SLOVENSKI STANDARD
SIST EN 12354-1:2001

01-september-2001

Akustika v stavbah - Ocenjevanje akustiļ nih lastnosti stavb iz lastnosti sestavnih delov - 1. del: Izolirnost pred zvokom v zraku med prostori

Building Acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 1: Airborne sound insulation between rooms

Bauakustik - Berechnung der akustischen Eigenschaften von Gebäuden aus den Bauteileigenschaften - Teil 1: Luftschalldämmung zwischen Räumen

Acoustique du bâtiment - Calcul de la performance acoustique des bâtiments a partie de la performance des éléments - Partie 1: Isolement acoustique aux bruits aériens entre des locaux

Ta slovenski standard je istoveten z: EN 12354-1:2000

ICS:

91.120.20	Akustika v stavbah. Zvoļ na izolacija	Acoustics in building. Sound insulation

SIST EN 12354-1:2001 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12354-1

April 2000

ICS 91.120.20

English version

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

Bauakustik - Berechnung der akustischen Eigenschaften von Gebäuden aus den Bauteileigenschaften - Teil 1: Luftschalldämmung zwischen Räumen

This European Standard was approved by CEN on 20 August 1999.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 12354-1:2000 E

Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 126 "Acoustic properties of building products and of buildings", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2000, and conflicting national standards shall be withdrawn at the latest by October 2000.

It is the first version of a series of standards, specifying calculation models in Building Acoustics. 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.

During the preparation of this standard it became clear that some of the element data necessary based on standardized measurement methods are not yet available, hence some informative annexes have been added to explain what is needed, to indicate possible measurement methods and to illustrate this with some indicative acoustical data. These annexes should form the basis for new or revised standards for building elements, which would replace these annexes.

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 mean time, 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 organisation, 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.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This document describes calculation models designed to estimate the airborne 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 ; 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.

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.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 20140-10, *Acoustics - Measurement of sound insulation in buildings and of building elements - Part 10 : Laboratory measurement of airborne sound insulation of small building elements (ISO 140-10:1991).*

EN 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 140-1:1997).*

EN 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 140-3:1995).*

EN ISO 140-4, *Acoustics - Measurement of sound insulation in buildings and of building elements - Part 4 : Field measurements of airborne sound insulation between rooms (ISO 140-4:1998).*

EN ISO 717-1, *Acoustics - Rating of sound insulation in buildings and of building elements - Part 1 : Airborne sound insulation (ISO 717-1:1996).*

prEN ISO 10848-1, *Acoustics - Laboratory measurement of the flanking transmission of airborne and impact noise between adjoining rooms – Part 1 : Frame document (ISO/DIS 10848-1:1998).*

3 Relevant quantities

3.1 Quantities to express building performance

The sound insulation between rooms in accordance with EN ISO 140-4 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 ($D_{nT,w} + C$).

3.1.1 Apparent sound reduction index R'

Minus ten 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'.

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

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 :

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

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.

3.1.2 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.

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

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.

3.1.3 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.

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

where

A_o is the reference absorption area given as 10 m^2.

3.1.4 Relation between quantities

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

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

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

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

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 $R_w(C ; C_{tr})$.

3.2.1 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 :

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

This quantity is to be determined in accordance with EN ISO 140-3.

3.2.2 Sound reduction index improvement 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.

Annex D gives information on the determination and the use of this quantity.

3.2.3 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 building 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 ; $A_o = 10$ m^2.

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

where

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

This quantity is to be determined in accordance with EN 20140-10.

3.2.4 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 ; $A_o = 10$ m^2.

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

The subscript s indicates the type of transmission system considered.

This quantity is to be determined with a measurement method which is comparable to EN 20140-10.

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

3.2.5 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 ; $A_o = 10$ m^2.

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

This quantity is to be determined according to prEN ISO 10848-1.

NOTE For suspended ceilings EN 20140-9 is available, where the subscript 'c' is used instead of the more general 'f'. For access floors a standard is in preparation : prEN ISO 140-11 (see annex F).

3.2.6 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 equation :

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

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 :

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

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

NOTE 1 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} is to be determined in accordance with prEN ISO 10848-1.

NOTE 2 For the time being values for this quantity can be taken from annex E or be deduced from available data on the junction velocity level difference according to annex E.

3.2.7 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 and directly radiated from it (structure-borne) 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 structure-borne transmission. The latter is called flanking transmission.

3.3.3 Indirect airborne transmission

Indirect transmission of sound energy via an airborne transmission path mainly, e.g. ventilation systems, suspended ceilings and corridors

3.3.4 Indirect structure-borne transmission (flanking transmission)

Transmission of sound energy from a source room to a receiving room via structural (vibrational) paths in the construction mainly, e.g. walls, floors, ceilings.

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 :

$$\overline{D_{v,ij}} = \frac{D_{v,ij} + D_{v,ji}}{2} \quad \text{dB} \qquad (12)$$

3.3.6 Flanking sound reduction index R_{ij}

Minus ten 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 construction j in the receiving room due to incident sound on construction 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.

$$R_{ij} = -10 \lg \tau_{ij} \quad \text{dB} \qquad (13)$$

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 :

$$R' = -10 \lg \tau' \quad \text{dB} \tag{14}$$

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

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 ;

k is the number of systems with indirect airborne transmission.

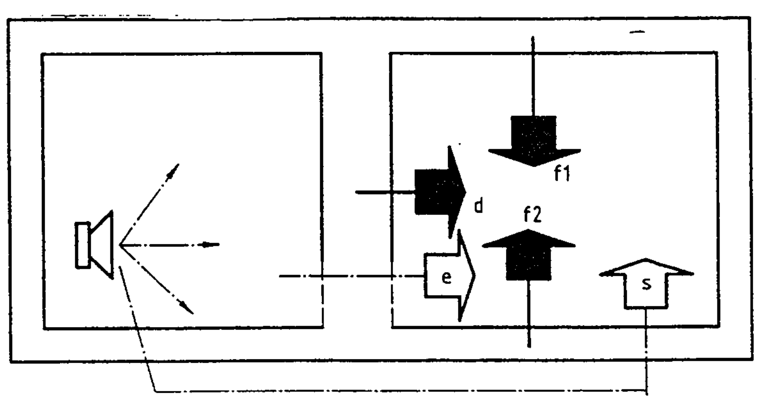

Figure 1 — Illustration of the different contributions to the total sound transmission to a room : d - radiated directly from the separating element, f1 and f2 – radiated from flanking elements, e – radiated from components mounted in the separating element, s – indirect transmission

The sound radiated by a structural element can be considered to be the sum of structure-borne sound transmission through several paths. Each path can be identified by the element i on which the sound is incident in the source room and the radiating element j in the receiving room. The paths for a flanking element and the separating element are shown in Figure 2, where in the source room the elements i are designated by F for the flanking element and D for the separating element and in the receiving room the elements j are designated by f for a flanking element and d for the separating element.

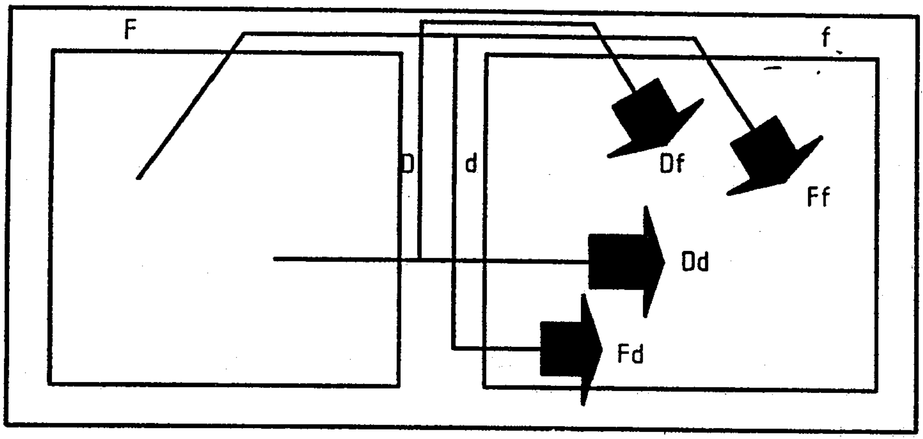

Figure 2 — Definition of sound transmisson paths ij between two rooms

The main assumptions with this approach are that the transmission paths described can be considered to be independent and that the sound and vibrational fields behave statistically. Within these restrictions this approach is quite general, in principle allowing for various types of structural elements, i.e. monolithic elements, cavity walls, lightweight double leaf walls, and different positioning of the two rooms. However, the available possibilities to describe the transmission by each path imposes restrictions in this respect. The model presented is therefore restricted to adjacent rooms, while the type of elements is mainly restricted by the available information on the vibration reduction index to monolithic and lightweight double elements. Some indications are given in 4.2.4 for the application to other double elements such as cavity walls.

The transmission factor for the separating element consists of contributions from the direct transmission and n flanking transmission paths.

$$\tau_d = \tau_{Dd} + \sum_{F=1}^{n} \tau_{Fd} \tag{15}$$

The transmission factor for each of the flanking elements f in the receiving room consists of contributions from 2 flanking transmission paths.

$$\tau_f = \tau_{Df} + \tau_{Ff} \tag{16}$$

The transmission factors for these structure-borne transmission paths are related to the sound reduction index for direct transmission (R_{Dd}) and the flanking sound reduction index (R_{ij}) as follows :

$$\tau_{Dd} = 10^{-R_{Dd}/10}$$

$$\tau_{ij} = 10^{-R_{ij}/10} \tag{17}$$

The transmission factors for the direct and indirect airborne transmission are related to the element normalized level difference ($D_{n,e}$) and the normalized level difference for indirect airborne transmission ($D_{n,s}$) as follows :

$$\tau_e = \frac{A_o}{S_s} 10^{-D_{n,e}/10}$$

$$\tau_s = \frac{A_o}{S_s} 10^{-D_{n,s}/10} \qquad (18)$$

where

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

A_o is the reference equivalent sound absorption area, in square metres.

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 has to be performed for octave bands from 125 Hz to 2 000 Hz or for 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 EN ISO 717-1.

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

The detailed model deals with both the structure-borne transmission and the direct and indirect airborne transmission. Since these transmission paths can be considered as independent they are treated separately. The calculation of the structure-borne transmission is described in section 4.2. The direct and indirect airborne transmission is described in section 4.3.

The simplified model calculates the building performance as a single number rating, based on the single number ratings of the performance of the elements involved. The simplified model considers only the structure-borne transmission and is described in section 4.4.

4.2 Detailed model for structure-borne transmission

4.2.1 Input data

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

— sound reduction index of separating element : R_S ;

— sound reduction index for element i in source room : R_i ;

— sound reduction index for element j in receiving room : R_j ;

— sound reduction index improvement by additional layers for separating element in the source room and/or in the receiving room : ΔR_D, ΔR_d ;

— sound reduction index improvement by additional layers for element i in the source room and/or element j in the receiving room : ΔR_i, ΔR_j ;

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

— vibration reduction index for each transmission path from element i to element j : K_{ij} ;

— area of separating element : S_s ;