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Acoustics — Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms —

Part 1: Frame document

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Acoustique — Mesurage en laboratoire des transmissions latérales du bruit aérien et des bruits de choc entre des pièces adjacentes —

Partie 1: Document cadre

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 10848-1 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 Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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ISO 10848 consists of the following parts, under the general title *Acoustics — Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms*:

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- *Part 1: Frame document*
- *Part 2: Application to light elements when the junction has a small influence*
- *Part 3: Application to light elements when the junction has a substantial influence*

The following part is under preparation:

- *Part 4: Application to all other cases*

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Acoustics — Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms —

Part 1: **Frame document**

1 Scope

ISO 10848 specifies measurement methods to be performed in a laboratory test facility in order to characterize the flanking transmission of one or several building components. The performance of the building components is expressed either as an overall quantity for the combination of elements and junction (such as $D_{\text{n,f}}$ and/or $L_{\text{n,f}}$) or as the vibration reduction index K_{ij} of a junction.

This part of ISO 10848 contains definitions, general requirements for test specimens and test rooms, and measurement methods. Guidelines are given for the selection of the quantity to be measured depending on the junction and the types of building elements involved. Other parts of ISO 10848 specify the application for different types of junction and building elements.

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The quantities characterizing the flanking transmission can be used to compare different products, or to express a requirement, or as input data for prediction methods, such as EN 12354-1 and EN 12354-2.

2 Normative references

The following referenced documents are indispensable for the application 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 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 140-3:1995, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 3: Laboratory measurements of airborne sound insulation of building elements*

ISO 140-6:1998, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 6: Laboratory measurements of impact sound insulation of floors*

ISO 354, *Acoustics — Measurement of sound absorption in a reverberation room*

ISO 3382, *Acoustics — Measurement of the reverberation time of rooms with reference to other acoustical parameters*

ISO 7626-1, *Vibration and shock — Experimental determination of mechanical mobility — Part 1: Basic definitions and transducers*

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ISO 10848-2:2006, *Acoustics — Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms — Part 2: Application to light elements when the junction has a small influence*

ISO 10848-3:2006, *Acoustics — Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms — Part 3: Application to light elements when the junction has a substantial influence*

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 60651, *Sound level meters*

IEC 60804, *Integrating-averaging sound level meters*

IEC 60942, *Sound calibrators*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
average sound pressure level in a room
L
ten times the common logarithm of the ratio of the space and time average of the sound pressure squared to the square of the reference sound pressure, the space average being taken over the entire room with the exception of those parts where the direct radiation of a sound source or the near field of the boundaries (walls, etc.) is of significant influence

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NOTE 1 This quantity is expressed in decibels.

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NOTE 2 If a continuously moving microphone is used, L is determined by

$$L = 10 \ \lg \frac{\frac{1}{T_\mathrm{m}} \int_0^{T_\mathrm{m}} p^2(t)\mathrm{d}t}{p_0^2} \ \mathrm{dB} \tag{1}$$

where

p is the sound pressure, in pascals;

p_0 is the reference sound pressure, in pascals; p_0 = 20 µPa;

T_m is the integration time, in seconds.

NOTE 3 If fixed microphone positions are used, L is determined by

$$L = 10 \ \lg \frac{p_1^2 + p_2^2 + \ldots + p_n^2}{n \cdot p_0^2} \ \mathrm{dB} \tag{2}$$

where p_1, p_2, ... p_n are r.m.s. (root mean square) sound pressures at n different positions in the room, in pascals.

NOTE 4 In practice usually the sound pressure levels L_i are measured. In this case L is determined by

$$L = 10 \ \lg \frac{1}{n} \sum_{i=1}^{n} 10^{L_i/10} \ \mathrm{dB} \tag{3}$$

where L_i are the sound pressure levels L_1 to L_n at n different positions in the room, in decibels.

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3.2
normalized flanking level difference
$D_{n,f}$
difference in the space and time averaged sound pressure level produced in two rooms by one or more sound sources in one of them, when the transmission only occurs through a specified flanking path

NOTE $D_{n,f}$ is normalized to an equivalent sound absorption area (A_0) in the receiving room and is expressed in decibels:

$$D_{n,f} = L_1 - L_2 - 10 \lg \frac{A}{A_0} \text{ dB} \tag{4}$$

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;

A_0 is the reference equivalent sound absorption area, in square metres; $A_0 = 10 \text{ m}^2$.

3.3
normalized flanking impact sound pressure level
$L_{n,f}$
space and time averaged sound pressure level in the receiving room produced by a standard tapping machine operating at different positions on a tested floor in the source room, when the transmission only occurs through a specified flanking path

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NOTE $L_{n,f}$ is normalized to an equivalent sound absorption area (A_0) in the receiving room and is expressed in decibels

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$$L_{n,f} = L_2 + 10 \lg \frac{A}{A_0} \text{ dB} \tag{5}$$

where

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;

A_0 is the reference equivalent sound absorption area, in square metres; $A_0 = 10 \text{ m}^2$.

3.4
average velocity level
L_v
ten times the common logarithm of the ratio of the time and space averaged mean squared normal velocity of an element to the squared reference velocity v_0 ($v_0 = 1 \times 10^{-9}$ m/s)

$$L_v = 10 \lg \frac{\frac{1}{T_m} \int_0^{T_m} v^2(t) \mathrm{d}t}{v_0^2} \text{ dB} \tag{6}$$

NOTE 1 It should be stressed that the reference velocity preferred in ISO 1683 is 1×10^{-9} m/s, although a common reference value in some countries is still $v_0 = 5 \times 10^{-8}$ m/s.

NOTE 2 Instead of the average velocity level, the average acceleration level L_a can be measured. The reference acceleration preferred in ISO 1683 is 1×10^{-6} m/s^2.

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NOTE 3 If airborne or stationary structure-borne excitation is used, the spatial averaging is calculated with

$$L_v = 10 \ \lg \frac{v_1^2 + v_2^2 + \cdots + v_n^2}{n \cdot v_0^2} \ \text{dB} \tag{7}$$

where v_1, v_2, v_n are r.m.s. (root mean square) velocities at n different positions on the element, in metres per second.

NOTE 4 For transient structure-borne excitation, use Equations (9) and (10).

3.5
structural reverberation time
T_s
time that would be required for the velocity or acceleration level in a structure to decrease by 60 dB after the structure-borne sound source has stopped

NOTE 1 The quantity is expressed in seconds.

NOTE 2 The definition of T_s with a decrease by 60 dB of the velocity or acceleration level in a structure can be fulfilled by linear extrapolation of shorter evaluation ranges.

3.6
velocity level difference
$D_{v,ij}$
difference between the average velocity level of an element i and that of an element j, when only the element i is excited (airborne or structure-borne)

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$$D_{v,ij} = L_{v,i} - L_{v,j} \tag{8}$$

NOTE 1 If a transient structure-borne excitation is used, then the normal velocity should be measured simultaneously on both elements and the velocity level difference determined by:

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$$D_{v,ij} = \frac{1}{M \ N} \sum_{m=1}^{M} \sum_{n=1}^{N} (D_{v,ij})_{mn} \ \text{dB} \tag{9}$$

where

M is the number of excitation points on element i;

N is the number of transducer positions on each element for each excitation point;

$(D_{v,ij})_{mn}$ is the velocity level difference as given by Equation (10) for one excitation point and one pair of transducer positions only, in decibels:

$$(D_{v,ij})_{mn} = 10 \ \lg \frac{\int_0^{T_m} v_i^2(t) \ dt}{\int_0^{T_m} v_j^2(t) \ dt} \ \text{dB} \tag{10}$$

and

v_i, v_j are the normal velocities at points on elements i and j respectively, in metres per second;

T_m is the integration time, in seconds.

NOTE 2 For practical purposes, Equation (8) is preferable to Equation (9).

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3.7
direction-averaged velocity level difference
$\overline{D_{v,ij}}$
arithmetic average of $D_{v,ij}$ and $D_{v,ji}$ as defined by the following equation:

$$\overline{D_{v,ij}} = \frac{1}{2}(D_{v,ij} + D_{v,ji}) \text{ dB} \quad (11)$$

where

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

$D_{v,ji}$ is the difference between the average velocity level of an element j and that of an element i, when only the element j is excited, in decibels.

3.8
equivalent absorption length a_j of an element j
length of a fictional totally absorbing junction of the element j when the critical frequency is assumed to be 1 000 Hz, giving the same losses as the total losses of the element j in a given situation

NOTE 1 a_j is expressed in metres.

NOTE 2 It is given by the following equation:

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$$a_j = \frac{2{,}2\ \pi^2\ S_j}{T_{s,j}\ c_0 \sqrt{\frac{f}{f_{ref}}}} \quad (12)$$

where

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$T_{s,j}$ is the structural reverberation time of the element j, in seconds;

S_j is the surface area of the element j, in square metres;

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

f is the current frequency, in hertz;

f_{ref} is the reference frequency, in hertz (f_{ref} = 1 000 Hz).

NOTE 3 For lightweight, well-damped types of elements where the actual situation has no real influence on the sound reduction index and damping of the elements, a_j is taken as numerically equal to the surface area S_j of the element: $a_j = S_j / l_0$, where the reference length l_0 = 1 m.

3.9
vibration reduction index
K_{ij}
value given by the following equation and expressed in decibels:

$$K_{ij} = \overline{D_{v,ij}} + 10 \ \lg \frac{l_{ij}}{\sqrt{a_i a_j}} \text{ dB} \quad (13)$$

where

$\overline{D_{v,ij}}$ is the direction-averaged velocity level difference between elements i and j, in decibels;

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

a_i, a_j are the equivalent absorption lengths of elements i and j, in metres.

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NOTE It follows from Equations (11) to (13) that K_{ij} can be obtained from measurements of the velocity level difference in both directions across the junction as well as the structural reverberation time of the two elements.

3.10
light element
element for which the boundary conditions, when mounted in the test facility, have no influence on the test result, for example because the element is much lighter than the surrounding test facility (see 8.2) or highly damped

NOTE 1 A test element may be regarded as highly damped in case of a strong decrease in vibration across the element as specified in 4.3.4.

NOTE 2 Timber or metal-framed stud walls or wooden floors on beams often fulfil this definition of a light element.

4 Quantities to characterize flanking transmission

4.1 General

In this part of ISO 10848, the flanking transmission by coupled elements and junctions is characterized in two ways:

— by an overall transmission quantity for a specified flanking path ($D_{n,f}$ or $L_{n,f}$);

— by the vibration transmission over a junction (K_{ij}).

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Each of these quantities has its own restrictions and field of application.

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4.2 Normalized flanking level difference $D_{n,f}$ and normalized flanking impact sound pressure level $L_{n,f}$

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$D_{n,f}$ and $L_{n,f}$ characterize the flanking transmission over an element in the source room and an element in the receiving room, including the sound radiation in the receiving room. $D_{n,f}$ and $L_{n,f}$ depend on the dimensions of the elements involved.

$D_{n,f}$ is measured with airborne excitation. For measurements of $L_{n,f}$, a standard tapping machine is used.

4.3 Vibration reduction index, K_{ij}

4.3.1 General

The vibration reduction index K_{ij} is defined in EN 12354-1 as a situation invariant quantity to characterize a junction between elements. K_{ij} is determined according to Equation (13). It is based on power transmission considerations as a simplification of statistical energy analysis (SEA) theory. This implies in principle that the basic assumptions of SEA are strictly met.

The main assumptions are that:

— the coupling between i and j is weak;

— the vibration fields in the elements are diffuse.

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K_{ij} might not be relevant in the following cases:

a) elements that are strongly coupled, such that the individual elements cannot be considered as SEA subsystems (see 4.3.3);

b) elements where the vibration field cannot be considered as reverberant due to a significant decrease in vibration with distance across the element, for example due to high internal losses or periodic structure (see 4.3.4);

c) low modal overlap factors or low mode counts.

The limitations are important for the frequency range where reliable measurements are expected, and/or for the accuracy of the measurement results.

K_{ij} is measured with structure-borne or airborne excitation.

NOTE 1 With airborne excitation the vibrations of the source element are both forced and resonant. Since forced vibrations do not always contribute to the vibration transmission through a junction, K_{ij} measured with airborne excitation tends to be greater than when measured with structure-borne excitation. This is mainly the case below the critical frequency, and the mentioned difference is therefore most important for lightweight elements.

NOTE 2 If values for R_i and R_j measured for elements i and j according to ISO 140-3 or ISO 15186-1 [4] are available, K_{ij} can be determined indirectly from $D_{\text{n,f}}$ by

$$K_{ij} = D_{\text{n,f}} - \frac{R_i + R_j}{2} - 10 \ \lg\left(\frac{\sqrt{a_i \ a_j}}{l_{ij}}\right) + 10 \ \lg\left(\frac{\sqrt{S_i \ S_j}}{A_0}\right)$$

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In theory, this equation is only correct when R_i and R_j are associated with resonant transmission only. However, measured values obtained with ISO 140-3 or ISO 15186-1 also include forced transmission. In this part of ISO 10848, K_{ij} is always measured directly as given by Equation (13) or (14).

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4.3.2 K_{ij} for lightweight well-damped elements

For lightweight, well-damped types of elements (for example, timber or metal-framed stud walls or wooden floors on beams) where the actual situation has no real influence on the sound reduction index and damping of the elements, Equation (13) can be simplified as:

$$K_{ij} = \overline{D_{v,ij}} + 10 \ \lg\frac{l_{ij}}{\sqrt{S_i S_j}} \ \text{dB} \tag{14}$$

However, K_{ij} is often not relevant for such elements because the vibration fields are not reverberant, and the application of K_{ij} for light elements in prediction models such as EN 12354-1 and EN 12354-2 has in several cases been shown to be inaccurate. Therefore, the validity and practical use of K_{ij} shall be evaluated for each specific case. An example of a useful application of K_{ij} as given by Equation (14) is the comparison of different junctions between the same elements.

4.3.3 Strong coupling between elements

The measured value of K_{ij} may not be relevant due to strong coupling, if the following condition is not satisfied:

$$D_{v,ij} \geqslant 3 - 10 \ \lg\left(\frac{m_i \ f_{\text{c}j}}{m_j \ f_{\text{c}i}}\right) \text{dB} \tag{15}$$

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where

m_i, m_j are the masses per unit area of the elements, in kilograms per square metre;

f_{ci}, f_{cj} are the critical frequencies of the elements, in hertz, for example determined by Equation (20).

Inequality (15) is mainly of importance for heavy elements. If inequality (15) is not satisfied, try for example to increase the energy loss by providing the edges of the elements with damping material or connecting them to other structures.

4.3.4 Strong decrease in vibration across an element

If the measured velocity level decreases by more than 6 dB over the allowed measurement area for any element of the tested junction when the accelerometer is moved away from a stationary vibration source (keeping the minimum distance given in 7.2.4), then the measured value of K_{ij} may not be relevant.

NOTE A velocity level decrease of more than 6 dB can occur in, for example, lightweight elements such as timber or metal-framed stud walls or wooden floors on beams. In some types of masonry walls, it can occur at high frequencies.

4.4 Selection of the principle of measurement

The different possibilities mentioned below are summarized in Table 1 according to the types of junction and elements.

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In certain cases, the tested specimen is placed in such a way in the test facility that only one path is dominant. This is generally the case for suspended ceilings, or access floors, or lightweight façades laterally mounted in the test facility. The separating element is only built to separate the two volumes and has no substantial effect on the flanking transmission. Typically, the separating element is not rigidly connected to the flanking element, and the gap between separating and flanking element is sealed with a flexible material.

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In these cases, verifications shall be carried out to make sure that only the path considered is dominant, then the measurements may be done without any further action to separate path ij.

ISO 10848-2 deals with this type of element. $D_{n,f}$ and $L_{n,f}$ are the relevant quantities to be measured.

In certain other cases, the tested junction is formed by three or four light elements (light compared to the walls of the test facility), which are connected by a solid junction or coupling elements or mortars. This is the case, for example, for T or X junctions of plasterboard or chipboard on studs. In these cases, 3 or 6 different paths ij exist.

Verifications shall be made to make sure that no flanking path occurs through the test facility. Then, depending on the measured quantity, it may be necessary to separate each of path ij by shielding other paths ij both on the source and receiving sides.

ISO 10848-3 deals with these types of junction. For lightweight, well-damped elements where the actual situation (dimensions and boundary conditions) has no real influence on the sound reduction index and damping of the elements, $D_{n,f}$ and $L_{n,f}$ are the relevant quantities to measure. If the acoustical properties of the elements are substantially influenced by the actual situation, K_{ij} as specified by Equation (13) is the relevant quantity to measure. For special applications such as, for example, comparison of different junctions between the same elements, K_{ij} can also be measured between well-damped elements. The validity of measured values of K_{ij} is checked according to 4.3.4.

For all other cases, typically combinations of heavy or heavy and light masonry constructions, it may be necessary to provide a structural break between the tested elements and the test facility and, if the airborne method is selected, to separate each path ij by appropriate shielding both in source and receiving sides.

ISO 10848-4 deals with these types of junction. For junctions between heavy elements, it is recommended to measure K_{ij}. Structure-borne excitation is most appropriate.

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