3 150	1,2
17	4 000	1
18	5 000	0,5

K.4.3 Direct measurement of sound intensity

As an alternative to using the sound pressure level measurement method, the sound intensity method may be employed to directly determine the sound intensity levels (see ISO 15186-1). The test room, referred to as the receiving room throughout the whole ISO 15186-1, shall then be any room meeting the requirements of the field indicator, F_{pI}, with the background noise as specified in ISO 15186-1:2000, 6.4.2 and 6.5.

If $L_{I\mathrm{m}}$ is the sound intensity level directly measured over a measuring surface, S_{m}, for each one-third octave band centre frequency, then the sound intensity level, L_I, radiated by the test specimen shall be given by Formula (K.4):

$$L_I = L_{I\mathrm{m}} + 10\lg\left(S_{\mathrm{m}} / S_{\mathrm{e}}\right)\mathrm{dB} \tag{K.4}$$

From this, the A-weighted value and octave band values can be deduced in the same way as given in K.4.1.

K.5 Test report

See ISO 10140-3. The following additional information shall also be reported:

a) equipment and methodology used for measurements of sound pressure levels and rainfall rates;

b) description of the artificial rainfall generation system, including its characteristics and, if the system differs from the water tank described in ISO 10140-5:2010/Amd 1:2014, Annex H, the methodology used for the measurements of the rainfall rate, fall velocity and drop diameter (and spread angle, if applicable), as well as the results and date of these measurements;

c) rainfall type and rainfall rate, in millimetres per hour (mm/h);

d) position of the artificial rainfall generation system with respect to the test specimen, as well as the area and location of the test specimen sprayed (for large specimens, this shall be given for all three different positions of the artificial rainfall generation system);

e) the sound intensity levels, L_I, and the normalized sound intensity levels, $L_{I\text{norm}}$, as a function of frequency shall be expressed with a precision of 0,1 dB, and presented in a table and a graph. The graph shall indicate values in decibels as a function of frequency on a logarithmic scale and the following dimensions should be used:

— 5 mm per one-third octave band;

— 20 mm per 10 dB.

The global A-weighted sound intensity level, $L_{I\text{A}}$, and the global A-weighted normalized sound intensity level, $L_{I\text{Anorm}}$, shall also be provided, expressed with a precision of 0,1 dB. The corresponding rainfall rate shall be given.

f) If test on a reference specimen has been performed, the normalized sound intensity levels, $L_{I\ \text{norm}}$, as a function of frequency, shall be presented in a table and in graph form and the global A-weighted normalized sound intensity level, $L_{I\text{Anorm}}$, shall be reported.

K.6 Additional information — Normalization using a reference test specimen

For comparison purposes, a reference test specimen as described and mounted according to the specifications given in ISO 10140-5:2010/Amd 1:2014, Annex I, and exposed to the heavy rain type, should be measured.

The sound intensity levels, L_I, obtained for the specimen tested according to this annex should be normalized with respect to the results obtained for the test reference specimen, using the correction term $\Delta L_{I\text{c}}$ defined in ISO 10140-5:2010/Amd 1:2014, Annex I and leading to the normalized sound intensity levels defined by:

$$L_{I\text{norm}} = L_I - \Delta L_{I\text{c}} \qquad \text{(K.5)}$$

The one-third octave band levels, $L_{I\text{norm}}$, can then be combined and converted to yield the A-weighted sound intensity level, $L_{I\text{Anorm}}$, by applying the standardized A-weighting factors as shown in K.4.

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