INTERNATIONAL STANDARD

ISO 12354-2

First edition
2017-07

Building acoustics — Estimation of acoustic performance of buildings from the performance of elements —

Part 2: Impact sound insulation between rooms

Acoustique du bâtiment — Calcul de la performance acoustique des bâtiments à partir de la performance des éléments —

Partie 2: Isolement acoustique au bruit de choc entre des locaux

Reference number
ISO 12354-2:2017(E)

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.

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 World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This first edition cancels and replaces ISO 15712-2:2005, which has been technically revised.

A list of all the parts in the ISO 12354 series can be found on the ISO website.

Introduction

This document is part of a series specifying calculation models in building acoustics.

Although this document covers the main types of building construction it cannot as yet cover all variations in the construction of buildings. It sets out an approach for gaining experience for future improvements and developments.

The accuracy of this document can only be specified in detail after widespread comparisons with field data, which can only be gathered over a period of time after establishing the prediction model. To help the user in the meantime, indications of the accuracy have been given, based on earlier comparisons with comparable prediction models and an estimation procedure, similar to the one proposed in ISO 12354-1 for airborne sound insulation, can be used for impact sound insulation. It is the responsibility of the user (i.e. a person, an organization, the authorities) to address the consequences of the accuracy, inherent for all measurement and prediction methods, by specifying requirements for the input data and/or applying a safety margin to the results or applying some other correction.

This document is intended for acoustical experts and provides the framework for the development of application documents and tools for other users in the field of building construction, taking into account local circumstances.

The calculation models described use the most general approach for engineering purposes, with a clear link to measurable quantities that specify the performance of building elements. The known limitations of these calculation models are described in this document. Other calculation models also exist, each with their own applicability and restrictions.

The models are based on experience with prediction for dwellings; they could also be used for other types of buildings provided the construction systems and dimensions of elements are not too different from those in dwellings.

This document also provides details for application to lightweight constructions (typically steel or wood framed lightweight elements as opposed to heavier masonry or concrete elements) and with the possibility of characterizing the impact sound performance of stairs (see Annex F).

Building acoustics — Estimation of acoustic performance of buildings from the performance of elements —

Part 2:
Impact sound insulation between rooms

1 Scope

This document specifies calculation models designed to estimate the impact sound insulation between rooms in buildings, primarily using measured data which characterize direct or indirect flanking transmission by the participating building elements and theoretically-derived methods of sound propagation in structural elements.

A detailed model is described for calculation in frequency bands, in the frequency range 1/3 octave 100 Hz to 3150 Hz in accordance with ISO 717-1, possibly extended down to 1/3 octave 50 Hz if element data and junction data are available (see Annex E); the single number rating of buildings can be determined from the calculation results. A simplified model with a restricted field of application is deduced from this, calculating directly the single number rating, using the single number ratings of the elements; the uncertainty on the apparent impact sound pressure level calculated using the simplified model can be determined according to the method described in ISO 12354-1:2017, Annex K (see Clause 5).

This document describes the principles of the calculation scheme, lists the relevant quantities and defines its applications and restrictions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 717-2:2013, *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, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 3: Measurements of impact sound insulation*

ISO 10848-1, *Acoustics —Laboratory measurement of flanking transmission of airborne and impact sound between adjoining rooms — Part 1: Frame document*

ISO 10848-4, *Acoustics — Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms — Part 4: Application to junctions with at least one heavy element*

ISO 12354-1:2017, *Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 1: Airborne sound insulation between rooms*

ISO 16283-2, *Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 2: Impact sound insulation*

3 Terms and definitions

For the purposes of this document, the following terms and definitions, and the symbols and units listed in Annex A, apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Quantities to express building performance

NOTE The impact sound insulation between rooms in accordance with ISO 16283-2 can be expressed in two related quantities. These quantities are determined in frequency bands (one-third-octave bands or octave bands) from which the single number rating for the building performance can be obtained in accordance with ISO 717-2, for instance $L'_{n,w}$, $L'_{nT,w}$ or ($L'_{nT,w} + C_I$).

3.1.1
normalized impact sound pressure level
L'_n
impact sound pressure level corresponding to the reference equivalent absorption area in the receiving room, which is evaluated from

$$L'_n = L_i + \left(10 \lg \frac{A}{A_o} \right) \text{dB}$$

where

L_i is the impact sound pressure level measured in the receiving room, in decibels;

A is the measured equivalent absorption area of the receiving room, in square metres;

A_o is the reference equivalent absorption area; for dwellings $A_o = 10$ m^2.

Note 1 to entry: This quantity shall be determined in accordance with ISO 16283-2.

3.1.2
standardized impact sound pressure level
L'_{nT}
impact sound pressure level corresponding to a reference value of the reverberation time in the receiving room, which is evaluated from

$$L'_{nT} = L_i - \left(10 \lg \frac{T}{T_o} \right) \text{dB}$$

where

T is the reverberation time in the receiving room, in seconds;

T_o is the reference reverberation time (for dwellings: $T_o = 0{,}5$ s).

Note 1 to entry: This quantity shall be determined in accordance with ISO 16283-2.

3.2 Quantities to express element performance

NOTE 1 The quantities expressing the element performance are used as part of the input data to estimate building performance. These quantities are determined in one-third-octave bands and can also be expressed in octave bands. In relevant cases a single number rating for the element performance can be obtained from this, in accordance with ISO 717-2, for instance $L_{nw}(C_I)$, ΔL_w ($C_{I\Delta}$) or ΔL_{lin} and $R_w(C; C_{tr})$.

NOTE 2 For the calculation, additional information on the elements can be necessary; for example, mass per unit area m' in k/m², type of element, material, type of junction, etc.

3.2.1
normalized impact sound pressure level
L_n
impact sound pressure level corresponding to the reference equivalent sound absorption area in the receiving room, which is evaluated from

$$L_n = L_i + \left(10 \lg \frac{A}{A_o} \right) \text{dB}$$

where

L_i is the impact sound pressure level measured in the receiving room by using the standard tapping machine in accordance with ISO 16283-2, in decibels;

A is the measured equivalent absorption area of the receiving room, in square metres;

A_o is the reference equivalent absorption area with $A_o = 10\ \text{m}^2$.

Note 1 to entry: This quantity shall be determined in accordance with ISO 10140-3.

3.2.2
reduction of impact sound pressure level
ΔL
improvement of impact sound insulation
reduction in normalized impact sound pressure level resulting from installation of the test floor covering, which is evaluated from

$$\Delta L = L_{no} - L_n \ \text{dB}$$

where

L_{no} is the normalized impact sound pressure level in the absence of floor covering, in decibels;

L_n is the normalized impact sound pressure level when the floor covering is in place, in decibels.

Note 1 to entry: This quantity shall be determined in accordance with ISO 10140-3.

3.2.3
reduction of impact sound pressure level
ΔL_d
reduction of impact sound pressure level by an additional layer on the receiving side of the separating element (floor)

Note 1 to entry: This quantity shall be determined in accordance with ISO 10140 (all parts).

3.2.4
normalized flanking impact sound pressure level
$L_{n,f}$
space and time average sound pressure level in the receiving room produced by a standardized tapping machine operating at different positions on the element in the source room, normalized to the reference equivalent sound absorption area (A_o) in the receiving room, which is evaluated from

$$L_{n,f} = L_i + \left(10 \lg \frac{A}{A_o} \right) \text{dB}$$

Note 1 to entry: A_0 = 10 m². Transmission is only considered to occur through a specified flanking element, e.g. access floor.

Note 2 to entry: This quantity shall be determined in accordance with ISO 10848-1.

Note 3 to entry: For clarity, the term $L_{n,f}$ is used when only one flanking path determines the sound transmission (such as with access floors) and the term $L_{n,f,ij}$ is used when only one specified transmission path *ij* out of several paths is considered (such as with structure-borne sound transmission on junctions of three or four connected elements).

Note 4 to entry: For access floors see ISO 10848–2.

3.2.5
sound reduction index
R
ten times the common logarithm of the ratio of the sound power W_1 incident on a test specimen to the sound power W_2 transmitted through the specimen, which is evaluated from

$$R = \left(10 \lg \frac{W_1}{W_2} \right) \text{dB}$$

Note 1 to entry: This quantity shall be determined in accordance with ISO 10140-2.

3.2.6
sound reduction improvement index
ΔR
difference in sound reduction index between a basic structural element with an additional layer (e.g. a resilient wall skin, a suspended ceiling, a floating floor) and the basic structural element without this layer

Note 1 to entry: For impact direct transmission, this quantity shall be determined in accordance with ISO 10140-1:2016, Annex G.

Note 2 to entry: ISO 12354-1:2017, Annex D gives information on the determination and the use of this quantity.

3.2.7
vibration reduction index
K_{ij}
quantity related to the vibrational power transmission over a junction between structural elements, normalized in order to make it an invariant quantity, which is determined by normalizing the direction-averaged velocity level difference over the junction, to the junction length and the equivalent absorption length, if relevant, of both elements in accordance with

$$K_{ij} = \frac{D_{v,ij} + D_{v,ji}}{2} + \left(10 \lg \frac{l_{ij}}{\sqrt{a_i a_j}} \right) \text{dB}$$

where

$D_{v,ij}$ is the velocity level difference between elements i and j, when element i is excited, in decibels;

$D_{v,ji}$ is the velocity level difference between elements j and i, when element j is excited, in decibels;

l_{ij} is the common length of the junction between element i and j, in metres;

a_i is the equivalent absorption length of element i, in metres;

a_j is the equivalent absorption length of element j, in metres.

Note 1 to entry: The equivalent absorption length is given by

$$a = \frac{2,2\,\pi^2 S}{c_0 T_s}\sqrt{\frac{f_{ref}}{f}}$$

where

T_s is the structural reverberation time of the element i or j, in seconds;

S is the area of element i or j, in square metres;

f is the centre band frequency, in Hertz;

f_{ref} is the reference frequency; f_{ref} = 1000 Hz;

c_0 is the speed of sound in air, in metres per second.

Note 2 to entry: The equivalent absorption length is the length of a fictional totally-absorbing edge of an element if its critical frequency is assumed to be 1 000 Hz, giving the same loss as the total losses of the element in a given situation.

Note 3 to entry: The quantity K_{ij} shall be determined in accordance with ISO 10848-1 and ISO 10848-4.

Note 4 to entry: Values for this quantity can be taken from ISO 12354–1:2017, Annex E of or be deduced from available data on the junction velocity level difference according to that annex.

3.2.8

normalized direction-averaged vibration level difference

$\overline{D_{v,ij,n}}$

difference in velocity level between elements i and j, averaged over the excitation from i and excitation from j, and normalized to the junction length and the measurement areas on both elements in accordance with

$$\overline{D_{v,ij,n}} = \frac{D_{v,ij} + D_{v,ji}}{2} + \left(10\lg\frac{l_{ij}l_0}{\sqrt{S_{m,i}S_{m,j}}}\right)\text{dB}$$

where

$D_{v,ij}$ is the velocity level difference between element i and j, when element i is excited, in decibels;

$D_{v,ji}$ is the velocity level difference between element j and i, when element j is excited, in decibels;

l_{ij} is the common length of the junction between element i and j, in metres;

$S_{m,i}$ is area of element i over which the velocity is averaged, in square metres;

$S_{m,j}$ is area of element j over which the velocity is averaged, in square metres;

l_0 is the reference junction length, in metres; l_0 = 1 m.

Note 1 to entry: The quantity $\overline{D_{v,ij,n}}$ shall be determined in accordance with ISO 10848-1 and ISO 10848-4.

Note 2 to entry: In case of Type B elements, as defined in 3.3, the use of K_{ij} (3.2.7) is no longer valid (non-uniform vibration field); however, the notion of vibration level difference is still appropriate[20] and this quantity can be normalized as defined in 3.2.8.

3.2.9
direction-averaged junction velocity level difference

$\overline{D_{v,ij}}$

average of the junction level difference from element i to j and from element j to i, evaluated from

$$\overline{D_{v,ij}} = \frac{D_{v,ij} + D_{v,ji}}{2}$$

3.3 Other terms and quantities

3.3.1
Type A element
element with a structural reverberation time that is primarily determined by the connected elements (up to at least the 1 000 Hz one-third-octave band), and a decrease in vibration level of less than 6dB across the element in the direction perpendicular to the junction line (up to at least the 1 000 Hz one-third-octave band)

3.3.2
Type B element
any element that is not a Type A element

3.3.3
impact direct transmission
transmission due to impact excitation and sound radiation from a separating element

3.3.4
flanking transmission
indirect structure-borne transmission
transmission of sound energy from an excited element in the source room to a receiving room via structural (vibrational) paths in the building construction, e.g. walls, floors, ceilings

4 Calculation models

4.1 General principles

The sound power radiated into the receiving room is due to sound radiated by each structural element in that room. The sound radiated by each of the structural elements is caused by sound transmitted to that element due to impact on a structural element in the source room. It is assumed that the transmission via each of these paths can be considered to be independent and that the sound and vibrational fields behave statistically, so that the impact sound pressure level L'_n can be obtained by addition of the energy transmitted via each path. The transmission paths considered are defined in Figures 1 and 2, where d indicates the direct impact sound transmission and f the flanking impact sound transmission.

For rooms above each other the total impact sound pressure level L'_n in the receiving room is determined by Formula (1):

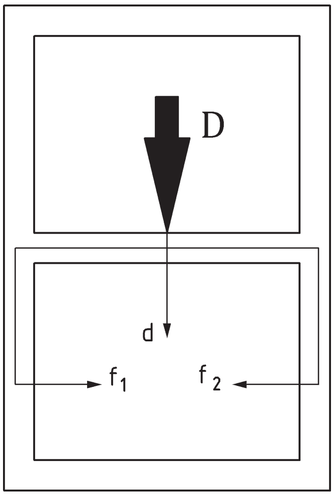
$$L'_n = \left(10 \lg \left(10^{L_{n,d}/10} + \sum_{j=1}^{n} 10^{L_{n,ij}/10} \right) \right) \text{dB} \qquad (1)$$

where

$L_{n,d}$ is the normalized impact sound pressure level due to impact direct transmission, in decibels;

$L_{n,ij}$ is the normalized impact sound pressure level due to flanking transmission, in decibels;

n is the number of elements.



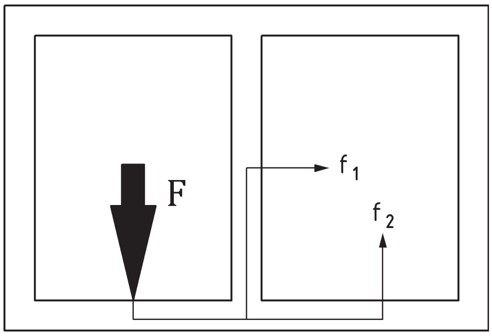
Key

d direct impact sound transmission

Dd direct path

Df_1 or Df_2 flanking path

Figure 1 — Definition of sound transmission paths between two rooms —above each other



Key

f flanking impact sound transmission

Ff_1 or Ff_2 flanking path

Figure 2 — Definition of sound transmission paths between two rooms —next to each other

For rooms next to each other the total impact sound pressure level L'_n in the receiving room is determined by Formula (2):

$$L'_n = \left(10 \lg \sum_{j=1}^{n} 10^{L_{n,ij}/10} \right) \text{dB} \qquad (2)$$

NOTE 1 For common situations the number of flanking elements to consider is n = 4 for rooms above each other and n = 2 for rooms next to each other.

The detailed model calculates the building performance in frequency bands, based on acoustic data for the building elements in frequency bands (one-third-octave bands or octave bands). As a minimum the calculation shall be performed for octave bands from 125 Hz to 2 000 Hz or for one-third-octave bands from 100 Hz to 3150 Hz. From this the single number rating for the building performance can be obtained in accordance with ISO 717-2.

NOTE 2 The calculations can be extended to higher or lower frequencies if element data are available for these frequencies. However, no information is available at this time on the accuracy of calculations for the extended lower frequency regions.

The detailed model is described in 4.2.

The simplified model calculates the building performance directly as a single number rating, based on the single number ratings of the performance of the elements involved.

The simplified model is described in 4.3.

The relation between the quantities $L'_{\rm nT}$ and $L'_{\rm n}$ is given by Formula (3):

$$L'_{\rm nT} = L'_{\rm n} - \left(10\,\lg\left(\frac{C_{\rm sab} V}{A_{\rm o} T_{\rm o}} \right) \right) {\rm dB} \tag{3}$$

where

C_{sab} is the Sabine constant, in seconds per metre with C_{sab}=0,16 s/m;

V is the volume of the receiving room, in cubic metres.

It is sufficient to estimate one of these quantities to deduce the other one. In this document the normalized impact sound pressure level $L'_{\rm n}$ is chosen as the prime quantity to be estimated.

A calculation example is given in Annex G.

4.2 Detailed model

4.2.1 Input data

The transmission for each of the paths can be determined from the following:

— normalized impact sound pressure level of the floor: $L_{\rm n;}$

— reduction of the impact sound pressure level of the floor covering: ΔL;

— reduction of the impact sound pressure level of additional layers on the receiving room side of the separating element i (floor): $\Delta L_{\rm d}$;

— sound reduction index of the excited element (floor): $R_{\rm i}$;

— sound reduction index for impact direct transmission of flanking element j in the receiving room: $R_{\rm j}$;

— sound reduction index improvement by internal layers of flanking element j in the receiving room: $\Delta R_{\rm j}$;

— structural reverberation time for an element in the laboratory: $T_{\rm s,lab}$;

— vibration reduction index for each transmission path between element i (floor) and element j: $K_{\rm ij}$;

— normalized direction-averaged velocity level difference between element i to element j: $\overline{D_{\rm v,ij,n}}$;

— flanking normalized impact sound pressure level $L_{\rm n,f}$;

NOTE Normally this concerns only transmission path Ff_2 if dominant for a given flanking element, but the quantity can also be applied to any isolated transmission paths ij.

— area of the separating element (floor): S_i;

— area of the flanking element j in the receiving room: S_j;

— common coupling length between element i (floor) and flanking element j: l_{ij}.

Information on normalized impact sound pressure level for common homogeneous floors is given in B.1.

Information on impact sound improvement index for common floor coverings is given in C.1.

Information on sound reduction index of common homogeneous elements is given in ISO 12354-1:2017, Annex B.

Information on sound reduction index improvement is given in ISO 12354-1:2017, Annex D.

Information on vibration reduction index and on flanking normalized level difference for common junctions is given in ISO 12354-1:2017, Annex E.

For each flanking transmission path the sound reduction index, R, of the elements involved (including the separating element) should relate to the resonant transmission only. It is correct to apply the laboratory sound reduction index above the critical frequency. Below the critical frequency, a correction shall be applied, particularly for elements with high critical frequency such as lightweight elements, as explained in ISO 12354-1:2017, Annex B. If the values of the sound reduction index are based on calculations from material properties, it is best to consider only resonant transmission over the frequency range of interest.

4.2.2 Transfer of input data to *in situ* values

4.2.2.1 General

Acoustic data for elements (separating and flanking structural elements, additional layers and coverings, junctions) shall be converted into *in situ* values before the actual determination of the sound transmission.

For additional layers and coverings, the *in situ* values can be taken as the laboratory value as an approximation, as shown by Formula (4):

$$\begin{aligned} \Delta R_{situ} &= \Delta R \quad \text{dB} \\ \Delta L_{situ} &= \Delta L \quad \text{dB} \\ \Delta L_{d,situ} &= \Delta L_d \quad \text{dB} \end{aligned} \tag{4}$$

If appropriate data for the impact sound improvement index ΔL_d by suspended ceilings on the receiving side of the separating floor is not available, the airborne sound improvement index ΔR shall be used with care; this approximation may lead to significant errors.

For elements and junctions, two cases shall be considered: Type A elements (4.2.2.2) and Type B elements (4.2.2.3).