SLOVENSKI STANDARD
oSIST prEN ISO 12354-1:2016

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Akustika v stavbah - Ocenjevanje akustičnih lastnosti stavb iz lastnosti sestavnih delov - 1. del: Izolirnost pred zvokom v zraku med prostori (ISO/DIS 12354-1:2016)

Building acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 1: Airborne sound insulation between rooms (ISO/DIS 12354-1:2016)

Bauakustik - Berechnung der akustischen Eigenschaften von Gebäuden aus den Bauteileigenschaften - Teil 1: Luftschalldämmung zwischen Räumen (ISO/DIS 12354-1:2016)

Acoustique du bâtiment - Calcul de la performance acoustique des bâtiments à partir de la performance des éléments - Partie 1: Isolement acoustique aux bruits aériens entre des locaux (ISO/DIS 12354-1:2016)

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91.120.20	Akustika v stavbah. Zvočna izolacija	Acoustics in building. Sound insulation

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

Part 1: Airborne sound insulation between rooms

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

Partie 1: Isolement acoustique aux bruits aériens entre des locaux

ICS: 91.120.20

ISO/CEN PARALLEL PROCESSING

This draft has been developed within the European Committee for Standardization (CEN), and processed under the **CEN lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

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Contents

Page

European foreword

This document (prEN 12354-1:2016) has been prepared by Technical Committee CEN/TC 126 “Acoustic properties of building elements and of buildings”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 12354-1:2000.

This document is the second edition of a standard, which forms a part of a series of standards specifying calculation models in building acoustics:

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

— EN 12354-2, *Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 2: Impact sound insulation between rooms*;

— EN 12354-3, *Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 3: Airborne sound insulation against outdoor sound*;

— EN 12354-4, *Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 4: Transmission of indoor sound to the outside*;

— EN 12354-5, *Building acoustics — Estimation of acoustic performance of building from the performance of elements — Part 5: Sounds levels due to the service equipment*;

— EN 12354-6, *Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 6: Sound absorption in enclosed spaces.*

In this second edition of the standard, greater details for application to lightweight constructions have been given. Although the standard 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 and an estimation procedure has been presented in an informative annex. 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.

Annex A (normative) forms an integral part of this part of EN 12354; Annexes B, C, D, E, F, G, H, I, J, K and L are informative.

1 Scope

This draft European Standard describes calculation models designed to estimate the airborne sound insulation between adjacent 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 – 3 150 Hz according to EN ISO 717-1, possibly extended down to 1/3 octave 50 Hz if element data and junction data are available (see Annex I); the single number rating 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; a method to determine uncertainty is proposed for the simplified model (see Annex K).

This document describes the principles of the calculation scheme, lists the relevant quantities and defines its applications and restrictions. 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 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. Users should, however, be aware that other calculation models also exist, each with their own applicability and restrictions.

The models are based on experience with predictions 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.

The 2000 edition of this standard has been revised with greater details for application to lightweight constructions (typically steel or wood framed lightweight elements as opposed to heavier masonry or concrete elements). When the first edition of the standard was published, there was a necessity for giving tables of data; but now more experimental data are available, so some of these tables have been removed.

2 Normative references

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

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

EN ISO 10140 (all parts), *Acoustics — Laboratory measurement of sound insulation of building elements (ISO 10140, all parts)*

EN ISO 10140-1:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 1: Application rules for specific products (ISO 10140-1:2010)*

EN ISO 10848 (all parts), *Acoustics — Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms (ISO 10848, all parts)*

EN ISO 15186-3, *Acoustics —Measurement of sound insulation in buildings and of building elements using sound intensity — Part 3: Laboratory measurements at low frequencies (ISO 15186-3)*

EN ISO 16283-1, *Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation (ISO 16283-1)*

3 Relevant quantities

3.1 Quantities to express building performance

3.1.1 General

The sound insulation between rooms in accordance with EN ISO 16283-1 can be expressed in terms of several 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 EN ISO 717-1, for instance R'_{w}, $D_{nT,w}$ or ($D_{nT,w} + C$).

3.1.2 Apparent sound reduction index *R*'

Minus 10 times the common logarithm of the ratio of the total sound power W_{tot} transmitted into the receiving room to the sound power W_1 which is incident on a separating element. This ratio is denoted by τ'.

$$R' = -10 \lg \tau' \, \text{dB} \tag{1}$$

where

$$\tau' = W_{tot} / W_1$$

In general the total sound power transmitted into the receiving room consists of the power radiated by the separating element, the flanking elements and other components.

The index *R'* it is normally determined from measurements according to:

$$R' = L_1 - L_2 + 10 \lg \frac{S_s}{A} \, \text{dB} \tag{2}$$

where

L_1 is the average sound pressure level in the source room, in decibels;

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

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

S_s is the area of the separating element, in square metres.

3.1.3 Standardized level difference D_{nT}

The difference in the space and time average sound pressure levels produced in two rooms by one or more sound sources in one of them, corresponding to a reference value of the reverberation time in the receiving room.

$$D_{nT} = L_1 - L_2 + 10 \lg \frac{T}{T_o} \, \text{dB} \tag{3}$$

where

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

T_o is the reference reverberation time; for dwellings given as 0,5 s.

3.1.4 Normalized level difference D_n

The difference in the space and time average sound pressure levels produced in two rooms by one or more sound sources in one of them, corresponding to the reference equivalent sound absorption area in the receiving room.

$$D_n = L_1 - L_2 - 10\lg\frac{A}{A_o}\ \text{dB} \tag{4}$$

where

A_o is the reference absorption area given as 10 m².

3.1.5 Relation between quantities

The level differences are related to the apparent sound reduction index as follows:

$$D_n = R' + 10\lg\frac{A_o}{S_s} = R' + 10\lg\frac{10}{S_s}\ \text{dB} \tag{5 a)}$$

$$D_{nT} = R' + 10\lg\frac{0{,}16\,V}{T_o\,S_s} = R' + 10\lg\frac{0{,}32\,V}{S_s}\ \text{dB} \tag{5 b)}$$

where

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

It is sufficient to estimate one of these quantities in order to deduce the other ones. In this document the apparent sound reduction index R' is chosen as the prime quantity to be estimated.

3.2 Quantities to express element performance

3.2.1 General

The quantities expressing the performance of the elements 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 EN ISO 717-1, for instance $R_w(C; C_{tr})$.

3.2.2 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:

$$R = 10\lg\frac{W_1}{W_2}\ \text{dB} \tag{6}$$

This quantity shall be determined in accordance with the EN ISO 10140 series or EN ISO 15186-3 (use of acoustical intensity).

3.2.3 Sound reduction improvement index ΔR

The 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.

This quantity shall be determined in accordance with EN ISO 10140-1:2010, Annex G.

3.2.4 Element normalized level difference $D_{n,e}$

The difference in the space and time average sound pressure level produced in two rooms by a source in one, where sound transmission is only due to a small technical element (e.g. transfer air devices, electrical cable ducts, transit sealing systems). $D_{n,e}$ is normalized to the reference equivalent sound absorption area (A_o) in the receiving room; A_o = 10 m².

$$D_{n,e} = L_1 - L_2 - 10 \lg \frac{A}{A_o} \text{ dB} \tag{7}$$

where

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

This quantity shall be determined in accordance with EN ISO 10140-1:2010, Annex E.

3.2.5 Normalized level difference for indirect airborne transmission $D_{n,s}$

The difference in the space and time average sound pressure level produced in two rooms by a source in one of them. Transmission is only considered to occur through a specified path between the rooms (e.g. ventilation systems, corridors). $D_{n,s}$ is normalized to the reference equivalent sound absorption area (A_o) in the receiving room; A_o = 10 m².

$$D_{n,s} = L_1 - L_2 - 10 \lg \frac{A}{A_o} \text{ dB} \tag{8}$$

The subscript s indicates the type of transmission system considered.

This quantity shall be determined with a measurement method which is comparable to EN ISO 10140-1:2010, Annex G.

NOTE Dedicated measurement methods for specific systems should be prepared by CEN/TC 126 or CEN/TC 211 (see Annex F).

3.2.6 Flanking normalized level difference $D_{n,f}$

The difference in the space and time average sound pressure level produced in two rooms by a source in one of them. Transmission is only considered to occur through a specified flanking path between the rooms (e.g. suspended ceiling, access floor, façade). $D_{n,f}$ is normalized to the reference equivalent sound absorption area (A_o) in the receiving room; A_o = 10 m².

$$D_{n,f} = L_1 - L_2 - 10 \lg \frac{A}{A_o} \text{ dB} \tag{9}$$

This quantity shall be determined according to EN ISO 10848-1, -2 and -3.

3.2.7 Vibration reduction index K_{ij}

This quantity is related to the vibrational power transmission over a junction between structural elements, normalized in order to make it an invariant quantity. It is determined by normalizing the direction-averaged velocity level difference over the junction, to the junction length and the equivalent sound absorption length, if relevant, of both elements in accordance with the following formula:

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

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;

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

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

The equivalent absorption length is given by:

$$a = \frac{2{,}2\pi^2 S}{c_0 T_s} \sqrt{\frac{f_{ref}}{f}} \tag{11}$$

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} = 1 000 Hz;

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

NOTE 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.

The quantity K_{ij} shall be determined in accordance with EN ISO 10848-1 and -4.

3.2.8 Normalized direction-averaged vibration level difference $\overline{D_{v,ij,n}}$

In case of lightweight often highly damped junction elements, the use of K_{ij} is no longer valid (non uniform vibration field); however the notion of vibration level difference is still appropriate [30] and this quantity can be normalized as follows:

$\overline{D_{v,ij,n}}$ is the 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 the following formula:

$$\overline{D_{v,ij,n}} = \frac{D_{v,ij} + D_{v,ji}}{2} + 10 \lg \frac{l_{ij} l_0}{\sqrt{S_{m,i} \, S_{m,j}}} \quad \text{dB} \tag{12}$$

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_o is the reference lenght, in metres; l_o = 1 m.

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

3.2.9 Other element data

For the calculations additional information on the element can be necessary, e.g.:

— mass per unit area m', in kilograms per square metre;

— type of element;

— material;

— type of junction.

3.3 Other terms and quantities

3.3.1 Direct transmission

Transmission due only to sound incident on a separating element that is then directly radiated by the element or transmitted through parts of it (airborne) such as slits, air moving devices or louvres.

3.3.2 Indirect transmission

Transmission of sound from a source room to a receiving room, through transmission paths other than the direct transmission path. It can be divided into airborne transmission and flanking transmission.

3.3.3 Indirect airborne transmission

Indirect transmission of sound energy via an airborne transmission path mainly, e.g. ventilation systems, corridors, double facades.

3.3.4 Flanking transmission

Transmission of sound energy from a source room to a receiving room via structure borne (vibrational) paths in the construction mainly, e.g. walls, floors, ceilings. With cavity walls and supended ceilings also airborne transmission can contribute or even dominate.

3.3.5 Direction-averaged junction velocity level difference $\overline{D_{v,ij}}$

The average of the junction velocity level difference from element i to j and element j to i:

$$\overline{D_{v,ij}} = \frac{D_{v,ij} + D_{v,ji}}{2}\ \text{dB} \tag{13}$$

3.3.6 Flanking sound reduction index R_{ij}

Minus 10 times the common logarithm of the flanking transmission factor τ_{ij}, which is the ratio of the sound power W_{ij} radiated from a flanking element j in the receiving room due to incident sound on element i in the source room to the sound power W_1 which is incident on a reference area in the source room. The area of the separating element is chosen as the reference area.

$$R_{ij} = -10 \lg \tau_{ij} \text{ dB} \tag{14}$$

where

$$\tau_{ij} = W_{ij} / W_1$$

NOTE The area of the separating element is chosen as the reference since then the contribution of each transmission path to the total transmission is directly indicated, which is not the case with other choices.

4 Calculation models

4.1 General principles

The sound power in the receiving room is due to sound radiated by the separating structural elements and the flanking structural elements in that room and by the relevant direct and indirect airborne sound transmission. The total transmission factor can be divided into transmission factors, related to each element in the receiving room and the elements and systems involved in the direct and indirect airborne transmission:

$$R' = -10 \lg \tau' \quad \text{dB} \tag{15}$$

$$\tau' = \tau_d + \sum_{f=1}^{n} \tau_f + \sum_{e=1}^{m} \tau_e + \sum_{s=1}^{k} \tau_s$$

where the indices d, f, e and s refer to the different contributions to the sound transmission illustrated in Figure 1 and where

- τ' is the sound power ratio of total radiated sound power in the receiving room relative to incident sound power on the common part of the separating element;
- τ_d is the sound power ratio of radiated sound power by the common part of the separating element relative to incident sound power on the common part of the separating element. It includes the paths Dd and Fd shown in Figure 2;
- τ_f is the sound power ratio of radiated sound power by a flanking element f in the receiving room relative to incident sound power on the common part of the separating element. It includes paths Ff and Df shown in Figure 2;
- τ_e is the sound power ratio of radiated sound power in the receiving room by an element in the separating element due to direct airborne transmission of incident sound on this element, relative to incident sound power on the common part of the separating element;
- τ_s is the sound power ratio of radiated sound power in the receiving room by a system s due to indirect airborne transmission of incident sound on this transmission system, relative to incident sound power on the common part of the separating element;
- n is the number of flanking elements; normally $n = 4$, but it can be smaller or larger;
- m is the number of elements with direct airborne transmission;