INTERNATIONAL STANDARD

ISO 10848-5

First edition
2020-08

Acoustics — Laboratory and field measurement of the flanking transmission for airborne, impact and building service equipment sound between adjoining rooms —

Part 5:
Radiation efficiencies of building elements

Acoustique — Mesurage en laboratoire et sur site des transmissions latérales du bruit aérien, des bruits de choc et du bruit d'équipement technique de bâtiment entre des pièces adjacentes —

Partie 5: Efficacité de rayonnement des éléments de construction

COPYRIGHT PROTECTED DOCUMENT

Contents

Page

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 126, *Acoustic properties of building elements and of buildings,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 10848 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

ISO 10848 (all parts) specifies laboratory and field measurement methods to characterize the flanking transmission of one or several building components.

This document describes the measurement of the radiation efficiency of an element using structure-borne excitation and/or acoustical excitation. Both these radiation efficiencies are required to estimate the sound reduction index due to resonant transmission only, according to ISO 12354-1:2017, Annex B.

For Type B elements as defined in ISO 10848-1 and ISO 12354-1, the radiation efficiency of an element using structure-borne excitation is required to calculate flanking transmission. It is also required to estimate adaptation terms used in predicting service equipment sound according to EN 12354-5.

v

Acoustics — Laboratory and field measurement of the flanking transmission for airborne, impact and building service equipment sound between adjoining rooms —

Part 5:
Radiation efficiencies of building elements

1 Scope

This document specifies measurement methods to characterize in the laboratory the acoustic radiation of a building element when it is directly excited by an airborne or structure-borne source. It is applicable to single-leaf and double-leaf elements (see ISO 12354-1:2017 Annex F, F2). The measured quantity can be used as input data for prediction methods, such as ISO 12354-1 and ISO 12354-2, to compare products, or to express a requirement.

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 10140-5, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 5: Requirements for test facilities and equipment*

ISO 10848-1:2017, *Acoustics — Laboratory and field measurement of flanking transmission for airborne, impact and building service equipment sound between adjoining rooms — Part 1: Frame document*

ISO 12999-1, *Acoustics — Determination and application of measurement uncertainties in building acoustics — Part 1: Sound insulation*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
average velocity level
L_v
ten times the common logarithm of the ratio of the time and space averaged mean-square normal velocity of an element to the squared reference velocity, for which the time averaged velocity at position *i* is determined as follows:

$$v_i = \frac{1}{T_m} \int_0^{T_m} v_i^2(t)\,\mathrm{d}t$$

where

v_0 is the reference velocity, in metres per second; $v_0 = 1 \times 10^{-9}$ m/s

T_m is the integration time, in seconds.

Note 1 to entry: This quantity is expressed in decibels.

Note 2 to entry: When considering sound radiation, using 5×10^{-8} m/s as a reference velocity leads to simpler formulae; however, 10^{-9} m/s is the reference used in ISO 10848-1; hence this reference has also been used in this document. As a result, 34 dB has been added in the formulae given in 3.5 and 3.6, and in Formula (A.3).

Note 3 to entry: With stationary airborne or structure-borne excitation, the spatial averaging is calculated as follows:

$$L_v = 10 \lg\left(\frac{v_1^2 + v_2^2 + \ldots + v_n^2}{n\, v_0^2}\right)$$

where

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

3.2
average sound pressure level in a room
L_p

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

Note 1 to entry: This quantity is expressed in decibels.

Note 2 to entry: In the case of stationary airborne or structure-borne excitation and if a continuously moving microphone is used, L_p is determined as follows:

$$L_p = 10 \lg\left(\frac{\dfrac{1}{T_{int}} \displaystyle\int_0^{T_{int}} p^2(t)\,dt}{p_0^2}\right)$$

where

p is the sound pressure, in pascals;

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

T_{int} is the integration time, in seconds.

Note 3 to entry: In the case of stationary airborne or structure-borne excitation and if fixed microphone positions are used, L_p is determined as follows:

$$L_p = 10 \lg\left(\frac{p_1^2 + p_2^2 + \ldots + p_n^2}{n \cdot p_0^2}\right)$$

where

$p_1, p_2, \ldots p_n$ are rms sound pressures at n different positions in the room, in pascals.

In practice, usually the sound pressure levels $L_{p,i}$ are measured. In this case L_p is determined as follows:

$$L_p = 10 \lg\left(\frac{1}{n}\sum_{i=1}^{n} 10^{L_{p,i}/10}\right)$$

where

$L_{p,i}$ are the sound pressure levels at position i from n different positions in the room, in decibels.

3.3
radiation function
L_{RF}
difference between the average sound pressure level in the receiving room and the average velocity level of the element on the receiving room side, determined as follows:

$$L_{RF} = L_p - L_v$$

Note 1 to entry: This quantity is expressed in decibels.

Note 2 to entry: In the case of stationary excitation using a single source at different positions, the radiation function is determined as follows:

$$L_{RF} = \frac{1}{M} \sum_{m=1}^{M} (L_{RF})_m$$

where

M is the number of excitation positions (airborne or structure borne);

$(L_{RF})_m$ is the radiation function for excitation position m.

Note 3 to entry: If transient structure-borne excitation is used, then sound pressure level and velocity level are measured simultaneously, each at one location and for one excitation position, and the radiation function is determined as follows:

$$L_{RF} = \frac{1}{MN} \sum_{m=1}^{M} \sum_{n=1}^{N} (L_{RF})_{mn}$$

where

M is the number of excitation points on the element;

N is the number of measurement positions which are the same in the room and on the element;

$(L_{RF})_{mn}$ is the point-to-point radiation function for one excitation position, determined as follows:

$$(L_{RF})_{mn} = \left[10 \lg \left(\frac{\int_0^{T_{int}} p_{mn}^2(t)\,\mathrm{d}t}{\int_0^{T_{int}} v_{mn}^2(t)\,\mathrm{d}t} \right) \right] - 86$$

where

T_{int} is the integration time, in s.

3.4
radiation efficiency
σ
ratio of the radiated sound power to the power radiated by a large baffled piston with a uniform mean-square velocity equal to the spatial-average mean-square velocity of the element, calculated from the radiation function as follows:

$$\sigma = \frac{A}{4S} \cdot 10^{\frac{L_{RF} + 34}{10}}$$

where

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

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

Note 1 to entry: The notation σ_a is used when the element vibrates under airborne excitation.

Note 2 to entry: The notation σ_s is used when the element vibrates under structure-borne excitation.

Note 3 to entry: Below the critical frequency (or the lowest critical frequency for orthotropic plates), the radiation efficiency strongly depends on the type of excitation, element dimensions and boundary conditions (i.e. arrangement of baffles around the edges of the element) in the laboratory. The data obtained using this document therefore only approximate the radiation efficiency, if used for prediction in other situations.

3.5
radiation index for airborne excitation
$L_{\sigma,a}$
radiation efficiency for airborne excitation, determined as follows:

$$L_{\sigma,a} = 10\lg(\sigma_a) = L_{RF} + \left(10\lg\left(\frac{A}{4S}\right) + 34\right)$$

Note 1 to entry: This quantity is expressed in decibels.

3.6
radiation index for structure-borne excitation
$L_{\sigma,s}$
radiation efficiency for structure-borne excitation, determined as follows:

$$L_{\sigma,s} = 10\lg(\sigma_s) = L_{RF} + \left(10\lg\left(\frac{A}{4S}\right) + 34\right)$$

Note 1 to entry: This quantity is expressed in decibels.

4 Instrumentation

The equipment shall fulfil the requirements given in ISO 10848-1:2017, Clause 5.

5 Test arrangement

The test facility shall comply with the requirements for laboratory sound insulation measurements of building elements specified in ISO 10140-5. These requirements set the size of the test opening for walls and floors as well as reduced-size test openings for other elements.

6 Measurement methods

6.1 General

Airborne excitation shall be from an airborne sound source in the source room.

Structure-borne excitation shall be on the source room side of the tested element; however, measurements can be taken with only a receiving room, hence if no source room exists then excitation is applied to the side of the element that is on the opposite side to the receiving room.

Sound pressure measurements shall be carried out in the receiving room.

Vibration measurements shall be carried out on the receiving room side of the element.

The measurement shall be performed using one-third octave band filters in the frequency range defined in ISO 10848-1:2017, 7.4.

6.2 Measurement of $L_{\sigma,a}$

6.2.1 Generation of sound field in the source room

Steady-state airborne sound is generated in the source room according to ISO 10848-1:2017, 7.1.1.1, and the output from the loudspeaker shall not be changed during the measurement of sound pressure and velocity.

6.2.2 Measurement of the average sound pressure level in the receiving room

The measurement in the receiving room shall be performed according to ISO 10848-1:2017, 7.1.2.

6.2.3 Measurement of reverberation time of the room and evaluation of the equivalent sound absorption area

The equivalent sound absorption area that is used in the formulae given in 3.4 and 3.5 is evaluated from the reverberation time according to ISO 10848-1:2017, 7.1.3.

6.2.4 Measurement of the average velocity level of the element

The measurement shall be carried out using accelerometers according to ISO 10848-1:2017, 7.2.3. If multiple sound sources are used simultaneously, a minimum of 12 accelerometer positions shall be used for Type A elements and a minimum of 18 positions for Type B elements. If a single sound source is used, a minimum of 2 excitation positions shall be used and, for each excitation position, a minimum of 6 accelerometer positions shall be used for Type A elements and a minimum of 9 positions for Type B elements.

All positions shall be randomly distributed over the surface of the element.

NOTE   Some inhomogeneous elements have a large variation in the velocity level over the surface of the element; hence for such elements it can be necessary to use more than the minimum number of accelerometer and excitation positions.

For Type B elements such as plasterboard/timber cladding on timber or metal frames it should be possible to identify the area of the cladding that is directly above the frame. The total number of accelerometer positions should be distributed in the area above the frames and the area in-between the frames in proportion to the ratio of these areas.

6.2.5 Calculation of the radiation index

The radiation function is calculated as described in 3.3, and the radiation index is calculated as described in 3.5.

6.3 Measurement of $L_{\sigma,s}$

6.3.1 Generation of vibration on the source element

The element shall be excited with a structure-borne source according to ISO 10848-1:2017, 7.2.4. The structure-borne excitation may be stationary or transient.

6.3.2 Procedure for Type A and Type B elements

The measurement procedure for Type A and Type B elements shall be similar to the procedure described in ISO 10848-1:2017, 7.2.5: on the element, a minimum of 3 excitation positions shall be used for Type A elements and a minimum of 6 excitation positions shall be used for Type B elements. A minimum of 3 measurement positions per excitation position shall be used in the receiving room and on the element.

All positions shall be randomly distributed over the surface of the element.

For inhomogeneous elements (such as double-leaf walls or elements created from many strips of material that are bonded together such that defects or small unbonded areas can occur), the vibration field can be highly variable over the surface with structure-borne excitation. For these elements, it is recommended that the number of excitation and measurement positions be increased towards the maximum number that is feasible whilst maintaining the minimum distances specified in ISO 10848-1:2017, 7.2.5.

For highly damped walls, there are indications that it can be necessary to use measurement positions that are closer than 1 m from the excitation point to obtain a representative radiation efficiency[5]. However, as the velocity level differences in ISO 10848-1 are all measured using measurement positions with a minimum distance of 1 m from the excitation point, this procedure is used in this document; then the combination of a measured radiation efficiency and a measured normalized direction-average vibration level difference can reasonably be used to estimate the sound insulation as described in ISO 12354.

6.3.3 Measurement using stationary excitation

Steady-state excitation shall be applied according to ISO 10848-1:2017, 7.2.6; the radiation function is then determined as defined in 3.3 for each excitation position on the element.

6.3.4 Measurement using transient excitation

Transient excitation shall be applied according to ISO 10848-1:2017, 7.2.7; the radiation function is then determined as defined in 3.3.

6.3.5 Measurement of reverberation time and evaluation of the equivalent sound absorption area

The equivalent sound absorption area contained in the formulae in 3.4 and 3.6 is evaluated from the reverberation time according to ISO 10848-1:2017, 7.1.3.

6.3.6 Radiation index calculation

The radiation function is calculated as defined in 3.3 and the radiation index is calculated using the formula given in 3.6.

7 Precision

The measurement procedure shall give satisfactory repeatability, which shall be determined in accordance with the method described in ISO 12999-1, and shall be verified from time-to-time, particularly when a change is made in the procedure or instrumentation.

Organizations should periodically perform comparison measurements on the same test specimen to check repeatability and reproducibility of their test procedures.

8 Expression of results

For the statement of the radiation efficiency, the results shall be given in terms of the radiation index, expressed in dB at all frequencies of measurement with one decimal, in tabular form and in the form of a curve.

Graphs in the test report shall show the value plotted against frequency, using the following dimensions:

— 5 mm for one-third octave;

— 20 mm for 10 dB.

9 Test report

The test report shall contain at least the following information:

a) reference to this document, i.e. ISO 10848-5:2020;

b) name of the organization that performed the measurements;

c) identification of the test site as laboratory (including name and address of the testing laboratory) or field;

d) date of test;

e) name of client;

f) manufacturer's name and product identification;

g) description of the test element with sectional drawing and mounting conditions, including size, thickness, mass per area, materials, curing time and conditions of components;

h) statement indicating who mounted the laboratory test object (test institute or manufacturer);

i) brief description of test procedures and equipment, including any deviations from the procedures and any unusual features observed;

j) type of excitation (airborne using either single or multiple sound source(s), structure-borne excitation using stationary or transient source);

k) number of excitation positions;

l) radiation index as a function of frequency.

Annex A
(informative)

Measurement of radiation efficiency using sound intensity

A.1 General

If sound transmission through the constructions of the test facility has a substantial influence on the test result with the normal procedure of this document, and if this sound transmission is difficult to control, the measurement of the radiated sound from the test specimen using the intensity technique should be considered.

A.2 Measurement procedure

A suitable procedure for the intensity measurement in the receiving room is given in ISO 15186-1, where only airborne excitation and laboratory measurements are considered. In this case, requirements for loudspeaker, noise and source positions, are the same as in ISO 10848-1.

In the case of structure-borne excitation, the procedure given in ISO 15186-1 for the intensity measurement in the receiving room is applicable when the structure-borne excitation is stationary.

The intensity radiation function is determined from Formula (A.1):

$$L_{RF,I} = \overline{L_{I_n}} - L_v \tag{A.1}$$

where

$\overline{L_{I_n}}$ is the average normal sound intensity level over the measurement surface enclosing the tested element in the receiving room, measured according to ISO 15186-1;

L_v is the average velocity level measured on the tested element (see 3.1).

In the case of stationary excitation using a single source at different positions, the intensity radiation function shall be determined using Formula (A.2):

$$L_{RF,I} = \frac{1}{M} \sum_{m=1}^{M} \left(L_{RF,I} \right)_m \tag{A.2}$$

where

M is the number of excitation positions;

$(L_{RF,I})m$ is the intensity radiation function for excitation position m.

A.3 Calculation of the intensity radiation index

The intensity radiation index, $L_{\sigma,I}$, in decibels, is then determined from Formula (A.3):

$$L_{\sigma,I} = 10 \lg(\sigma_I) = L_{RF,I} + 34 \tag{A.3}$$

NOTE 1   The subscript "I" in the intensity radiation index can be replaced by "I,a" or "I,s" to indicate airborne or structure-borne excitation respectively.