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

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

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

Partie 16: Mesurage en laboratoire de l'amélioration de l'indice de réduction acoustique par un revêtement complémentaire

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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

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

ISO 140-16 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 126, *Acoustic properties of building products and of buildings*, in collaboration with Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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

— *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*

— *Part 9: Laboratory measurements of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it*

— *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*

— *Part 12: Laboratory measurement of room-to-room airborne and impact sound insulation of an access floor*

— *Part 13: Guidelines*

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

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

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

Introduction

There is a strong need to separately characterize the sound reduction effect of walls or floors and acoustic linings. On the one hand, different industries are involved. On the other hand, 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 part of ISO 140-16.

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 coincidence frequency of the basic structure is below the measured frequency range and the structural coupling between the lining and the basic structure is small. If the actual situation differs from these conditions, the effect of the lining is, at least to some extent, dependent on the properties of the basic structure. The independent characterization of the acoustic performance of a lining thus requires very heavy massive elements, while a lot of practical applications involve various lightweight elements. As a practical compromise, different steps of testing are provided.

— In any case, the lining is applied to either a heavy massive wall of about 350 kg/m^2 with its coincidence frequency around 125 Hz or to the standard concrete floor according to ISO 140-8, depending on the use of the lining. The measured improvement by the lining is given as a frequency spectrum and as a single-number improvement value in accordance with Annexes A and B. Being based on mean basic element characteristics, the results are largely independent of the particular features of the test facility and the basic element used and thus characterize the lining in the most general way.

— If the performance of a lining on a generalized lightweight solid wall is of interest, a standard lightweight basic wall of about 70 kg/m^2 and coincidence frequency around 500 Hz are used. The results are given as a frequency spectrum and as a single-number improvement value according to Annexes A and B. The central position of the coincidence frequency can strongly influence the improvement by the lining. Therefore, the results are not likely to be transferable to other basic constructions. But by using the weighting procedure in Annexes A and B, the influences of the particular test facility and basic construction are minimized, thus making the results comparable between different laboratories.

— 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 mean values of the 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.

Flexible, lightweight basic elements and elements with thickness resonances within the measured frequency range are outside the scope of this part of ISO 140, as their influence is not predictable.

For standardization reasons and comparability, all measurements and evaluations are normatively done in third-octave bands. Additional octave-band results can optionally be deduced from the third-octave band results.

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 140 yields the sound-reduction improvement for direct airborne sound transmission.

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

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

1 Scope

This part of ISO 140, as a complement to ISO 140-3, specifies the laboratory measurement of the improvement of the sound-reduction index of a wall or ceiling when covered by an additional acoustical lining. It also provides for individual non-standardized basic elements. This part of ISO 140 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.

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 140-1, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 1: Requirements for laboratory test facilities with suppressed flanking transmission*

ISO 140-3, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 3: Laboratory measurements of airborne sound insulation of building elements*

ISO 140-8, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 8: Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a heavyweight standard floor*

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

ISO 717-2, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 2: Impact sound insulation*

3 Terms, definitions and symbols

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

3.1
sound reduction index
R
ten times the logarithm to the base 10 of the ratio of the sound power, W_1, that is incident on the test specimen to the sound power, W_2, transmitted through the specimen, in a stated frequency band, as given in Equation (1):

$$R = 10 \lg \frac{W_1}{W_2} \text{ dB} \quad (1)$$

3.2
weighted sound-reduction index
R_w
single-number quantity for airborne sound insulation rating of the reference curve after shifting it in accordance with the method specified in ISO 717-1

NOTE The weighted sound-reduction index is expressed in units of decibels.

3.3
sound reduction improvement index
ΔR
difference of the sound reduction indices of the basic element with and without the lining for each third-octave band, as given in Equation (2):

$$\Delta R = R_{\text{with}} - R_{\text{without}} \tag{2}$$

3.4
weighted sound reduction improvement index
ΔR_w
single-number value calculated from the sound reduction improvement index, ΔR, in accordance with Annexes A and B

NOTE An additional subscript indicates the basic element used: “heavy” for the heavyweight wall and floor according to 5.3.2. and 5.3.3, “light” for the lightweight wall according to 5.3.4.

EXAMPLE $\Delta R_{\text{w,heavy}}$.

3.5
direct difference of the weighted sound reduction indices
$\Delta R_{\text{w,direct}}$
difference of the weighted sound reduction indices of the basic element with and without lining, as given in Equation (3):

$$\Delta R_{\text{w,direct}} = R_{\text{w,with}} - R_{\text{w,without}} \tag{3}$$

3.6
A-weighted sound reduction improvement indices
$\Delta(R_w + C)$
$\Delta(R_w + C_{tr})$
A-level difference caused by the lining when the exciting sound source sends pink noise (C) or standardized traffic noise (C_{tr})

NOTE 1 C and C_{tr} are the spectrum-adaptation terms in accordance with ISO 717-1.

NOTE 2 For calculation see Annex A.

NOTE 3 An additional index indicates the basic element used: “heavy” for the heavyweight wall and floor in accordance with 5.3.2. and 5.3.3, “light” for the lightweight wall in accordance with 5.3.4.

EXAMPLE $\Delta(R_w\text{+C})_{\text{heavy}}$.

3.7
direct difference of the A-weighted sound reduction indices
$\Delta(R_w + C)_{direct}$
$\Delta(R_w + C_{tr})_{direct}$
difference between the A-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) and noise source characteristics, as given by Equations (4) and (5):

$$\Delta(R_w + C)_{direct} = (R_{w,with} + C_{with}) - (R_{w,without} + C_{without}) \quad (4)$$

$$\Delta(R_w + C_{tr})_{direct} = (R_{w,with} + C_{tr,with}) - (R_{w,without} + C_{tr,without}) \quad (5)$$

3.8
basic element
wall or ceiling (floor) to which the additional lining is fixed

3.9
sound reduction index of the basic reference curve
R_{ref}
sound reduction index of the matching basic reference curve of the matching basic reference element

3.10
$R_{w,ref}$
weighted sound reduction index of the basic reference curve
weighted sound reduction index of the matching basic reference curve of the matching basic reference element

4 Principle

Dependent on the application of the lining, the tests are carried out on a massive heavyweight wall or floor with its coincidence frequency near 125 Hz and without any abnormalities concerning its airborne sound transmission (like thickness resonances). The results, including the single-number improvement values, can be used to compare and predict the acoustic performance of additional linings, when combined with walls or ceilings meeting the above-mentioned conditions of low coincidence frequency and absence of abnormalities and having a mass per unit area at least ten times larger than that of the lining.

As additional linings are often applied to more lightweight, homogeneous massive walls, another basic wall is defined with a given coincidence frequency around 500 Hz. As a strong interaction of lining and wall is expected in this case, the results, including the single-number improvement values, are limited to this type of basic wall and may, thus, be mainly used to compare and estimate the acoustic performance of linings under similar conditions.

If individual, non-standardized basic elements are used, the only way to state a single-number result is to calculate the direct difference of the weighted sound reduction indices of the basic element with and without lining. This value depends on the features of the test facility and of the basic element and thus mainly allows a comparison of different linings under the same measuring conditions.

5 Test arrangement

5.1 Test facilities

The measurements shall be carried out in laboratory test facilities for walls or floors with suppressed flanking transmission in accordance with ISO 140-1.

5.2 Mounting of the specimens

The specimen, i.e. the additional lining, and the basic structure shall cover the whole test opening. 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, considering the following: there shall be no strong coupling between the basic element and the lining along the edges by the flanking elements of the laboratory. Either the flanking parts of the laboratory are heavy enough (for details see ISO 140-1) 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 but only flexibly sealed.

5.3 Basic elements

5.3.1 General

Corresponding to the application of the lining, the constructions given in 5.3.2 and 5.3.3 shall be used. The wall with medium coincidence frequency according to 5.3.4 shall be used in addition, when this case covers the field of application of the lining. Other basic elements may, optionally, be used for extra information, but the results are not usually comparable to measurement results determined by means of the obligatory basic elements. This shall be clearly stated with the results.

5.3.2 Basic wall with low coincidence frequency ("heavy basic wall")

Masonry, homogeneous concrete or concrete blocks with a mass per unit area, m, of (350 ± 50) kg/m^2. Material and thickness shall be chosen such that the coincidence frequency is located in the 125 Hz octave band. This may be calculated or measured. There shall be no cavities apart from grip holes and no thickness resonances below 3 150 Hz. The density of the blocks shall be at least 1 600 kg/m^3. If the wall is not airtight, it shall be plastered on the side facing the lining.

EXAMPLE Masonry of calcium silicate blocks. Density of the blocks, 1 700 kg/m^3 $\leqslant \rho <$ 1 800 kg/m^3; thickness of the blocks, 17,5 cm; with 10 mm of gypsum plaster on one side of the wall.

5.3.3 Basic floor with low coincidence frequency ("heavy basic floor")

A heavy homogeneous concrete floor shall be used in accordance with ISO 140-8.

5.3.4 Basic wall with medium coincidence frequency ("lightweight basic wall")

A wall of 10 cm cellular concrete, density ρ = (600 ± 50) kg/m^3, with 10 mm gypsum plaster on the side facing the lining shall be used.

This wall shall have a mass per unit area of about 70 kg/m^2 and a coincidence frequency within the 500 Hz octave band. Other material is allowed, as long as the same ranges of mass per unit area and coincidence frequencies are maintained.

6 Test procedure

The sound-reduction index of the basic element with and without the additional lining shall be measured in accordance with ISO 140-3 as third-octave band values. The basic element shall not change its sound-reduction index during the two measurements. Either the basic element shall be in final conditions or the two measurements shall be carried out within a sufficiently short time interval. For masonry and concrete, this shall be achieved by either a curing period of a minimum of two weeks or a time lag between the two sound reduction measurements that shall not exceed 1/3 of the curing time elapsed before the first measurement. As an example, when the two measurements are carried out within one day, they can be started three days after the end of construction of the (concrete or masonry) basic element.

7 Evaluation of results

From the sound reduction indices, R_{with} and R_{without}, the sound reduction improvement index, ΔR, is calculated according to Equation (2).

When the basic elements given in 5.3.2, 5.3.3 and 5.3.4 are used, the weighted sound reduction improvement index, ΔR_{w}, shall be evaluated from ΔR in accordance with Annexes A and B. For all other cases, direct differences according to 3.5 and 3.7 shall be stated.

8 Precision

The precision of this measuring method is about the same as the precision of the measurement given in ISO 140-8.

9 Expression of results

All results of R_{with}, R_{without} and ΔR shall be given as third-octave band levels to one decimal place. Octave band values, ΔR_{oct}, expressed in decibels, shall be calculated from the corresponding third-octave band values, ΔR_n, as given in Equation (6):

$$\Delta R_{\text{oct}} = -10 \lg \left(\sum_{n=1}^{3} \frac{10^{\left(-\Delta R_n / 10\right)}}{3} \right) \qquad (6)$$

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

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

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

ΔR shall be shown as third-octave band levels over frequency in a graph scaled as follows:

a) 5 mm for a third-octave band;

b) 20 mm for 10 dB.

Another ΔR-graph in octave bands can be given optionally.

10 Test report

The test report shall contain the following:

a) reference to this part of ISO 140;

b) name and address of the testing laboratory;

c) manufacturer's name and product identification;

d) name and address of the person or the organization who ordered the test;

e) name and address of the person or the organization in charge of sampling, details of sampling and name and the address of the person or the organization in charge of installing the test object;

f) date of taking of the test object or test material, dates of construction of the basic element and the lining, date of the test and date of the issue of the test report;

g) detailed description of the basic element: dimensions, mass per unit area, materials, details of fitting into the test facility (boundary conditions of the element), including a reference to the corresponding basic element in 5.3 or statement that it is not one of those;

h) detailed description of the lining and details of the fitting into the test facility and of the fixing to the basic element;

i) description of the test facility: type of suppression of the flanking transmission, volumes of the test rooms, size of the test opening;

j) air temperature and humidity in the receiving room during the measurement;

k) a short description of the measuring method and a list of measuring equipment;

l) R_{with}, R_{without} and ΔR as specified in Clause 9, the single value of the basic support without lining, $R_{\text{w}}(C,C_{\text{tr}})_{\text{without}}$ and the single value of the basic support with lining, $R_{\text{w}}(C,C_{\text{tr}})_{\text{with}}$;

m) for standard basic elements in accordance with 5.3.2, 5.3.3 and 5.3.4: ΔR_{w}, $\Delta(R_{\text{w}} + C)$ and $\Delta(R_{\text{w}} + C_{\text{tr}})$ as specified in Annexes A and B, with an index in accordance with 3.4, indicating the basic element used;

n) 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 3.5 and 3.7, without any further index for the type of basic element;

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

Annex A
(normative)

Weighting procedure

A.1 General

To evaluate the single-number value, ΔR_w, from the third-octave band values, ΔR, the same procedure is used as when evaluating the weighted impact sound improvement, ΔL_w, from the normalized impact sound pressure levels, L_n, according to ISO 717-2. That means the measured values of the sound reduction improvement are applied to standardized reference basic constructions by calculation, and the difference of the weighted sound reduction indices of the reference construction with and without lining yields the weighted sound reduction improvement index, ΔR_w, of the lining. A corresponding procedure is used for the A-weighted sound reduction improvement indices of the lining, $\Delta(R_w + C)$ and $\Delta(R_w + C_{tr})$.

A.2 Procedure

Take the third-octave sound reduction improvement index values, ΔR , as measured. Add them to the sound reduction index, $R_{ref,\ without}$, of the matching basic reference element as given in Annex B, as shown in Equation (A.1):

$$R_{ref,with} = R_{ref,without} + \Delta R \tag{A.1}$$

Determine the weighted sound reduction indices, $R_{w,ref,with}$, in accordance with ISO 717-1 and take $R_{w,ref,without}$ from Table B.2, Table B.4 and Table B.6 or determine it also in accordance with ISO 717-1. The weighted sound reduction improvement index is, then, as given in Equation (A.2):

$$\Delta R_w = R_{w,ref,with} - R_{w,ref,without} \tag{A.2}$$

Determine the spectrum-adaption terms of the reference basic construction with and without lining in accordance with ISO 717-1:

— $C_{ref,with}$ and $C_{ref,without}$;

— $C_{tr,ref,with}$ and $C_{tr,ref,without}$.

The A-weighted sound reduction improvement indices, $\Delta(R_w + C)$ and $\Delta(R_w + C_{tr})$, result from Equations (A.3) and (A.4), respectively:

$$\Delta(R_w + C) = (R_{w,ref,with} + C_{ref,with}) - (R_{w,ref,without} + C_{ref,without}) \tag{A.3}$$

$$\Delta(R_w + C_{tr}) = (R_{w,ref,with} + C_{tr,ref,with}) - (R_{w,ref,without} + C_{tr,ref,without}) \tag{A.4}$$

Annex B
(normative)

Sound reduction indices of the reference basic elements

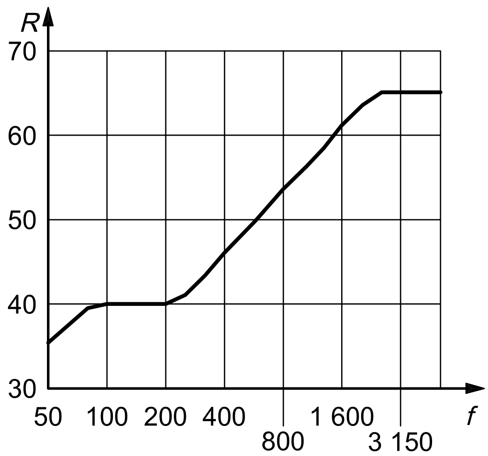
B.1 General

In this annex, the standardized values of the sound reduction indices, R, of the reference basic elements are given as well as the corresponding weighted sound reduction indices, R_w, and spectrum-adaptation terms, C and C_{tr}.

NOTE The reference curve values are calculated according to a proposal in Reference [3].

B.2 Basic wall with low coincidence frequency

The reference curve shown in Figure B.1 corresponds to the basic wall with a mass per unit area of 350 kg/m^2 as described in 5.3.2.



Key

f frequency, expressed in hertz

R sound reduction index, expressed in decibels

Figure B.1 — Reference curve for the basic wall with low coincidence frequency

Table B.1 — Third-octave band values of the reference curve for the basic wall with low coincidence frequency

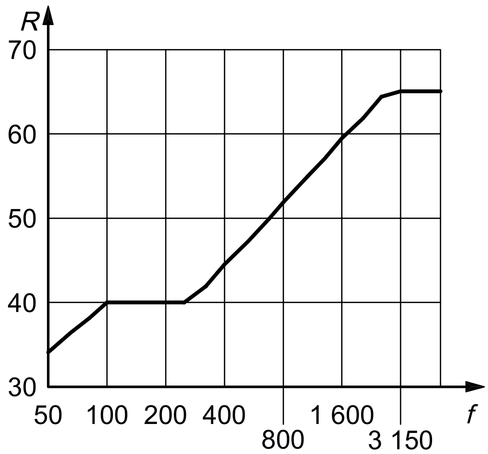
f Hz	R dB
50	35,3
63	37,3
80	39,4
100	40,0
125	40,0
160	40,0
200	40,0
250	41,0
315	43,5
400	46,1
500	48,5
630	51,0
800	53,6
1 000	56,0
1 250	58,4
1 600	61,1
2 000	63,6
2 500	65,0
3 150	65,0
4 000	65,0
5 000	65,0

Table B.2 — Weighted sound-reduction index and spectrum-adaption terms of the reference curve for the basic wall with low coincidence frequency

Parameter	**Value** dB
R_{W}	53
$C_{100\ \mathrm{to}\ 3\,150}$	– 1
$C_{100\ \mathrm{to}\ 5\,000}$	0
$C_{50\ \mathrm{to}\ 3\,150}$	– 1
$C_{50\ \mathrm{to}\ 5\,000}$	0
$C_{\mathrm{tr}100\ \mathrm{to}\ 3\,150}$	– 5
$C_{\mathrm{tr}100\ \mathrm{to}\ 5\,000}$	– 5
$C_{\mathrm{tr}50\ \mathrm{to}\ 3\,150}$	– 5
$C_{\mathrm{tr}50\ \mathrm{to}\ 5\,000}$	– 5

B.3 Basic floor with low-coincidence frequency

The reference curve shown in Figure B.2 corresponds to the basic floor made of 140 mm concrete as described in 5.3.2. The mass per unit area is about 300 kg/m^2.



Key

f frequency, expressed in hertz

R sound reduction index, expressed in decibels

Figure B.2 — Reference curve for the basic floor with low-coincidence frequency

Table B.3 — Third-octave-band values of the reference curve for the basic floor with low-coincidence frequency

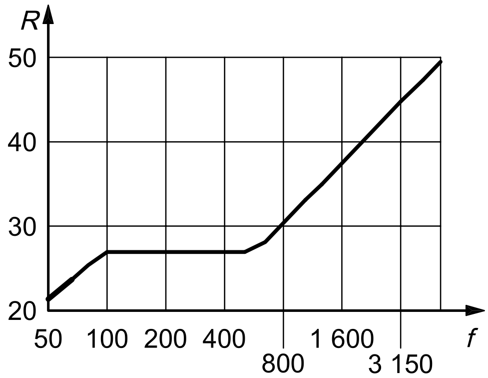
f Hz	*R* dB
50	34,0
63	36,0
80	38,1
100	40,0
125	40,0
160	40,0
200	40,0
250	40,0
315	41,8
400	44,4
500	46,8
630	49,3
800	51,9
1 000	54,4
1 250	56,8
1 600	59,5
2 000	61,9
2 500	64,3
3 150	65,0
4 000	65,0
5 000	65,0

Table B.4 — Weighted sound-reduction index and spectrum-adaption terms of the reference curve for the basic floor with low coincidence frequency

Parameter	Value dB
R_W	52
$C_{100\ \text{to}\ 3\,150}$	− 1
$C_{100\ \text{to}\ 5\,000}$	0
$C_{50\ \text{to}\ 3\,150}$	− 1
$C_{50\ \text{to}\ 5\,000}$	0
$C_{tr100\ \text{to}\ 3\,150}$	− 4
$C_{tr100\ \text{to}\ 5\,000}$	− 4
$C_{tr50\ \text{to}\ 3\,150}$	− 5
$C_{tr50\ \text{to}\ 5\,000}$	− 5

B.4 Basic wall with medium coincidence frequency

The reference curve shown in Figure B.3 corresponds to the basic wall with a mass per unit area of 70 kg/m^2 as described in 5.3.3.



Key

f frequency, expressed in hertz

R sound reduction index, expressed in decibels

Figure B.3 — Reference curve for the basic wall with medium-coincidence frequency

Table B.5 — Third-octave band values of the reference curve for the basic wall with medium coincidence frequency

f Hz	R dB
50	21,3
63	23,3
80	25,3
100	27,0
125	27,0
160	27,0
200	27,0
250	27,0
315	27,0
400	27,0
500	27,0
630	28,0
800	30,5
1 000	32,8
1 250	35,1
1 600	37,6
2 000	40,0
2 500	42,3
3 150	44,6
4 000	47,1
5 000	49,4

Table B.6 — Weighted sound-reduction index and spectrum-adaption terms of the reference curve for the basic wall with medium coincidence frequency

Parameter	**Value** dB
R_W	33
$C_{100 \text{ to } 3\,150}$	– 1
$C_{100 \text{ to } 5\,000}$	0
$C_{50 \text{ to } 3\,150}$	– 1
$C_{50 \text{ to } 5\,000}$	0
$C_{tr100 \text{ to } 3\,150}$	– 2
$C_{tr100 \text{ to } 5\,000}$	– 2
$C_{tr50 \text{ to } 3\,150}$	– 3
$C_{tr50 \text{ to } 5\,000}$	– 3

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