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

Part 4: Transmission of indoor sound to the outside

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

Partie 4: Transmission du bruit intérieur à 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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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 15712-4:2005, 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 alone is difficult to specify since it forms just one link in the chain of inside sound level, sound radiation and sound propagation outdoors; the first and last item are not covered by this document. The accuracy can only be specified after widespread comparisons with field data in combination with other prediction standards, i.e. those for outdoor sound propagation. 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.

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

Part 4: Transmission of indoor sound to the outside

1 Scope

This document specifies a calculation model to estimate the sound power level radiated by the envelope of a building due to airborne sound inside that building, primarily by means of measured sound pressure levels inside the building and measured data which characterize the sound transmission by the relevant elements and openings in the building envelope. These sound power levels, together with those of other sound sources in or in front of the building envelope, form the basis for the calculation of the sound pressure level at a chosen distance from a building as a measure for the acoustic performance of buildings.

The prediction of the inside sound pressure level from knowledge of the indoor sound sources is outside the scope of this document.

The prediction of the outdoor sound propagation is outside the scope of this document.

NOTE For simple propagation conditions an approach is given for the estimation of the sound pressure level in 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 7235, *Acoustics — Laboratory measurement procedures for ducted silencers and air-terminal units — Insertion loss, flow noise and total pressure loss*

ISO 10140-1:2016, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 1: Application rules for specific products*

ISO 16283-3, *Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 3: Airborne sound insulation of façades*

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

3.1.1
sound power level
L_W
sound power level of a substitute point sound source

3.1.2
directivity correction
D_c
deviation in decibels between the sound pressure level of a point sound source in a specified direction and the level of an omni-directional point source producing the same sound power level

3.2 Quantities to express element performance

NOTE For the calculations, additional information on constructions could be necessary; for example, the shape of the building envelope, areas, 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 or ISO 16283-1.

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; $A_0 = 10\ m^2$.

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

3.2.3
insertion loss
D
<of an element> reduction in sound power level at a given location behind the element due to the insertion of the element into the duct in place of a hard-walled duct section

Note 1 to entry: This quantity shall be determined in accordance with ISO 7235.

Note 2 to entry: For elements where this document does not apply equivalent methods should be used.

3.3 Other terms and quantities

3.3.1
sound pressure level
L_p
measure of sound at a specified reception point outside a building, due to the sound produced inside the building and by sources associated with the building as normally determined by measurements according to local requirements (specifying relevant positions, integration period and source conditions)

Note 1 to entry: The sound pressure level is normally A-weighted.

3.3.2
total attenuation due to propagation
A_{tot}
level difference between the radiated sound power and the sound pressure at a position at distance d from the building envelope due to the total of all propagation effects

Note 1 to entry: Propagation effects include geometrical divergence, air absorption, ground effect, screening, etc.

3.3.3
diffusivity term
C_d
level difference between the sound pressure level at 1 m to 2 m from the inside face of the relevant building element and the intensity level of the incident sound perpendicular to that element

Note 1 to entry: For a diffuse field and reflecting walls, the diffusivity term is C_d = −6 dB; for other situations it can have a value between 0 dB and −6 dB.

3.3.4
inside sound pressure level

$L_{p,in}$
sound pressure level inside the building, 1 m to 2 m from the considered element or segment of the building envelope

Note 1 to entry: In the case of a diffuse sound field, this corresponds to the average sound pressure level in the diffuse sound field.

3.3.5
substitute point source
point source for which the radiated sound is the same as that of a segment of the building envelope

Note 1 to entry: The segment can be composed of one or more building elements or of one or more openings.

4 Calculation model

4.1 General principles

The total sound pressure level at a reception point that is a chosen distance from a building is determined by the following contributions:

— the sound radiated by the elements of the building envelope due to the sound pressure level inside;

— the sound radiated by individual sound sources, fixed in or onto the outside of the building;

— the outdoor sound propagation (effects of distance, air absorption, ground effect, screening, reflections, etc.).

The sound radiation by the building envelope may be represented by the radiation of one or more substitute point sources. Each point source can represent the contribution of a segment of the building envelope or a group of individual sound sources. The number of point sources required to adequately

represent a building depends upon the distance of each reception point from the building and the variation in propagation effects. Normally, the building envelope is represented by at least one point source for each side, i.e. walls and roofs, but often several point sources are required for each side.

The sound pressure level at a reception point outside the building is determined from the contributions of each substitute point source according to Formula (1):

$$L_p = L_W + D_c - A_{tot} \quad (1)$$

where

L_p is the sound pressure level at a reception point outside the building due to the sound radiation of a substitute point source, in decibels;

L_W is the sound power level of the substitute point source, in decibels;

D_c is the directivity correction for the substitute point sources in the direction of the reception point, in decibels;

A_{tot} is the total attenuation that occurs during sound propagation from the substitute point source to the reception point, in decibels.

The calculation model described in this document is restricted to the calculation of the sound power level of the substitute point sources for the building elements and openings in the building envelope from data on

— the inside sound pressure level, and

— the elements which form the building envelope.

The model also gives indications of the directivity correction that can be expected for various types of elements. The inside sound pressure level will normally be the equivalent sound pressure level over a specified period according to the relevant requirements. However, other types of levels can also be used, for instance the maximum level. The calculation of the inside sound pressure level is outside the scope of this document.

The calculation of the contribution of individual sound sources is outside the scope of this document.

The total attenuation A_{tot} due to propagation effects, necessary for the prediction of the sound pressure level at the reception point, can be estimated according to available methods for outdoor propagation, based on a point source approach. The calculation of these propagation effects is outside the scope of this document.

NOTE One such method is given in ISO 9613-2, where the total attenuation is indicated as A. The total attenuation follows from the addition of the attenuation due to various propagation effects, such as geometrical divergence, air absorption, ground effect, screening, etc.

However, for simple propagation conditions an approach is given for the estimation of the sound pressure level in Annex E.

A calculation example is given in Annex G.

4.2 Determination of substitute point sound sources

The elements contributing to the sound radiation are divided into two groups:

— plane radiators, such as structural elements of the building envelope, i.e. walls, roof, windows, doors, including small building elements with an area of typically less than 1 m^2, such as grids and openings;

— larger openings, area typically 1 m^2 or more, i.e. large ventilation openings, open doors, open windows.

To calculate the sound propagation outside the building each element can be represented by a substitute point sound source. However, the building may also be divided into larger segments which are each represented by a substitute point sound source. For the segmentation the following rules apply:

— the sound propagation to the nearest reception points of interest (A_{tot}) is the same for all elements of a segment;

— the distance to the nearest reception point of interest is larger than twice the largest dimension of the segment;

— for the elements in a segment the same inside sound pressure level is applicable;

— for the elements in a segment the same directivity is applicable.

If one or more of these conditions is not fulfilled, choose different segments for instance smaller segments, until these conditions are met.

Unless otherwise specified in the propagation model, the point source representing a vertical segment is positioned at half the width of the segment and 2/3 the height of the segment; for all other segments the position is at the centroid of the segment.

4.3 Determination of the sound power level for a substitute point source

4.3.1 General

For each segment the sound power level is determined from the following input data:

— sound pressure level inside: $L_{p,in}$;

— sound reduction index of large building element i of the building envelope: R_i;

— element normalized level difference of small element i: $D_{n,e,i}$;

— insertion loss of silencing element for opening i: D_i;

— area of building element or opening i: S_i.

4.3.2 Segment of structural elements of the building envelope

The sound power level for the substitute point source is determined by Formula (2):

$$L_W = L_{p,in} + C_d - R' + 10 \lg \frac{S}{S_o} \tag{2}$$

where

$L_{p,in}$ is the sound pressure level at 1 m to 2 m from the inside of the segment, in decibels;

C_d is the diffusivity term for the inside sound field at the segment, in decibels;

R' is the apparent sound reduction index for the segment, in decibels;

S is the area of the segment, in square metres;

S_o is the reference area, in square metres ; $S_o = 1$ m^2.

The apparent sound reduction index for the segment follows from the data on the composing elements i by Formula (3):

$$R' = -10\lg\left(\sum_{i=1}^{m}\frac{S_i}{S}10^{-R_i/10} + \sum_{i=m+1}^{m+n}\frac{A_o}{S}10^{-D_{n,e,i}/10}\right) \quad (3)$$

where

R_i is the sound reduction index of element i, in decibels;

S_i is the area of element i, in square metres;

$D_{n,e,i}$ is the element normalized sound level difference for a small element i, in decibels;

A_o is the reference absorption area, in square metres; $A_o = 10\ m^2$;

m is the number of large elements of the segment;

n is the number of small elements of the segment.

Information on the inside sound pressure level and diffusivity of the sound field is given in Annex B, based on the type of enclosed space and internal conditions for the elements of the building envelope.

NOTE 1 In the case of an ideal diffuse sound field and non-absorbing elements $C_d = -6$ dB; for industrial spaces and segments which are non-absorbing at the inside a value of $C_d = -5$ dB is generally more appropriate.

NOTE 2 The contribution of structure-borne sound to the sound radiation is not incorporated into the model. It could roughly be incorporated through an adjusted sound reduction index; some indications are given in Annex C.

Information on the sound reduction index to be used is given in Annex C.

4.3.3 Segment of openings

The sound power level for the substitute point source is determined by Formula (4):

$$L_W = L_{p,in} + C_d + 10\lg\sum_{i=1}^{o}\frac{S_i}{S_o}10^{-D_i/10} \quad (4)$$

where

S_i is the area of opening i, in square metres;

D_i is the insertion loss for a silencing element for opening i, in decibels;

o is the number of openings of the segment.

The calculation of the sound power level is performed in frequency bands, based on acoustic data for the 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. 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.

NOTE For rough indications it could be sufficient to apply the model directly to A-weighted levels and single number ratings of the performance of building elements in accordance with ISO 717-1. Guidelines are given in Annex F.

