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

Part 3:
Airborne sound insulation against outdoor sound

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

Partie 3: Isolement aux bruits aériens venus de l'extérieur

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Foreword

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

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

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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 15712-3:2005, 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 standard 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. 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.

It 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 model is based on experience with predictions for dwelling; it can also be used for other types of buildings provided the dimensions of constructions are not too different from those in dwellings.

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

Part 3:
Airborne sound insulation against outdoor sound

1 Scope

This document specifies a calculation model to estimate the sound insulation or the sound pressure level difference of a façade or other external surface of a building. The calculation is based on the sound reduction index of the different elements from which the façade is constructed and it includes direct and flanking transmission. The calculation gives results which correspond approximately to the results from field measurements in accordance with ISO 16283-3. Calculations can be carried out for frequency bands or for single number ratings.

The calculation results can also be used for calculating the indoor sound pressure level due to for instance road traffic (see Annex E).

This document describes the principles of the calculation model, 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 10140-1:2016, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 1: Application rules for specific products*

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

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 sound insulation of façades in accordance with ISO 16283-3 can be expressed in several 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 717-1, for instance R'_w, $D_{ls,2m,nT,w}$ or $(R'_w + C_{tr})$.

3.1.1
apparent sound reduction index
$R'_{45°}$
<loudspeaker> airborne sound insulation of a building element when the sound source is a loudspeaker and the angle of incidence is 45°, which is evaluated from

$$R'_{45°} = L_{1,s} - L_2 + \left(10\ \lg\left(\frac{S}{A}\right)\right) - 1{,}5 \quad \text{dB}$$

where

$L_{1,s}$ is the average sound pressure level on the outside surface of the building element including the reflecting effects from the façade, in decibels;

L_2 is the average sound pressure level in the receiving room, in decibels;

S is the area of the building element, in square metres;

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

3.1.2
apparent sound reduction index
$R'_{tr,s}$
<traffic noise> airborne sound insulation of a building element when the sound source is traffic noise, which is evaluated from

$$R'_{tr,s} = L_{eq,1,s} - L_{eq,2} + \left(10\ \lg\left(\frac{S}{A}\right)\right) - 3 \quad \text{dB}$$

where

$L_{eq,1,s}$ is the average equivalent sound pressure level on the outside surface of the building element including the reflecting effects from the façade, in decibels;

$L_{eq,2}$ is the average equivalent sound pressure level in the receiving room, in decibels.

3.1.3
standardized level difference
$D_{2m,nT}$
difference between the outdoor sound pressure level at 2 m in front of the façade and the sound pressure level in the receiving room, corresponding to a reference value of the reverberation time, which is evaluated from

$$D_{2\,m,nT} = L_{1,2\,m} - L_2 + \left(10\ \lg\left(\frac{T}{T_0}\right)\right) \text{dB}$$

where

$L_{1,2m}$ is the average sound pressure level at 2 m in front of the façade including the reflecting effects from the façade, in decibels;

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

L_2 is the average sound pressure level in the receiving room, in decibels;

T_0 is the reference reverberation time, in seconds; for dwellings given as 0,5 s.

Note 1 to entry: The standardized level difference can be determined either with the prevailing traffic noise or with noise from a loudspeaker. This is indicated by adding the subscript “tr” and “ls” respectively, i.e. $D_{tr,2m,nT}$ or $D_{ls,2m,nT}$.

3.1.4
normalized level difference
$D_{2m,n}$
difference between the outdoor sound pressure level at 2 m in front of the façade and the sound pressure level in the receiving room, corresponding to a reference value of absorption area, which is evaluated from

$$D_{2\,m,n} = L_{1,2\,m} - L_2 - \left(10\ \lg \left(\frac{A}{A_0} \right) \right) \text{dB}$$

where A_0 is the reference equivalent sound absorption area, in square metres for dwellings given as 10 m².

Note 1 to entry: The normalized level difference can be determined either with the prevailing traffic noise or with noise from a loudspeaker. This is indicated by adding the subscript “tr” and “ls” respectively, i.e $D_{tr,2m,n}$ or $D_{ls,2m,n}$.

3.2 Quantities to express element performance

NOTE 1 The quantities expressing the performance of elements are used as part of the input data to estimate building performance. These quantities are determined in one-third-octave bands and can be expressed in octave bands as well. In relevant cases a single number rating for the element performance can be obtained from this, in accordance with ISO 717-1, for instance $R_w(C;C_{tr})$ and $D_{n,e,w}(C;C_{tr})$.

NOTE 2 For the calculations, additional information on constructions could be necessary; for example, the shape of the façade (see Annex C), the total façade area (see 4.3.1), etc.

3.2.1
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 10140-1:2016, Annexes A, B, C and D.

3.2.2
element normalized level difference
$D_{n,e}$
difference in the space and time average sound pressure level produced in two rooms by a source in one room, where sound transmission is only due to a small technical element (e.g. transfer air devices, electrical cable ducts, transit sealing systems), which is evaluated from

$$D_{n,e} = L_1 - L_2 - \left(10\ \lg \left(\frac{A}{A_0} \right) \right)\ \text{dB}$$

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

Note 1 to entry: $D_{n,e}$ is normalized to the reference equivalent sound absorption area (A_0) in the receiving room; A_0 = 10 m².

Note 2 to entry: This quantity shall be determined in accordance with ISO 10140-1:2016, Annex E.

3.2.3
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 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.

3.2.4
sound reduction index of joints or slits
R_s
difference in the space and time average sound pressure level produced in two rooms by a source in one room, where sound transmission is only through the joint or the slit, which is evaluated from

$$R_s = L_1 - L_2 + \left(10\lg\left(\frac{S_o \cdot l}{A \cdot l_o}\right)\right)$$

Note 1 to entry: R_s is normalized to the length l of the joint or slit and the equivalent sound absorption area A in the receiving room, with $S_o = 1\ \text{m}^2$ and $l_o = 1$ m.

Note 2 to entry: This quantity shall be determined in accordance with ISO 10140-1:2016, Annex J.

3.3 Other terms and quantities

3.3.1
sound reduction index of façade for diffuse incident sound field
R'
sound reduction index of the façade as it hypothetically can be measured with a diffuse incident sound field in the actual field situation

Note 1 to entry: This quantity is used as a common calculation quantity from which the various quantities for the building performance can be obtained.

Note 2 to entry: In some countries the building performance is not expressed in one of the measurable quantities, but in this quantity R'.

3.3.2
façade shape level difference
ΔL_{fs}
difference between the sound level of the incident sound, $L_{1,in}$, on a shaped façade and the sound level on the surface of the façade plane, $L_{1,s}$, plus 6 dB, which can be determined according to

$$\Delta L_{fs} = L_{1,in} - L_{1,s} + 6\ \text{dB}$$

where

$L_{1,in}$ is the average sound pressure level at the position of the façade plane, without the façade being present, in decibels;

$L_{1,s}$ is the average sound pressure level on the outside surface of the actual façade plane, in decibels.

Note 1 to entry: Information on the façade shape level difference and the method to determine its values is given in Annex C.

4 Calculation models

4.1 General principles

“Façade” is understood to mean the whole outer surface of a room. The façade can consist of different elements, e.g. window, door, wall, roof, ventilation equipment; the sound transmission through the façade is due to the sound transmission by each of these elements. It is assumed that the transmission for each element is independent from the transmission of the other elements. The different types of exterior sound fields used in the various measurement situations defined for the determination of the quantities to express the building performance lead to different values. However, it is a reasonably proven assumption that the transmission for a diffuse incident sound field is sufficiently representative for these varying types of exterior sound fields. Therefore, the apparent sound reduction index of the façade for diffuse incident sound is calculated, from which all other quantities are deduced.

The apparent sound reduction index R' of the façade for diffuse incident sound is calculated by adding the sound power directly transmitted by each of the elements and the sound power transmitted by flanking transmission. As shown by Formula (1):

$$R' = \left(-10 \lg \left(\sum_{i=1}^{n} \tau_{e,i} + \sum_{f=1}^{m} \tau_f \right) \right) \text{dB} \qquad (1)$$

where

$\tau_{e,i}$ is the sound power ratio of radiated sound power by a façade element i due to direct transmission of incident sound on this element, relative to incident sound power on the total façade;

τ_f is the sound power ratio of radiated sound power by a façade or flanking element f in the receiving room due to flanking transmission, relative to incident sound power on the total façade;

n is the number of façade elements for direct transmission;

m is the number of flanking façade elements.

NOTE 1 The sound power ratio τ_e indicates directly the contribution of the element to the total sound transmission; for this purpose $R_p = -10 \lg \tau_e$ could be designated as the partial sound reduction index.

NOTE 2 For direct transmission only, Formulae (7) and (8) could be integrated in Formula (1), resulting in the often used expression for the sound reduction index of composed elements.

For direct transmission the sound power ratio τ_e can be determined for each façade element directly from the acoustic data on that element, including the contribution of each composing part; see 4.2. Alternatively this sound power ratio for one or more elements could be estimated from acoustic data on each of the composing parts of that element; see Annex B. The choice depends on regulations and the available acoustic data. Guidelines for the practical use of the model are given in Annex F.

For flanking transmission the sound power ratio τ_f can be determined according to 4.3.

The apparent sound reduction index of the façade is determined from Formulae (2) and (3):

$$R'_{45°} = R' + 1 \text{ dB} \qquad (2)$$

$$R'_{tr,s} = R' \text{ dB} \qquad (3)$$

NOTE 3 These equations represent the average relation between the quantities. For the single number rating the variation around the average is typically ± 1 dB. For frequency bands the spread is typically ± 2 dB for façades composed from various elements. However, in special cases, e.g. where the transmission is completely dominated by single glass panes, the difference between the two quantities at frequencies around and above the coincidence frequency is less systematic and can be much larger.

The standardized level difference of a façade depends on the sound reduction index of the façade as seen from the inside, the influence of the outside shape of the façade, like balconies, and the room dimensions. It follows from Formula (4):

$$D_{2m,nT} = R' + \Delta L_{fs} + \left(10\,\lg\left(C_{sab} \frac{V}{T_0 S} \right) \right) \text{dB} \qquad (4)$$

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;

S is the total area of the façade as seen from the inside (i.e. the sum of the area of all façade elements), in square metres;

ΔL_{fs} is the level difference due to façade shape, in decibels.

NOTE 4 The standardized level difference can be used to estimate the sound pressure level inside; see Annex E.

Information on the level difference due to the façade shape is given in Annex C.

The model can be used to calculate the building performance in frequency bands, based on acoustic data for the building elements in frequency bands (one-third-octave bands or octave bands). The calculation is performed at least for the octave bands from 125 Hz to 2 000 Hz or for the one-third-octave bands from 100 Hz to 3 150 Hz. From these results the single number rating for the building performance can be deduced in accordance with ISO 717-1. The calculations can be extended to higher or lower frequencies if acoustic data are available for such a larger frequency range. Information of airborne sound insulation in the low frequency range down to 50 Hz can be found in ISO 12354-1:2017, Annex I. The issues of field measurement of façade sound insulation in the low frequency range are specifically considered in ISO 16283-3.

The model can also be used to calculate directly the single number rating for the building performance, based on the single number ratings of the elements involved. It concerns the weighting in accordance with ISO 717-1. The resulting estimate of the building performance is given in the same type of single number rating as is used for the building elements, i.e. using R_w and $D_{n,e,w}$ for elements results in $R'_{45°,w}$ for the façade; using (R_w + C_{tr}) and ($D_{n,e,w}$ + C_{tr}) for elements results in ($D_{2m,nT,w}$ + C_{tr}) for the façade. These spectrum adaptation terms refer to the frequency range covered by the octave bands from 125 Hz to 2 000 Hz or the one-third-octave bands from 100 Hz to 3 150 Hz. If a larger frequency range is considered the appropriate spectrum adaptation term for such a larger frequency range should be used.

NOTE 5 For convenience the sums with the spectrum adaptation term for buildings can be denoted by one symbol, for instance $R'_w + C_{tr} = R'_{Atr}$ and $D_{2m,nT,w} + C_{tr} = D_{2m,nT,Atr}$.

NOTE 6 The energetic summation involved in the model is exact for (R_w + C_{tr}) and a reasonable approximation for R_w.

The two sound level differences, $D_{2m,nT}$ and $D_{2m,n}$, are directly related to each other, as shown by Formula (5):

$$D_{2m,n} = D_{2m,nT} - \left(10\,\lg\left(C_{sab} \frac{V}{A_0 T_0} \right) \right) \text{dB} \qquad (5)$$

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.

