BRITISH STANDARD

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Incorporating corrigendum February 2007

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

Part 14: Guidelines for special situations in the field

ICS 91.120.20

British Standards

National foreword

This British Standard is the UK implementation of EN ISO 140-14:2004. It is identical to ISO 140-14:2004, incorporating corrigendum February 2007.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by ISO corrigendum February 2007 is indicated in the text by [AC1) (AC1].

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

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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English version

Acoustics - Measurement of sound insulation in buildings and of building elements - Part 14: Guidelines for special situations in the field (ISO 140-14:2004)

Acoustique - Mesurage de l'isolation acoustique des immeubles et des éléments de construction - Partie 14: Lignes directrices pour des situations particulières in situ (ISO 140-14:2004)

Akustik - Messung der Schalldämmung in Gebäuden und von Bauteilen - Teil 14: Leitfäden für besondere bauliche Bedingungen (ISO 140-14:2004)

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Foreword

This document (EN ISO 140-14:2004) has been prepared by Technical Committee ISO/TC 43 "Acoustics" in collaboration with Technical Committee CEN/TC 126 "Acoustic properties of building products and of buildings", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2005, and conflicting national standards shall be withdrawn at the latest by February 2005.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Endorsement notice

The text of ISO 140-14:2004 has been approved by CEN as EN ISO 140-14:2004 without any modifications.

INTERNATIONAL STANDARD

ISO 140-14

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

Part 14:
Guidelines for special situations in the field

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

Partie 14: Lignes directrices pour des situations particulières in situ

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Contents

Page

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.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 140-14 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

ISO 140 consists of the following parts, under the general title *Acoustics — Measurement of sound insulation in buildings and of building elements*:

AC1 This first edition of ISO 140-14 cancels and replaces ISO/TR 140-13:1997, which has been technically revised. AC1

— *Part 1: Requirements for laboratory test facilities with suppressed flanking transmission*

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

— *Part 3: Laboratory measurements of airborne sound insulation of building elements*

— *Part 4: Field measurements of airborne sound insulation between rooms*

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

— *Part 6: Laboratory measurements of impact sound insulation of floors*

— *Part 7: Field measurements of impact sound insulation of floors*

— *Part 8: Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a heavyweight standard floor*

AC1 *Text deleted* AC1

— *Part 10: Laboratory measurement of airborne sound insulation of small building elements*

— *Part 11: Laboratory measurements of the reduction of transmitted impact sound by floor coverings on lightweight reference floors*

AC1 *Text deleted* AC1

— *Part 14: Guidelines for special situations in the field*

AC1 — *Part 16: Laboratory measurement of the sound reduction index improvement by additional lining*

— *Part 18: Laboratory measurement of sound generated by rainfall on building elements* AC1

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

Part 14: Guidelines for special situations in the field

1 Scope

This part of ISO 140 concerns field measurements of airborne sound insulation and impact sound insulation, and is to be used as a supplement to ISO 140-4 and ISO 140-7. It contains guidelines on sound insulation measurements in special situations in the field not directly covered by ISO 140-4 and ISO 140-7.

NOTE The basic standards ISO 140-4 and ISO 140-7 specify the measurement procedure in detail under ideal conditions, but give only little information on how to establish a suitable measurement set-up in rooms differing from simple box-shaped rooms of normal living room size. When it comes to very large rooms, long and narrow rooms, staircases, coupled rooms, etc., no guidance is given in the basic standards, which is why the guidelines in this part of ISO 140 have been prepared. Use of the guidelines will contribute to improvement in the reproducibility of building acoustics field measurements and, furthermore, facilitate the performance of measurements by avoiding time-consuming considerations in actual measurement situations.

This part of ISO 140 is primarily applicable to measurements in rooms in dwellings, schools, hotels, etc., with volumes less than 250 m^3.

It is not mandatory to use these guidelines in connection with measurements according to ISO 140-4 and ISO 140-7 unless this is stated elsewhere.

2 Normative references

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

ISO 140-4:1998, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 4: Field measurements of airborne sound insulation between rooms*

ISO 140-7:1998, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 7: Field measurements of impact sound insulation of floors*

3 Technical background

The guidelines in this part of ISO 140 are based on the results presented in ISO/TR 140-13. The guidelines consist of extracts from this Technical Report.

The guidelines have been prepared based on some theoretical considerations, a few experimental investigations, and on practical experience from performing a great number of field measurements.

The principle is that examples of suitable measurement set-ups are shown in diagrammatic sketches. Efforts have been made to present examples (some very realistic and some very unusual) which should permit selection of an example from which a suitable measurement set-up can be established in nearly all field situations. The possibility of creating a suitable measurement set-up inspired by the sketches but not fully identical to any of them is the main reason for presenting the guidelines as informative annexes.

The loudspeaker and microphone positions indicated in the sketches should only be considered as guidance to show how they should be arranged. All requirements given in ISO 140-4 concerning distances to room boundaries, displacement of the loudspeakers in relation to the planes parallel to room boundaries, etc., shall be fulfilled.

Not all the sketches are referred to in the text. Sketches not referred to should be regarded as additional examples.

Notice that in two situations the guidelines might be in conflict with the basic standards. These situations are explained as follows.

Situation 1: The method described in ISO 140-4 for measurement of airborne sound insulation presumes approximately diffuse sound fields in the source room as well as the receiving room. It is required that the microphone positions be evenly distributed within the entire volume of the rooms.

If, for example, the source room is a very long, narrow corridor with absorbing ceiling and a carpet on the floor, a considerable sound pressure level decay of 10 dB to 20 dB can occur from one end of the room to the other. In principle, measurement cannot be performed according to ISO 140-4 because the sound field is not diffuse, and because averaging the sound pressure level in a room with a considerable sound pressure level decay has no meaning.

However, often a measurement is needed. In this situation, this part of ISO 140 suggests that the sound source be placed at a certain maximum distance from the partition common to the source room and the receiving room, i.e. a “virtual” and limited source room volume is defined in the part of the corridor closest to the common partition according to these guidelines.

Situation 2: For measurement of impact sound insulation in situations with a large floor area in the source room, a discrepancy can be observed between results obtained according to this part of ISO 140 and the basic standard. According to this part of ISO 140, the tapping machine should not be placed too far away from the receiving room. This will in some situations lead to a higher sound pressure level in the receiving room than obtained according to ISO 140-7, where it is stated that the tapping machine positions shall be distributed over the total floor area in the source room.

4 Test report

ISO 140-4 and ISO 140-7 specify what information shall be included in the test report. If the guidelines in this part of ISO 140 have been used, this should be mentioned under the item “Brief description of details of procedure and equipment” in ISO 140-4:1998, Clause 9, item i), and in ISO 140-7:1998, Clause 8, item h). A short description of the applied measurement procedure should be given. Any deviation from the requirements in ISO 140-4 or ISO 140-7 should be reported.

5 Annexes

This part of ISO 140 has two different application areas: airborne sound insulation and impact sound insulation. In order to facilitate practical application, the guidelines are laid down in separate annexes, with examples of suitable measurement arrangements in the form of diagrammatic sketches, and also graphical explanations and tabulated figures. The informative annexes are the following:

— Annex A: Airborne sound insulation

— Annex B: Impact sound insulation

— Annex C: Diagrammatic sketches

— Annex D: Combinations of tapping machine positions and microphone positions

— Annex E: Explanation of terms.

Annex A
(informative)

Airborne sound insulation

A.1 General

This annex is a supplement to ISO 140-4.

That part of the separating partition common to both the source and receiving rooms is named the “common partition”. The total surface of the separating partition is named the “partition” for both horizontal and vertical measurements. (See Annex E for an explanation of these terms.)

A.2 Principles

A.2.1 Frequency range of measurement

The sound reduction index should be measured using one-third-octave band filters in a frequency range of at least 100 Hz to 3 150 Hz.

These guidelines have been prepared for use in the frequency range 100 Hz to 3 150 Hz. However, the basic principles of the guidelines may also be used for measurements in the frequency range 50 Hz to 80 Hz according to ISO 140-4:1998, Annex D, and in the frequency range 4 000 Hz to 5 000 Hz.

These guidelines are applicable to measurements in one-third-octave bands as well as in octave bands.

A.2.2 Room conditions

The room volumes should not exceed 250 m^3. However, the guidelines may also be useful for measurements between rooms not fulfilling this limitation.

For horizontal measurements carried out in one direction only, the largest room is usually chosen to be the source room. However, if one of the rooms is regular with a well-defined volume while the other has a complicated geometry, the well-defined room should be used as the receiving room, even if it is the larger of the two rooms.

NOTE According to ISO 140-4, alternatively two measurements can be carried out in opposite directions and finally be averaged. However, measurements in two directions are quite time-consuming because two complete measurement set-ups are needed and the reverberation time has to be measured twice.

For vertical measurements, the lower room should preferably be used as the source room. The upper room may be the source room provided that an omnidirectional loudspeaker is used, situated at a sufficient distance above the floor to prevent incidence of direct sound. Preferably, the stand carrying the loudspeaker should be placed on soft material to prevent structure-borne sound entering into the floor.

When calculating the sound reduction index, the volume of the receiving room and the area of the common partition are needed. The volumes of objects in the receiving room with closed non-absorbing surfaces, such as wardrobes, cabinets and installation shafts, are subtracted from the total volume of the receiving room. The area of the common partition will not be reduced if fixed cabinets, wardrobes, etc., are covering a part of the common partition.

A.2.3 Number of microphone and loudspeaker positions

The recommended number of microphone and loudspeaker positions in the source and receiving room is stated in Table A.1.

Table A.1 — Number of microphone and loudspeaker positions determined from the floor area of the source and receiving room

Measurement set-up	Floor area of the room m^2	Number of loudspeaker and microphone positions		
		Loudspeakers (source room only)	Fixed microphones	Rotating microphones
A	< 50	2	5 (10)	1 (2)
B	50 to 100	2	10 (10)	2 (2)
C	> 100	3	15 (15)	3 (3)
NOTE The numbers in parentheses are the total numbers of sound pressure level measurements to be carried out in the room.				

If the floor area is less than 50 m^2 and the distance between the two loudspeaker positions is at least 1,4 m as required in ISO 140-4, the same five microphone positions or the same path of a rotating microphone may be used for both loudspeakers (measurement set-up A). If the requirements in ISO 140-4 concerning the distance between loudspeaker positions cannot be fulfilled, measurement set-up B should be used.

Two loudspeaker positions should be used in rooms with floor areas in the range 50 m^2 to 100 m^2. The same five fixed microphone positions or the same position of the rotating microphone should not be used for both loudspeakers. This means that a total of ten fixed microphone positions or two positions of a rotating microphone are required (measurement set-up B).

To achieve the highest obtainable accuracy under all measurement conditions, it is generally recommended to use measurement set-up B also for rooms with floor area less than 50 m^2. This is especially relevant for oblong or angular rooms.

If the floor area exceeds 100 m^2, it is recommended to use three loudspeaker positions, 15 fixed microphone positions or, alternatively, three positions of a rotating microphone.

As stated in ISO 140-4, in the source and receiving rooms, fixed microphone positions shall be evenly distributed within the space permitted, and in the case of a rotating microphone the position(s) shall be chosen to cover the entire room volume as far as possible.

In small rooms with volumes less than 10 m^3, a maximum number of uncorrelated microphone positions are obtained by the use of fixed microphone positions.

A.2.4 Horizontal measurements

Examples of suitable loudspeaker and microphone positions for horizontal measurements are shown in Annex C, Examples 1 to 14 (for symbols, see C.2).

The loudspeaker positions are normally chosen to be as close as possible, considering the minimum distances stated in ISO 140-4, to the two corners at the back wall of the source room opposite the common partition. For source rooms with a floor area exceeding 50 m^2, the loudspeakers should not be placed at a distance from the common partition exceeding 10 m or 2,5 times the width of the partition in the source room. The criterion of the two giving the shortest distance is chosen. (See Annex C, Examples 1, 2 and 3.) If the source room floor area is limited (see Example 2), the limited area is used when selecting the number of loudspeaker and microphone positions from Table A.1.

If the sound transmission is dominated by transmission through a flanking wall or a flanking façade, the loudspeaker should not be placed close to such a building element.

A.2.5 Vertical measurements

Examples of suitable loudspeaker and microphone positions for vertical measurements are shown in Annex C, Examples 15 to 28 (for symbols, see C.2).

The loudspeaker positions are normally chosen to be as close as possible to the corners of the room, considering the minimum distance stated in ISO 140-4.

If the sound transmission is dominated by transmission through a flanking wall or a flanking façade, the loudspeaker should not be placed close to such building elements.

If the receiving room is smaller than the source room, the loudspeakers should be situated in that part of the source room closest to the common partition if the floor area of the source room exceeds 50 m^2. (See Annex C, Examples 21, 23 and 25.)

A.3 Unusual room types

A.3.1 Partly divided rooms

If a room is partly divided by a wall, as a "rule-of-thumb" the room is considered as two individual rooms if the area of the opening is equal to or less than one-third of the total area of the vertical section of the room in the plane containing the dividing wall. If the room is considered as one room volume, measurement set-up B should, if suitable, be used. The loudspeaker positions are situated to "cover" the entire area of the common partition as completely as possible. (Preferably the entire common partition should be visible from both loudspeaker positions.) The principles above are also applicable to room-dividing walls with a height less than the height of the room.

Examples of horizontal measurements between partly divided rooms are shown in Annex C, Examples 9, 10, 11, 12 and 13.

If one or both rooms for vertical measurements are partly divided by a wall, the same principles as for horizontal measurements should be used. (See Annex C, Examples 26, 27, 28, 30 and 31.)

Preferably, an opening between two coupled rooms should always be totally covered by sheets of, for example, plywood or gypsum board to achieve well-defined rooms.

A.3.2 Damped rooms

In large, strongly damped rooms (rooms with a short reverberation time), the sound pressure level can decrease considerably with increased distance to a sound source.

EXAMPLE A long, narrow corridor with absorbing ceiling and carpet on the floor.

In strongly damped receiving rooms, it may be necessary to limit the part of the receiving room volume in which the sound pressure level is sampled. Parts of the receiving room where the sound pressure level is 6 dB or more below the level in the part of the room closest to the common partition should be omitted. For horizontal measurements, a reference measurement position is chosen 0,5 m from the middle of the common partition and 1,5 m above floor level. For vertical measurements, a reference measurement position is chosen 1,5 m above the middle of the common partition. (See explanation of terms in Annex E.)

With the loudspeaker in the source room switched on, the sound pressure level decay may be estimated by measuring the A-weighted sound pressure level in the reference position and in positions with increasing distance to this. A hand-held sound level meter may be used. The limited receiving room volume is used for the measurement as well as for the calculation of the sound reduction index.

In strongly damped source rooms, the sound pressure level decay from a position 1 m in front of the sound source to a position 0,5 m in front of common partition should not exceed 6 dB. If this is the case, the loudspeaker should be moved closer to the common partition.

A.3.3 Staggered rooms

If the rooms are staggered and the floor area of the source room exceeds 50 m^2, the loudspeakers should be situated in that part of the source room closest to the common partition. For vertical measurements, the loudspeakers should not be placed at a distance from the back wall (see Annex E) of the source room exceeding 2,5 times the width of the source room, or 10 m. The criterion of the two giving the shorter distance is chosen. (See Annex C, Examples 17, 21 and 23.)

If the width of the common partition for horizontal measurements is less than half the width of the partition in the source room, the distance between the loudspeaker positions should be reduced to approximately 2,5 times the width of the common partition (this is relevant if the receiving room is much smaller than the source room, or if the rooms are staggered). The positions are chosen in that part of the room closest to the common partition. The distance should not be reduced to less than 5 m. (See Annex C, Examples 4 and 5.) Loudspeaker positions on the symmetrical lines of the room should be avoided. If the rooms are completely staggered (no common partition), the distance between the loudspeakers should not be reduced. (See Annex C, Example 6.)

Examples of vertical measurements are shown in Annex C, Examples 17, 18 and 19.

A.3.4 Extremely complicated room geometry

No detailed guidelines can be stated for measurements between rooms with extremely complicated room geometry. An example is measurement between open-planned, split-level dwellings, each consisting of several more or less coupled spaces. In such situations, it is almost impossible to state the volume of the receiving room and the area of the common partition. Furthermore, selection of loudspeaker and microphone positions often is very difficult. A principal rule in such situations is that the loudspeakers are placed in that part of the dwelling closest to what has been defined to be the common partition. Often three or four loudspeaker positions are required. In the receiving room, the microphone positions shall be evenly distributed within the space permitted for measurement in the room, as stated in ISO 140-4. The receiving room volume should be limited according to the 6 dB-rule described in A.3.2.

A.4 Measurements on doors

A.4.1 Loudspeaker and microphone positions

Normally, one side of the door can be regarded as the outside (e.g. the side of the door facing a corridor or a stairwell). In these situations the corridor or stairway should be used as source room. Two loudspeaker positions are used. The loudspeaker should be placed on the floor in a corner of the room opposite the door. It should be placed neither close to the door nor close to the wall in which the door is mounted.

When using fixed microphones, five positions are used both in the source room and in the receiving room.

When a rotating microphone is applied, one position is used in both the source room and the receiving room.

NOTE For doors mounted between two regular rooms (e.g. hotel rooms or classrooms), where an indoor and outdoor side cannot be defined, the principles stated above can also be used.

A.4.2 Doors between a corridor and a room (e.g. an entrance hall)

In the corridor, loudspeaker positions placed at a distance of approximately 6 m apart should be used. To avoid symmetry, the positions should be displaced so one position is situated, for example, 2,5 m to the right of the door and the other 3,5 m to the left. (See Annex C, Example 14.)

A.4.3 Doors between a stairwell and a room

In narrow stairwells without suitable corners, the two loudspeakers should preferably be placed half a storey up and half a storey down, either on the stairflight or on a landing.

A.4.4 Determination of the sound reduction index of a door in a building

First, the sound reduction index for the door is measured. The measurement is made according to the rules in ISO 140-4:1998, Clauses 4.1 to 4.3. The apparent sound reduction index of the door is determined by Equation (A.1). By using this equation, it is assumed that all the sound is transmitted through the area S_d. If this assumption is correct, then R'_d is a correct value for the sound reduction index of the door.

$$R'_d = L_1 - L_2 + 10 \lg \left(S_d / A \right) \qquad \text{(A.1)}$$

where

- R'_d is the apparent sound reduction index of the door, in decibels;
- L_1 is the average sound pressure level in the source room, in decibels;
- L_2 is the average sound pressure level in the receiving room, in decibels;
- A is the equivalent absorption area in the receiving room, in square metres;
- S_d is the area of the free opening in which the door, including its frame, is mounted, in square metres.

Secondly, the door is provided with a suitable additional insulation to check the flanking transmission. The apparent sound reduction index for the insulated door is determined by

$$R'_{di} = L_{1i} - L_{2i} + 10 \lg \left(S_d / A \right) \qquad \text{(A.2)}$$

where L_{1i} and L_{2i} are the source and receiving room levels, respectively, in this situation.

NOTE It is presumed that the additional insulation works as intended, i.e. that the sound transmission through the additional insulated door is negligible compared with the transmission through the surrounding wall and other flanking paths.

By comparing the results obtained by Equations (A.1) and (A.2), the following alternative situations a), b) and c) can occur.

a) $R'_{di} - R'_d \geqslant 15$ dB

Without making any significant error, Equation (A.1) gives a correct value for the sound reduction index of the door.

b) 6 dB $< R'_{di} - R'_d <$ 15 dB

The transmission through the door is only somewhat larger than the transmission through the surrounding construction. This statement is true under the assumption that the additional insulation works as intended, i.e. that the transmission through the additionally insulated door is negligible in comparison with the transmission through the surrounding wall.

The approximate sound reduction index of the door is evaluated using the formula

$$R'_{d,app} = -10 \lg \left[10^{-R'_d/10} - 10^{-R'_{di}/10} \right] \qquad \text{(A.3)}$$

c) $R'_{di} - R'_d \leqslant 6$ dB

The sound reduction of the surrounding wall is too low to enable an accurate determination of the sound reduction of the door. As for situation b), this statement presupposes that the additional insulation is sufficiently high.

A lower limit of the sound reduction of the door is evaluated using the formula

$$R'_{\mathrm{d,app}} > R'_{\mathrm{d}} + 1{,}3\ \mathrm{dB} \tag{A.4}$$

If the only purpose of the test is to check whether the door fulfils a certain sound insulation requirement and this is fulfilled already by the apparent sound reduction index R'_{d}, then it is not necessary to perform the second measurement with the additional insulation and to determine $R'_{\mathrm{d,app}}$ because the following inequality always applies:

$$R'_{\mathrm{d,app}} \geqslant R'_{\mathrm{d}} \tag{A.5}$$

The different notations introduced in this clause for the sound reduction index should not be used when reporting measurements on doors. They are exclusively used to clarify the procedure described in this clause.

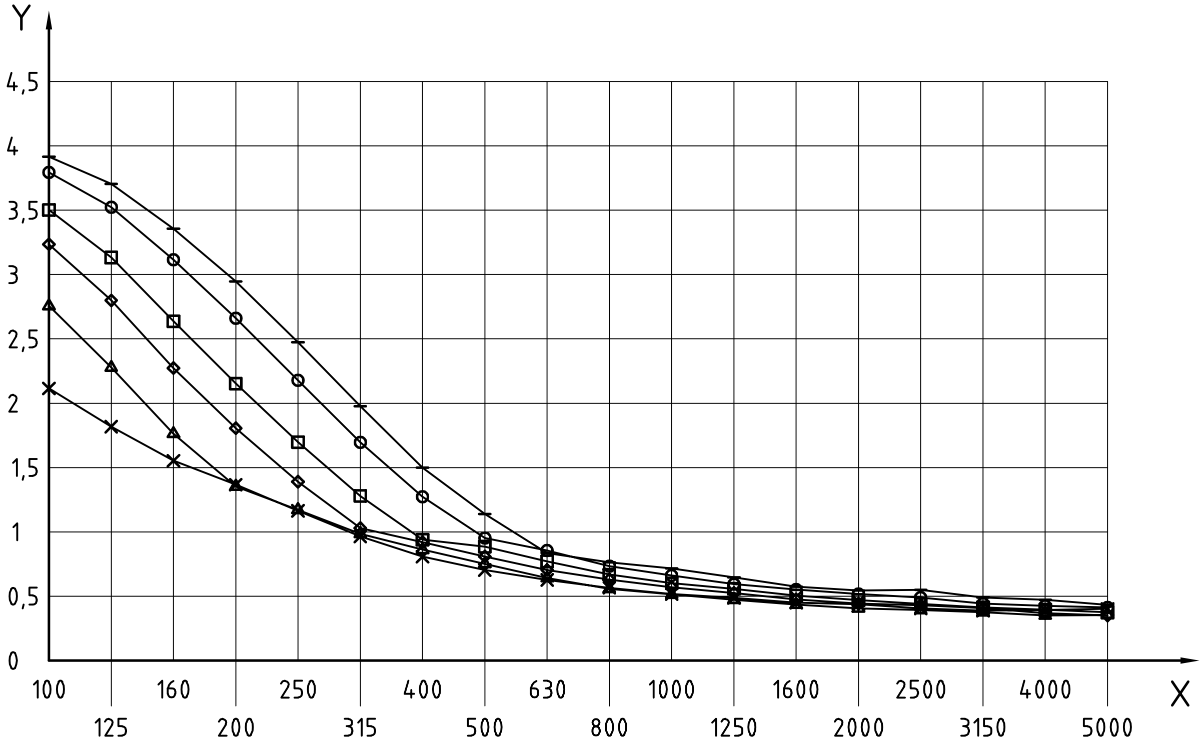
NOTE In certain situations it may be possible to determine the transmission through the surrounding wall by performing measurements in another adjacent receiving room with the same type of wall, but without a door present. In such cases the inconvenience of using the additional insulation can be avoided. Alternatively, the sound insulation of the door can be determined using the sound intensity technique (see ISO 15186-2 for details).

A.5 Diffuse-field evaluation procedure

This procedure may be used for evaluation of incomprehensible measurement results or prior to measurements whenever non-diffuse sound fields are expected to cause problems.

The sound pressure level is measured in ten fixed microphone positions by means of two loudspeakers (five microphone positions for each loudspeaker). In the source room, the position of the two loudspeakers should be the same as those used for the sound insulation measurement. In the receiving room, the measurement may be carried out by means of two loudspeakers or by sound radiated from the building structures when the loudspeakers in the source room are in operation. The microphone positions should be carefully distributed evenly over the total room volume.

The sample standard deviation of the ten measurements can be determined and compared with the theoretical expected values in Figure A.1.



Key

X frequency, in hertz

Y standard deviation, in decibels

10 m³ — 15 m³ — 30 m³ — 50 m³ — 100 m³ — 250 m³

Figure A.1 — Theoretical values of the spatial standard deviation of the sound pressure level measured at ten microphone positions in empty rooms with different volumes

Table A.2 — Numerical values of the curves in Figure A.1

Values in decibels

Frequency	**Volume,** m^3					
Hz	**10**	**15**	**30**	**50**	**100**	**250**
100	3,92	3,79	3,50	3,24	2,78	2,12
125	3,70	3,52	3,13	2,80	2,30	1,82
160	3,36	3.12	2,64	2,27	1,78	1,55
200	2,95	2,66	2,15	1,81	1,37	1,36
250	2,47	2,18	1,70	1,39	1,19	1,16
325	1,98	1,70	1,28	1,03	1,01	0,96
400	1,50	1,27	0,94	0,92	0,88	0,81
500	1,14	0,95	0,88	0,81	0,77	0,70
630	0,84	0,85	0,77	0,70	0,66	0,62
800	0,76	0,73	0,67	0,63	0,58	0,56
1 000	0,72	0,66	0,60	0,57	0,53	0,52
1 250	0,64	0,59	0,56	0,53	0,49	0,48
1 600	0,57	0,55	0,50	0,47	0,45	0,45
2 000	0,54	0,52	0,47	0,44	0,42	0,44
2 500	0,55	0,49	0,44	0,43	0,41	0,41
3 150	0,49	0,44	0,41	0,41	0,39	0,39
4 000	0,47	0,42	0,39	0,37	0,37	0,39
5 000	0,43	0,41	0,38	0,35	0,38	0,40

The values of standard deviations in Figure A.1 and Table A.2 are intended for optimizing the measurement set-up and should not be regarded as requirements to be fulfilled.

If the theoretical values are exceeded by a factor of 1,5, the following should be considered.

a) If excess is observed at low frequencies, an increase in the number of loudspeaker/microphone positions should be considered.

b) The limits have been determined for empty rooms with hard surfaces consisting of typical building materials. In rooms with a reverberation time which is shorter than in empty rooms (e.g. rooms with an absorbing ceiling or thick carpets), the spatial standard deviation will increase and the theoretical values may be exceeded, especially at higher frequencies.

c) In the middle and high frequency range, excess of the limits may be caused by a spatial sound pressure level decay in damped rooms. This may easily be checked by a systematic measurement of the sound pressure level at different positions in the room on a line perpendicular to the common partition in the receiving room, or in positions with increasing distance from the loudspeaker in the source room. If a considerable sound level decay appears, additional loudspeaker and microphone positions should be used and the 6-dB rule given in A.3.2 should be applied.

d) Especially in small, damped rooms, influence from the near field of the loudspeaker is a risk. If this is found to be the reason for an excess, the microphone positions should, if possible, be moved further away from the loudspeaker.

e) In a room partly divided by a wall, the limits can be exceeded because the dividing wall acts as a sound screen in some of the microphone positions.

A.6 Measurement of reverberation time

Measurement of the reverberation time in the receiving room should be carried out as described in ISO 140-4 or ISO 3382-2.

According to ISO 140-4, at least three microphone positions and one loudspeaker position shall be used with two excitations in each position. Alternatively, measurements may be carried out with six microphone positions with one excitation in each position. If a rotating microphone is used, the measurements may be carried out while the microphone boom is rotating, provided that the measurement positions are evenly distributed over the path. Preferably, the reverberation time should be measured at the same microphone positions as used for the sound pressure level measurements.

For field measurements, a sound pressure level decay of 20 dB should preferably be used.

The position of the loudspeaker is not usually critical. A suitable position is close to a corner of the room. In a room partly separated by a wall where the absorption is different in the two parts of the room, the reverberation time should be measured according to the above-mentioned procedure in both parts. If the coupled rooms are considered to be one room, the mean value of these measurements should be used in the calculation of the sound reduction index.

In rooms with floor areas exceeding 50 m^2, two loudspeaker positions and six fixed microphone positions or two positions of a rotating microphone should preferably be used (12 fixed microphone positions if only one excitation in each position).

Annex B
(informative)

Impact sound insulation

B.1 General

This annex is a supplement to ISO 140-7.

That part of the separating partition common to both the source room and the receiving room is named the "common partition". The total surface of the separating partition is named the "partition" for both horizontal and vertical measurements. (See explanation of terms in Annex E.)

The room in which the tapping machine is placed is named the source room. For vertical measurements, the upper room is the source room and the lower room the receiving room.

B.2 Principles

B.2.1 Frequency range of measurement

The impact sound insulation should be measured using one-third-octave band filters in a frequency range at least 100 Hz to 3 150 Hz.

These guidelines have been prepared for use in the frequency range 100 Hz to 3 150 Hz. However, the basic principles of the guidelines may also be used for measurements in the frequency range 50 Hz to 80 Hz according to ISO 140-7:1998, Annex C, and in the extended frequency range 4 000 Hz to 5 000 Hz.

These guidelines are applicable to measurements in one-third-octave bands as well as in octave bands.

B.2.2 Floor coverings

If different floor coverings are used in the same room (e.g. in a kitchen section and a living room section), measurements should be performed and reported from the two types of floors separately. The following guidelines should then be used on each of the two floor areas.

Measurements on soft floor coverings (such as carpets and PVC-layers) may be performed on a small sample (e.g. 1 m^2) which is moved between the different tapping machine positions. It should be noted that if the covering is to be fastened by an adhesive, the results from a measurement without adhesive can be misleading.

The use of a small sample of a heavy carpet with significant weight on a lightweight timber joist partition should be avoided since it may not take into account a damping or restraining effect on the flexural motions of the partition, which occurs when the total area is covered.

When a small sample is used, this should always be mentioned in the test report.

For soft coverings, it should be noted that some materials have an impact sound insulation which is dependent on the temperature. The temperature dependence should be evaluated if measurements are carried out under temperature conditions differing from normal room temperature.

When measuring on rough, tiled floors, the positions of the tapping machine shall be adjusted so that the hammers do not tap on the edges of the tiles. This will prevent the tiles being damaged and also prevent the measurement result being influenced by an uncharacteristic excitation of the floor.

B.2.3 Number of tapping machine and microphone positions

The number of tapping machine positions and microphone positions shall be determined according to Table B.1:

Table B.1 — Number of tapping machine positions and microphone positions determined from the floor area of source and receiving room

Floor area of the source room m^2	Number of positions	Floor area of the receiving room, m^2			
		⩽ 50		> 50	
		Partition type 1[a]	Partition type 2[b]	Partition type 1	Partition type 2
< 20	Tapping machine	4	4	4	4
	Fixed microphones	4	4	8	8
	Rotating microphone	1	1	2	2
20 to 50	Tapping machine	8	4	8	4
	Fixed microphones	4	4	8	8
	Rotating microphone	1	1	2	2
> 50	Tapping machine	8	8	8	8
	Fixed microphones	4	4	8	8
	Rotating microphone	1	1	2	2

[a] Partition type 1: Timber joist partitions, concrete partitions with ribs or beams and solid concrete partitions with a thickness less than 100 mm. Any kind of floor covering.

[b] Partition type 2: Solid concrete partitions with a thickness equal to or greater than 100 mm, clinker concrete elements and hollow concrete elements. Any kind of floor covering.

The combinations of tapping machine positions and microphone positions given in Table B.1 are shown in diagrammatic sketches in Annex D. The examples of tapping machine positions in Annex C are all shown for a partition type 2 as defined in Table B.1. If the actual partition is of type 1, the number of tapping machine positions shall be increased in the 20 m^2 to 50 m^2 range according to Table B.1.

For a partition type 1, at least one position of the tapping machine should be on top of a beam with an angle of 45° oriented with the direction of the beam.

For very small floor areas (e.g. in bathrooms), the minimum requirement for the distance between the tapping machine and the edges of the floor leads to a very limited area left for the four positions. However, the minimum number of tapping machine positions stated in Table B.1 should still be used. The tapping machine should be placed within the permitted area and the direction of the hammer connecting line should be changed for each measurement.

For rooms partly divided by a wall, the room is considered to be two rooms if the area of the opening is less than one-third of the total area of the vertical section of the room in the plane containing the wall (see also A.3.1). (See Annex C, Examples 30 and 31.)

B.3 Vertical measurements

B.3.1 General

In the following, “non-staggered rooms” means rooms where the horizontal contour of the smaller room can be totally contained in the horizontal contour of the larger room.

B.3.2 Non-staggered rooms

B.3.2.1 Rooms with floor area of the source room equal to or less than the floor area of the receiving room

The number of tapping machine positions and microphone positions should be chosen directly from Table B.1. The tapping machine positions should be distributed to cover the total floor area. (See Annex C, Example 29.)

B.3.2.2 Rooms with floor area of the source room larger than the floor area of the receiving room

If the floor area of the source room is equal to or less than 20 m^2, the values of Table B.1 should be used directly. If the floor area of the source room exceeds 20 m^2 and the area of the common partition is equal to or less than 20 m^2, a limited floor area of 20 m^2 should be used for the measurements. The tapping machine should be placed exclusively in this area. (See Annex C, Example 32.) If the area of the common partition exceeds 20 m^2, the tapping machine positions should be equally distributed over the total area of the common partition.

B.3.3 Staggered rooms

If the area of the common partition is greater than 20 m^2, the guidelines in B.3.2.1 and B.3.2.2 should be used.

If the area of the common partition is equal to or less than 20 m^2, or if there is no common part, a limited area of 20 m^2 should be used. (See Annex C, Examples 33 to 35.)

B.4 Horizontal measurements

If the floor area of the source room is equal to or less than 20 m^2, Table B.1 may be used directly. If the floor area exceeds 20 m^2, a limited area of 20 m^2 should be used. The dimensions of the limited floor area perpendicular to the partition in the source room should not be reduced to less than half the width of the partition in the source room. The other dimension of the limited area should not be less than the width of the partition in the receiving room. These recommendations should always be followed. In some special cases this implies that it will not be possible to limit the floor area to 20 m^2. (See Annex C, Examples 36 to 44.)

B.5 Corridors and staircases

B.5.1 Measurements of impact sound insulation from a corridor

Impact sound insulation measurements from a corridor to a room on the same storey or the storey below should be carried out by placing the tapping machine on a limited area of the corridor close to the receiving room. The area used should be the full width of the corridor and a length corresponding to an area of approximately 10 m^2.

Four tapping machine positions should be used, and the number of microphone positions should be chosen according to Table B.1. (See Annex C, Example 45.)

B.5.2 Measurements of impact sound insulation from staircases in apartment houses and internal stairs in apartments and terrace houses

Measurements should be carried out for the landings and the flights separately. Four tapping machine positions should be used on the landings as well as on the flights. The number of microphone positions should be chosen according to Table B.1.

The four tapping machine positions on the flights should be placed with one at step number two from the top of the flight and one at step number two from the bottom. The other two positions should be evenly distributed inbetween the top and bottom positions.

It may sometimes be difficult to place the tapping machine on narrow steps. A special support device may be used to extend the supporting legs at one side of the tapping machine. This allows the machine to stand on two steps. When a special support is used, care should be taken to ensure that the fall height of the hammers and the horizontal balance of the tapping machine is maintained. If such a modification is used, this should be mentioned in the test report.

The impact sound pressure level from a landing is usually measured in an adjoining room in which the highest level is expected. If the floor in an adjoining room in the same storey as the landing consists of, for example, boards on joists on a concrete slab, the impact sound pressure may be at its highest level in a room in the storey below the landing, because the wooden floor reduces the sound radiation from the concrete slab into the upper room.

If the flights are not fixed to the walls of a staircase, the impact sound pressure level from the flights should be measured in the same room as used for the measurement from the landings. If the flight is fixed to the wall, the receiving room used for measurements from the flight should be chosen as the room closest to the attachment points.

The guidelines stated above are also applicable for measurements on internal stairs (e.g. in a two-storey apartment).

B.6 Airborne sound contribution from the tapping machine

The airborne sound contribution from the tapping machine may be evaluated in the following way:

Determine the sound pressure level difference between source and receiving room by means of a pink noise signal from a loudspeaker placed in the source room ($L_{\mathrm{D,spk}}$).

Measure the sound pressure level in the source room from the tapping machine ($L_{\mathrm{S,tm}}$).

Measure the sound pressure level in the receiving room from the tapping machine ($L_{\mathrm{R,tm}}$).

If the difference ($L_{\mathrm{S,tm}} - L_{\mathrm{D,spk}}$) is 10 dB or more below $L_{\mathrm{R,tm}}$ at any frequency band of interest, the influence of the airborne sound from the tapping machine may be regarded as negligible.

B.7 Determination of room volume and reverberation time

For determination of the volume of the receiving room, see A.2.2.

For determination of the reverberation time of the receiving room, see A.6.

Annex C
(informative)

Diagrammatic sketches

C.1 Examples of suitable loudspeaker, tapping machine and microphone positions

Examples 1 to 14 are for horizontal measurements of airborne sound insulation (Figure C.1).

Examples 15 to 28 are for vertical measurements of airborne sound insulation (Figure C.2).

Examples 29 to 35 are for vertical measurements of impact sound insulation (Figure C.3).

Examples 36 to 45 are for horizontal measurements of impact sound insulation (Figure C.4).

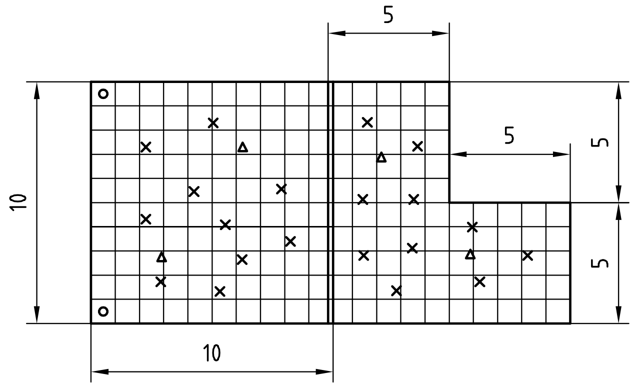
C.2 Symbols

The following symbols are used in this annex:

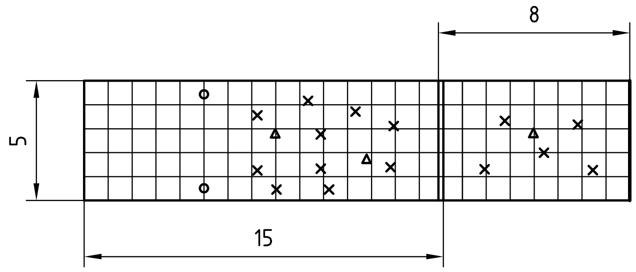
o	Loudspeaker
(o)	Alternative loudspeaker position
•	Tapping machine
×	Fixed microphone
Δ	Rotating microphone
———	Contour of rooms (U = upper room, L = lower room)
– – – – –	Contour of lower room with correct placing related to upper room
═══	Common partition
—·——·—	Limitation of floor area

All examples are horizontal sections.

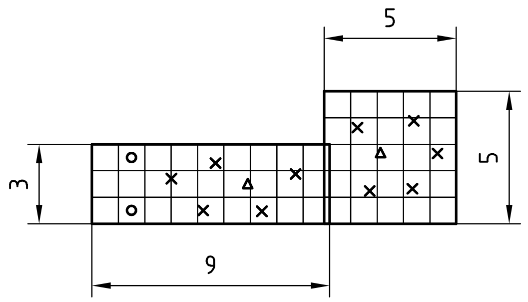
The dimensions of the rooms indicated on the sketches in metres are examples only, which together with the background grid are given to facilitate comparison with the specific guidelines stated in this part of ISO 140.



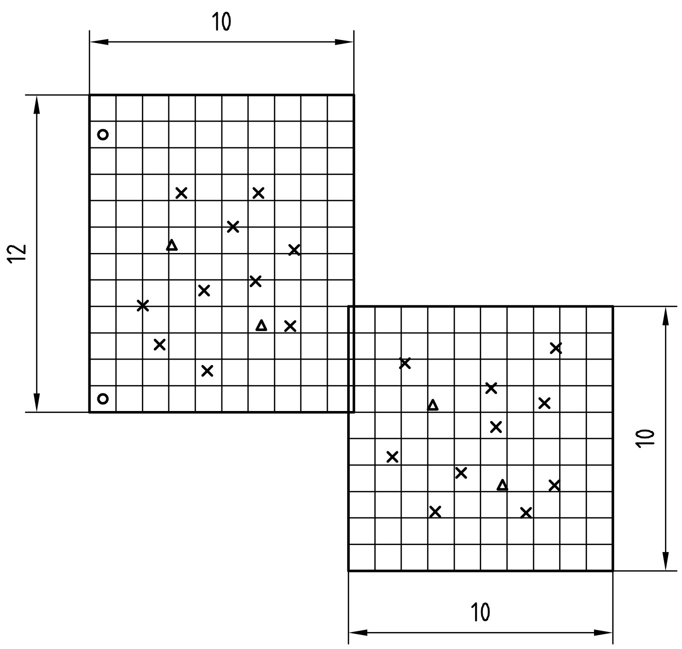
Example 1



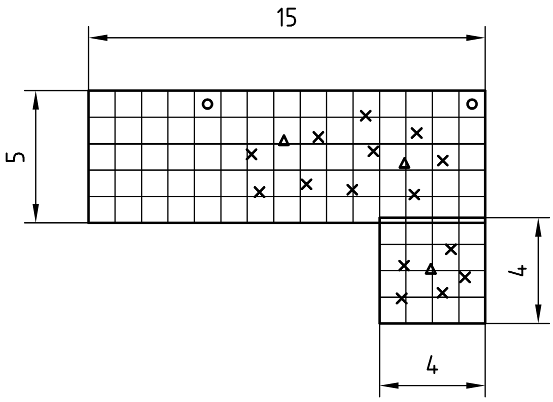
Example 2



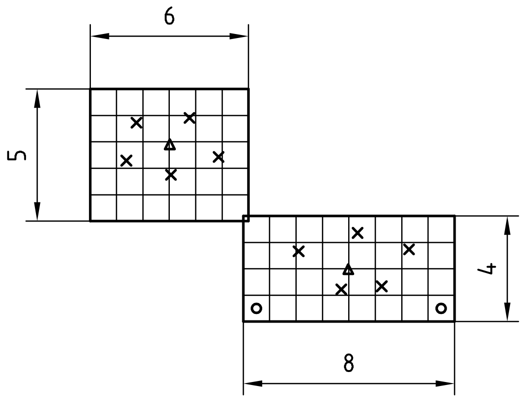
Example 3



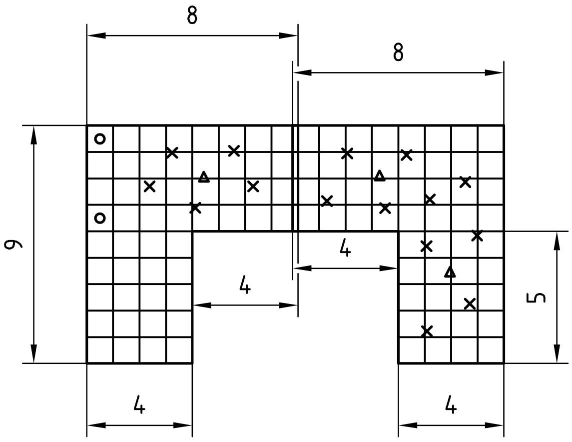
Example 4



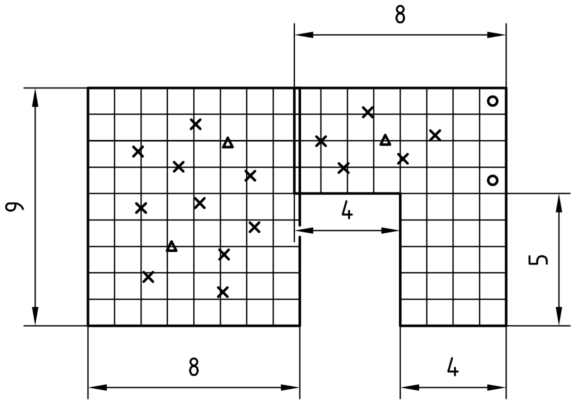
Example 5



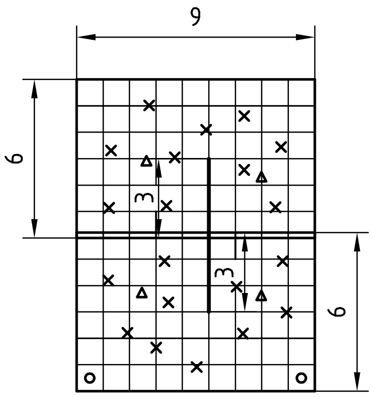
Example 6



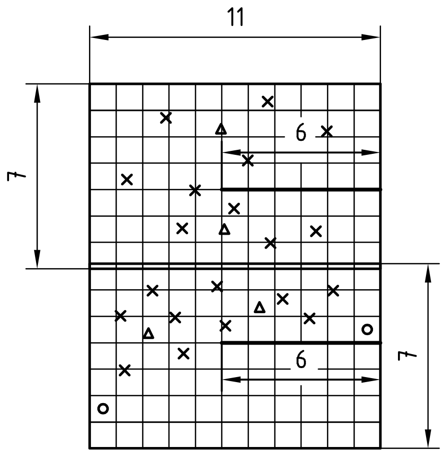
Example 7



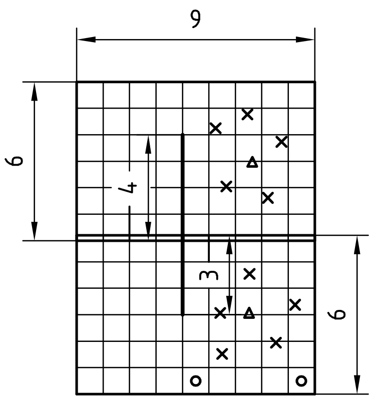
Example 8



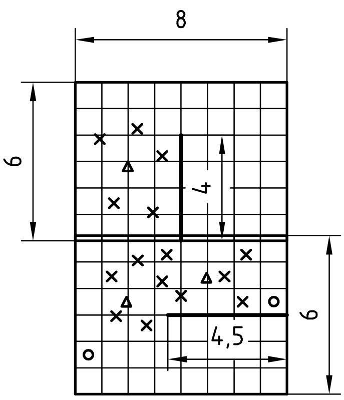
Example 9



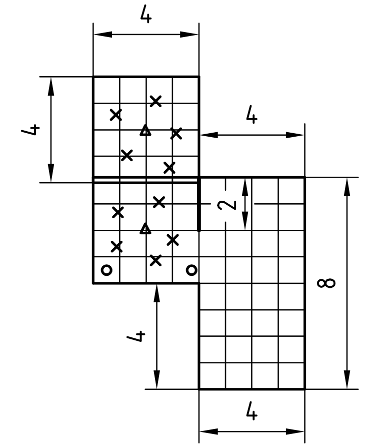
Example 10



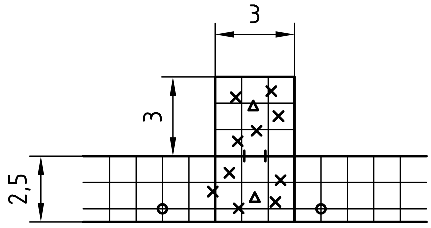
Example 11



Example 12

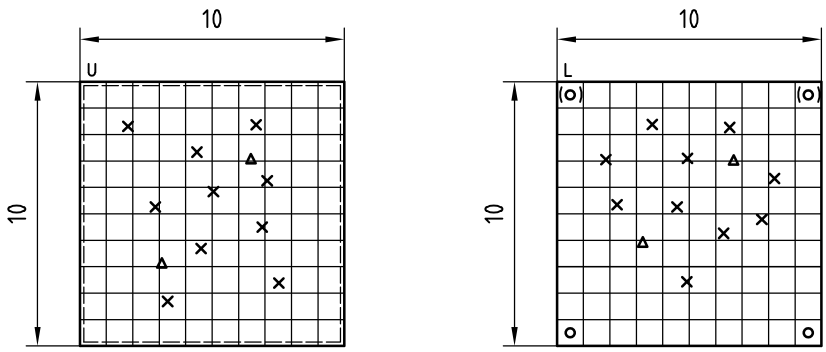


Example 13

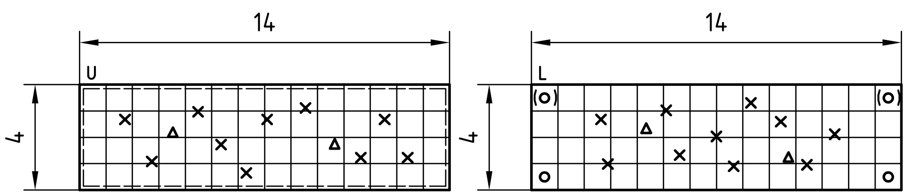


Example 14

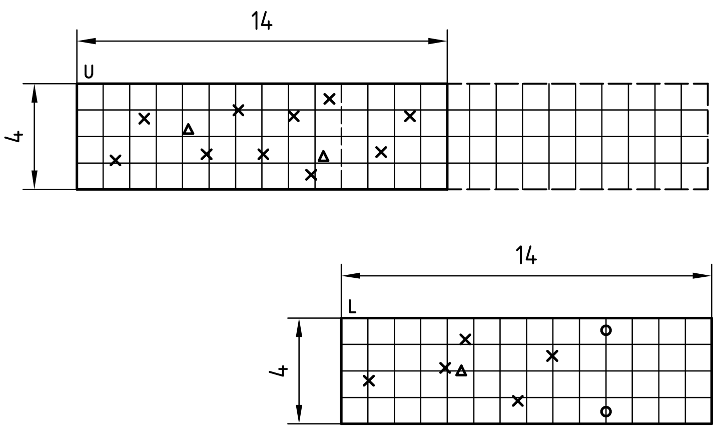
Figure C.1 — Airborne sound insulation — Horizontal measurements, scale 1:200, Examples 1 to 14



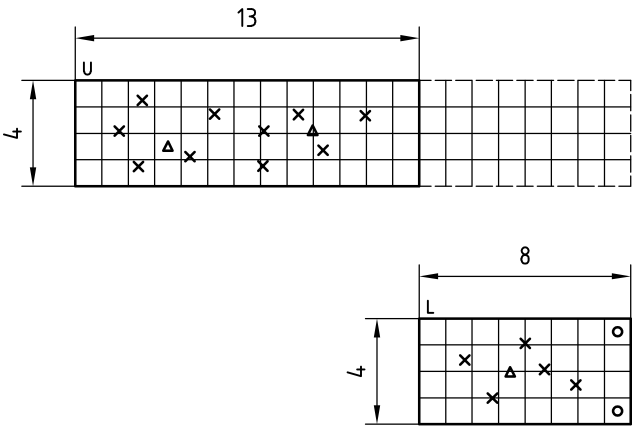
Example 15



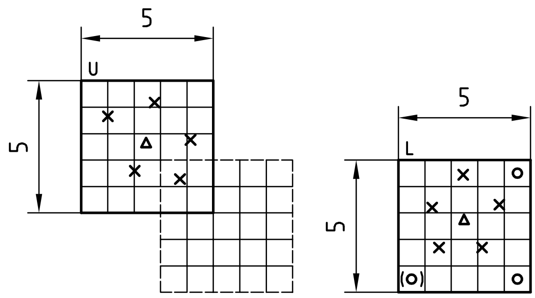
Example 16



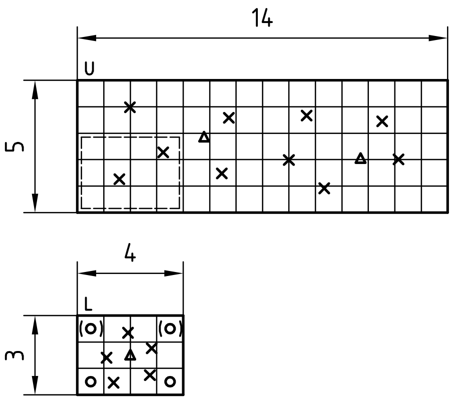
Example 17



Example 18

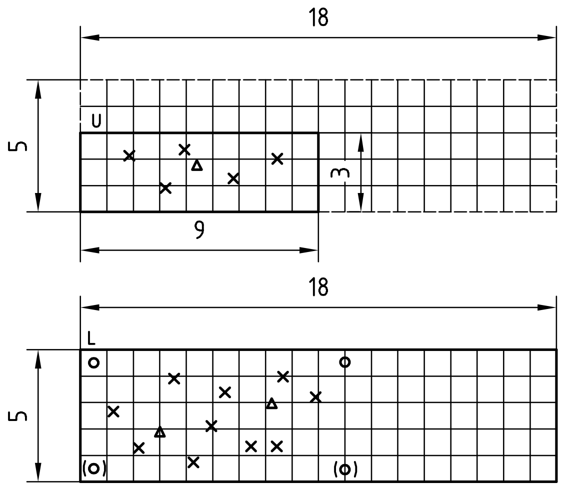


Example 19

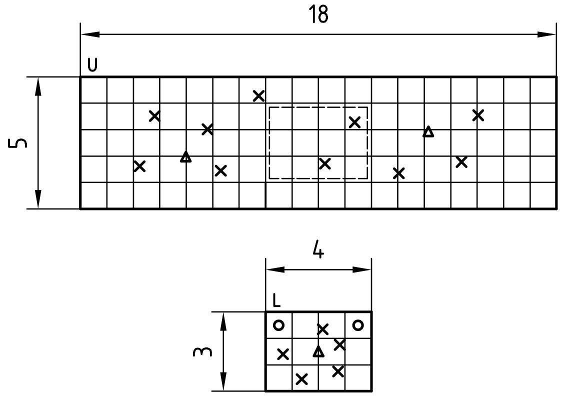


Example 20

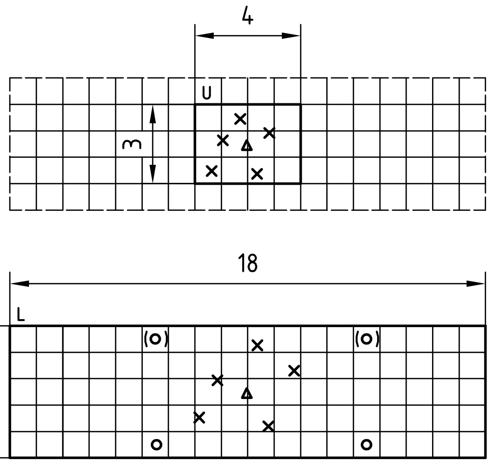
Example 21



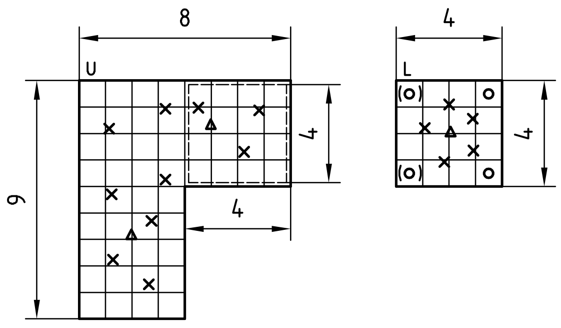
Example 22

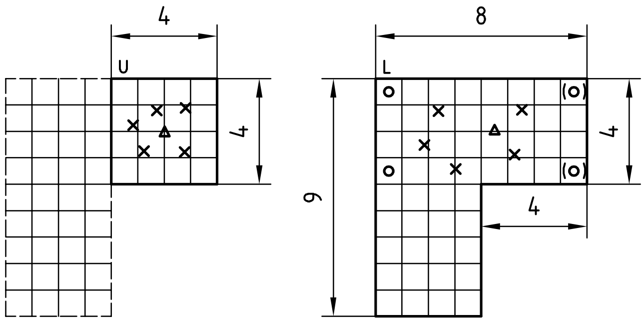


Example 23

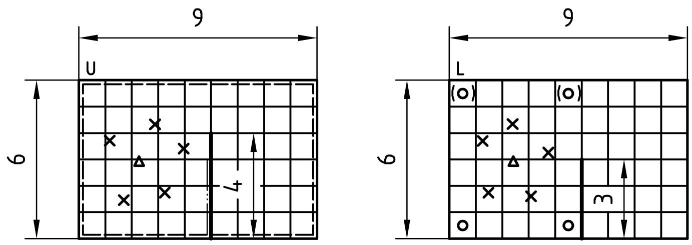


Example 24

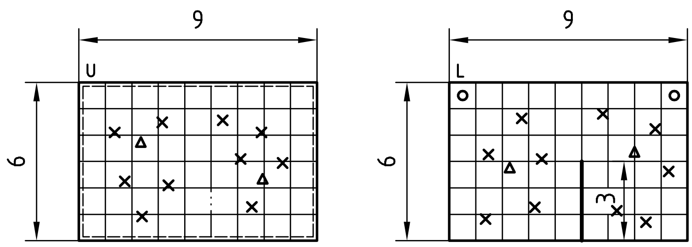




Example 25



Example 26



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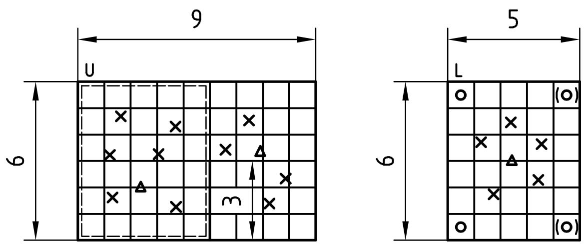
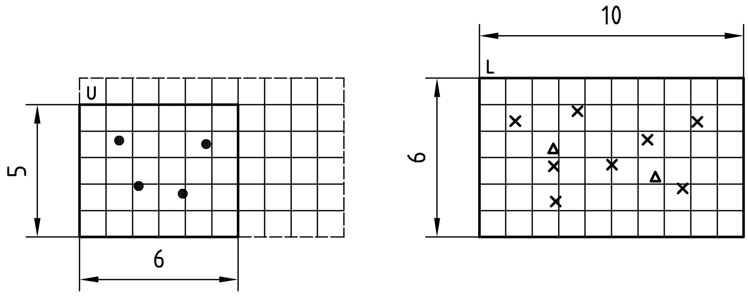


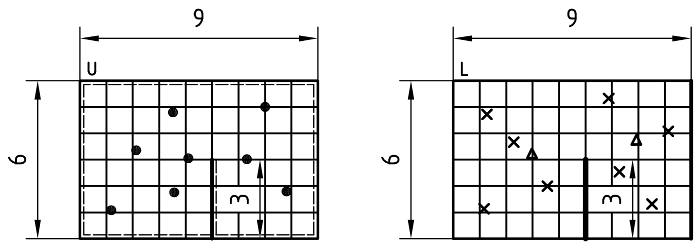
Example 28

NOTE Alternative loudspeaker positions are shown in brackets.

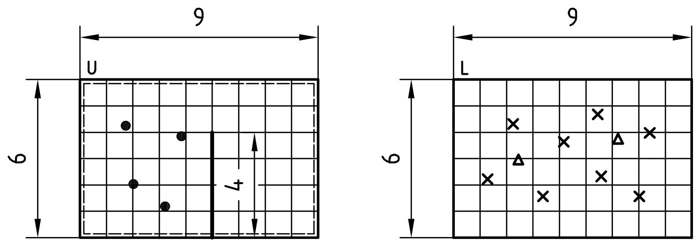
Figure C.2 — Airborne sound insulation — Vertical measurements, scale 1:200, Examples 15 to 28



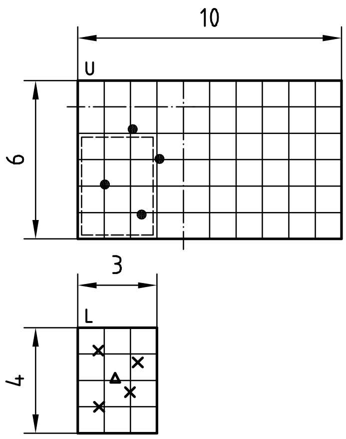
Example 29



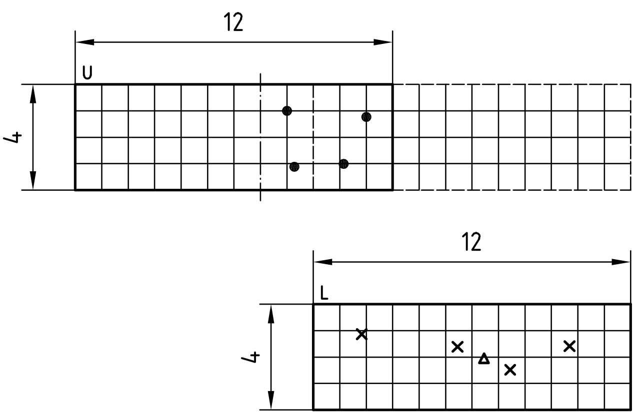
Example 30



Example 31

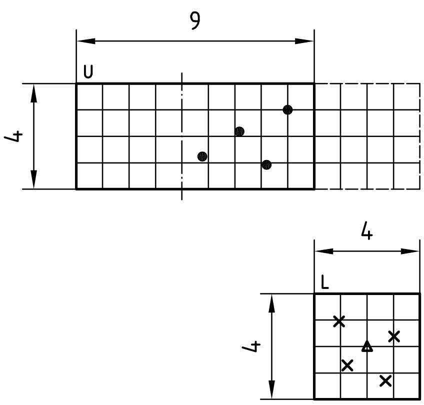


Example 32



Example 33

Example 34



Example 35

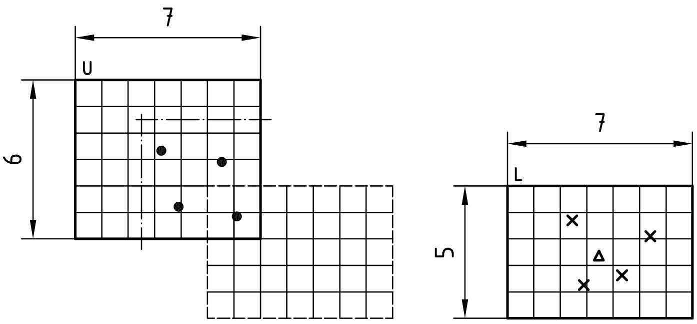
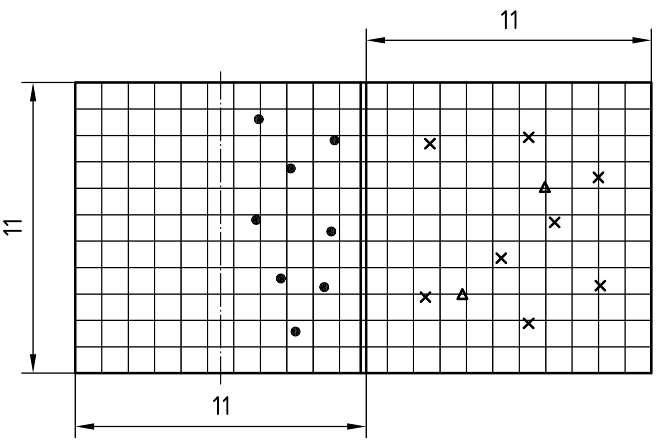
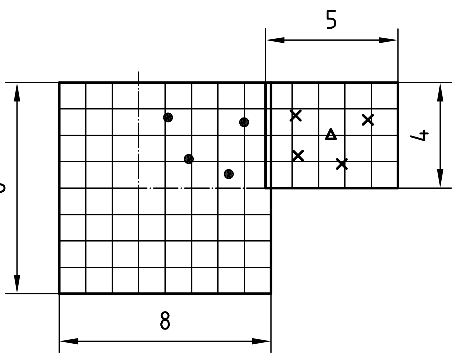


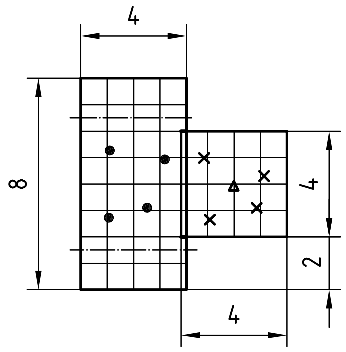
Figure C.3 — Impact sound insulation — Vertical measurements, scale 1:200, Examples 29 to 35

Example 36

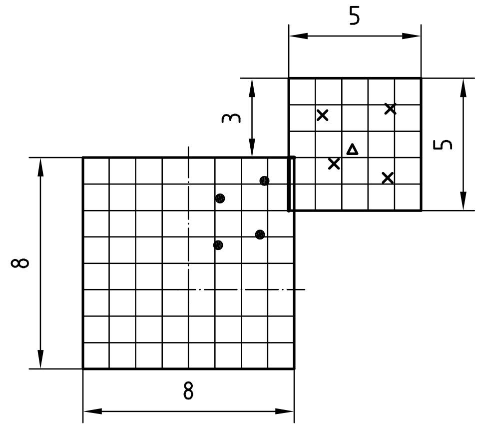


Example 37

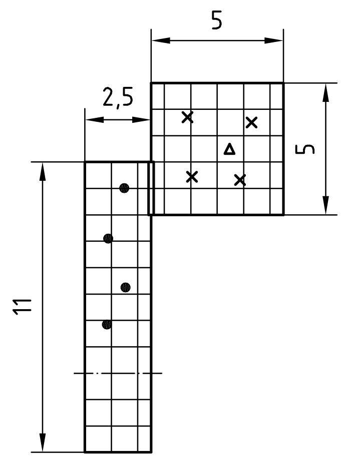




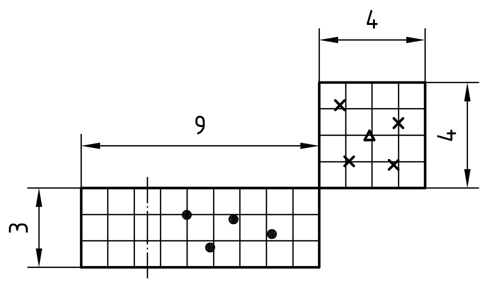
Example 38



Example 39

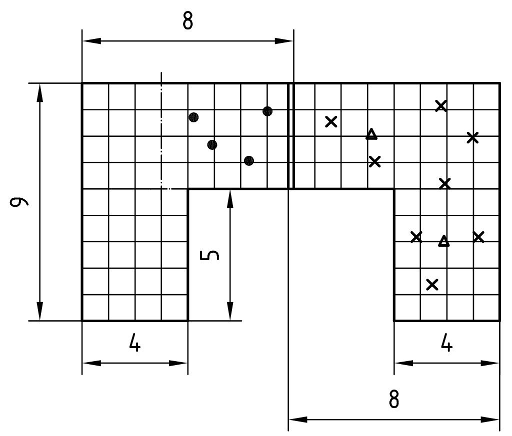


Example 40

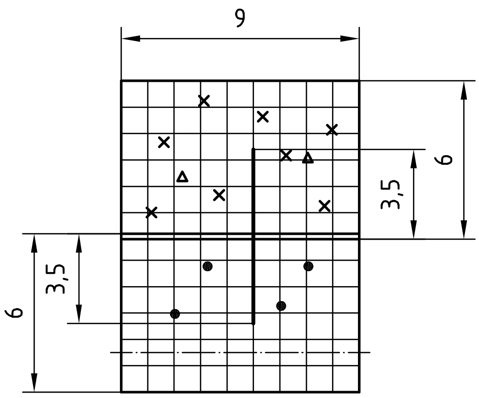


Example 41

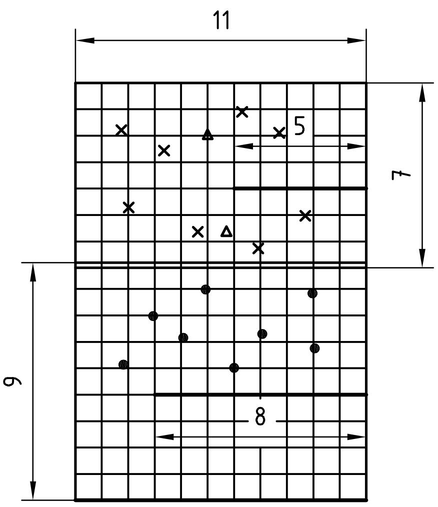
Example 42



Example 43



Example 44



Example 45

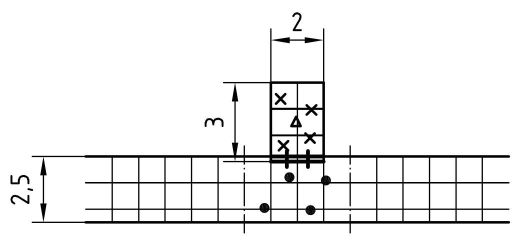
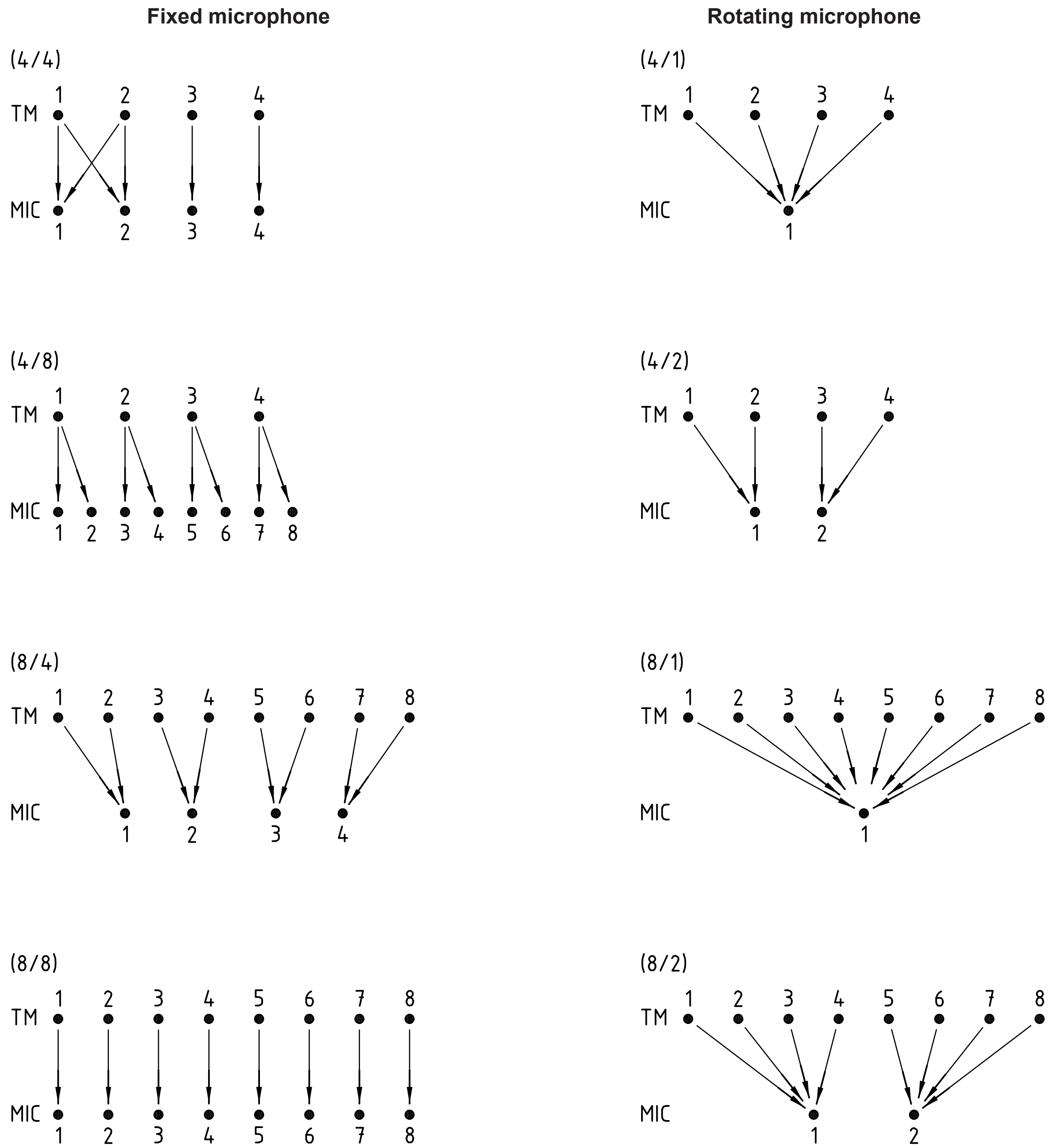


Figure C.4 — Impact sound insulation — Horizontal measurements, scale 1:200, Examples 36 to 45

Annex D
(informative)

Combinations of tapping machine positions and microphone positions



Key

TM tapping machine position

MIC microphone position

(x/x) number of tapping machine positions/number of microphone positions

(4/4) minimum number of positions stated in ISO 140-7 for fixed microphones

(4/1) minimum number of positions stated in ISO 140-7 for rotating microphones

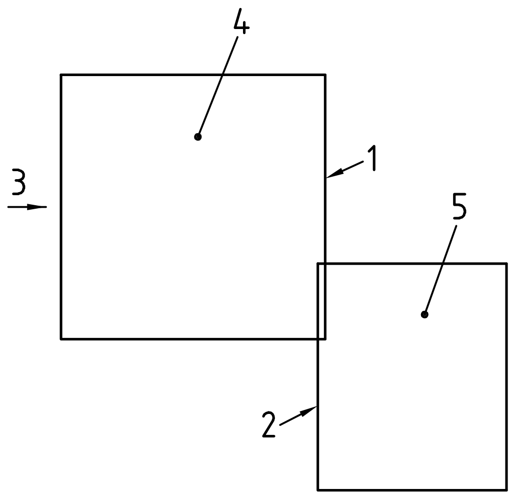
Figure D.1 — Examples of positions of tapping machines and microphones

Annex E
(informative)

Explanation of terms

For horizontal measurements, the terms used are shown in Figure E.1.

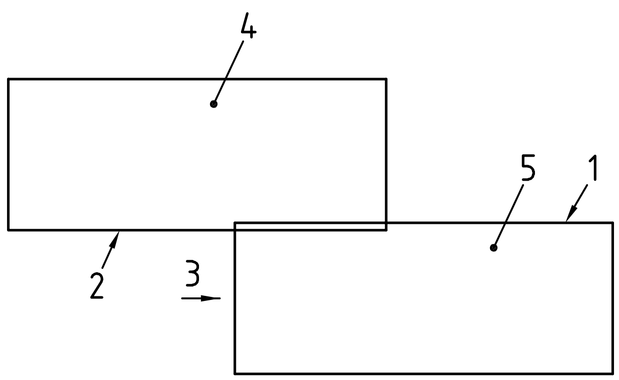
For the vertical measurements, the terms used are shown in Figure E.2.



Key

═══	common partition	3	back wall
1	partition, source room	4	source room
2	partition, receiving room	5	receiving room

Figure E.1 — Horizontal measurements



Key

═══	common partition	3	back wall
1	partition, source room	4	receiving room
2	partition, receiving room	5	source room

NOTE For measurements of impact sound insulation, 1 and 2 are interchanged.

Figure E.2 — Vertical measurements

Bibliography

[1] ISO/TR 140-13, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 13: Guidelines*

[2] ISO 3382-2, *Acoustics — Measurement of reverberation time — Part 2: Ordinary rooms*

[3] ISO 15186-2, *Acoustics — Measurement of sound insulation in buildings and of building elements using sound intensity — Part 2: Field measurements*

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