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Acoustics — Laboratory measurement of sound insulation of building elements —

Part 4: Measurement procedures and requirements

Acoustique — Mesurage en laboratoire de l'isolation acoustique des éléments de construction —

Partie 4: Exigences et modes opératoires de mesure

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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).

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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 Technical Committee 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).

This second edition cancels and replaces the first edition (ISO 10140-4:2010), which has been technically revised.

The main changes compared to the previous edition are as follows:

— all references in the text have been updated;

— in Clause 2, the normative references have been updated;

— in Clause 3, the terms and definitions have been updated;

— in 4.8 first and last paragraph have been edited;

— in 5.3.3 the Note has been edited.

A list of all parts in the ISO 10140 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 10140 (all parts) concerns laboratory measurement of the sound insulation of building elements (see Table 1).

ISO 10140-1 specifies the application rules for specific elements and products, including specific requirements for the preparation and mounting of the test elements, and for the operating and test conditions. ISO 10140-2 and ISO 10140-3 contain the general procedures for airborne and impact sound insulation measurements, respectively, and refer to this document and ISO 10140-5 where appropriate. For elements and products without a specific application rule described in ISO 10140-1, it is possible to apply ISO 10140-2 and ISO 10140-3. This document contains basic measurement techniques and processes. ISO 10140-5 contains requirements for test facilities and equipment. For the structure of ISO 10140 (all parts), see Table 1.

ISO 10140 (all parts) was developed to improve the layout for laboratory measurements, ensure consistency and simplify future changes and additions regarding mounting conditions of test elements in laboratory and field measurements. ISO 10140 (all parts) aims at presenting a well-written and arranged format for laboratory measurements.

ISO 10140-1 is planned to be updated with application rules for other products.

Table 1 — Structure and contents of ISO 10140 (all parts)

Relevant part of ISO 10140	Main purpose, contents and use	Detailed content
ISO 10140-1	It indicates the appropriate test procedure for elements and products. For certain types of element/product, it can contain additional and more specific instructions about quantities and test element size and about preparation, mounting and operating conditions. Where no specific details are included, the general guidelines are according to ISO 10140-2 and ISO 10140-3.	Appropriate references to ISO 10140-2 and ISO 10140-3 and product-related, specific and additional instructions on: — specific quantities measured; — size of test element; — boundary and mounting conditions; — conditioning, testing and operating conditions; — additional specifics for test report.
ISO 10140-2	It gives a procedure for airborne sound insulation measurements according to ISO 10140-4 and ISO 10140-5. For products without specific application rules, it is sufficiently complete and general for the execution of measurements. However, for products with specific application rules, measurements are carried out according to ISO 10140-1, if available.	— Definitions of main quantities measured — General mounting and boundary conditions — General measurement procedure — Data processing — Test report (general points)
ISO 10140-3	It gives a procedure for impact sound insulation measurements according to ISO 10140-4 and ISO 10140-5. For products without specific application rules, it is sufficiently complete and general for the execution of measurements. However, for products with specific application rules, measurements are carried out according to ISO 10140-1, if available.	— Definitions of main quantities measured — General mounting and boundary conditions — General measurement procedure — Data processing — Test report (general points)

Table 1 *(continued)*

Relevant part of ISO 10140	Main purpose, contents and use	Detailed content
ISO 10140-4	It gives all the basic measurement techniques and processes for measurement according to ISO 10140-2 and ISO 10140-3 or facility qualifications according to ISO 10140-5. Much of the content is implemented in software.	— Definitions — Frequency range — Microphone positions — SPL measurements — Averaging, space and time — Correction for background noise — Reverberation time measurements — Loss factor measurements — Low-frequency measurements — Radiated sound power by velocity measurement
ISO 10140-5	It specifies all information needed to design, construct and qualify the laboratory facility, its additional accessories and measurement equipment (hardware).	Test facilities, design criteria: — volumes, dimensions; — flanking transmission; — laboratory loss factor; — maximum achievable sound reduction index; — reverberation time; — influence of lack of diffusivity in the laboratory. Test openings: — standard openings for walls and floors; — other openings (windows, doors, small technical elements); — filler walls in general. Requirements for equipment: — loudspeakers, number, positions; — tapping machine and other impact sources; — measurement equipment. Reference constructions: — basic elements for airborne and impact insulation improvement; — corresponding reference performance curves.

Acoustics — Laboratory measurement of sound insulation of building elements —

Part 4:
Measurement procedures and requirements

1 Scope

This document specifies the basic measurement procedures for airborne and impact sound insulation of building elements in laboratory test facilities.

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 3382-2, *Acoustics — Measurement of room acoustic parameters — Part 2: Reverberation time in ordinary rooms*

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

ISO 10140-2, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurement of airborne sound insulation*

ISO 10140-3, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 3: Measurement of impact sound insulation*

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 18233, *Acoustics — Application of new measurement methods in building and room acoustics*

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
energy average sound pressure level in a room
L
ten times the common logarithm of the ratio of the space and time average of the squared sound pressure 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: *L* is expressed in decibels.

3.2
reverberation time
T
time required for the sound pressure level in a room to decrease by 60 dB after the sound source has stopped

Note 1 to entry: The reverberation time is expressed in seconds.

Note 2 to entry: The reverberation time is usually calculated using linear extrapolation of much shorter evaluation ranges than 60 dB.

3.3
structural reverberation time
T_s
time required for the acceleration level in a structure to decrease by 60 dB after the structure-borne sound source has stopped

Note 1 to entry: The structural reverberation time is expressed in seconds.

Note 2 to entry: T_s is usually calculated using linear extrapolation of much shorter evaluation ranges than 60 dB, normally 15 dB or 20 dB.

3.4
background noise level
measured sound pressure level in the receiving room from all sources other than the loudspeaker or tapping machine in the source room

3.5
continuously moving microphone
microphone that, with respect to a fixed point,

a) moves with approximately constant speed in a circle, or

b) sweeps, over a fixed time period, to and fro along the arc of a circle, which is as large as possible, but is not to be less than 270°

4 Measurement procedures and requirements

4.1 Frequency range

All quantities shall be measured using one-third octave band filters having at least the following centre frequencies, in hertz:

100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1 000, 1 250, 1 600, 2 000, 2 500, 3 150, 4 000, 5 000.

If additional information in the low-frequency range is required, use one-third octave band filters with the following centre frequencies, in hertz:

50, 63, 80.

For additional measurements at low frequencies, guidance is given in Annex A.

4.2 Measurement of sound pressure levels

4.2.1 General

Obtain the energy average sound pressure level using a single microphone moved from position to position, an array of fixed microphones or a continuously moving microphone.

4.2.2 Minimum separation distances for microphone positions

The following separation distances are minimum values and shall be exceeded where possible:

a) 0,7 m between fixed microphone positions;

b) 0,7 m between any microphone position and the room boundaries;

c) 0,7 m between any microphone position and any diffusers;

d) 1,0 m between any microphone position and the test element;

e) 1,0 m between any microphone position and the sound source.

4.2.3 Averaging times

4.2.3.1 Fixed microphone positions

At each individual microphone position, the averaging time shall be at least 6 s for each frequency band, with centre frequencies in the frequency range of 100 Hz to 400 Hz. For bands of higher frequencies, it is permissible to decrease the time to not less than 4 s.

4.2.3.2 Continuously moving microphone

The averaging time shall cover a whole number of traverses and shall not be less than 30 s. Using a moving loudspeaker, the measurement period shall equal the time of movement of the loudspeaker which shall be at least 30 s.

4.2.4 Energy average sound pressure level

4.2.4.1 Fixed microphone positions

The energy average sound pressure level is determined using Formula (1).

$$L = 10 \lg \frac{p_1^2 + p_2^2 + \ldots + p_n^2}{n p_0^2} \tag{1}$$

where

$p_1, p_2, \ldots, p_n$ are root-mean-square (r.m.s.) sound pressures at n different positions in the room.

In practice, the sound pressure levels are usually measured and the energy average level, L, shall be determined using Formula (2).

$$L = 10 \lg \frac{1}{n} \sum_{j=1}^{n} 10^{L_j/10} \tag{2}$$

where

$L_1, L_2, \ldots, L_n$ are the sound pressure levels at n different positions in the room.

4.2.4.2 Continuously moving microphone

The energy average sound pressure level is determined using Formula (3).

$$L = 10 \lg \frac{\frac{1}{T_m} \int_0^{T_m} p^2(t) \mathrm{d}t}{p_0^2} \tag{3}$$

where

p is the sound pressure, in pascals;

p_0 is the reference sound pressure and is equal to 20 µPa;

T_m is the integration time, in seconds.

4.3 Correction for background noise level

Measurements of background noise levels shall be made to ensure that the observations in the receiving room are not affected by the background noise. Extraneous sound, such as noise from outside the test room, electrical noise in the receiving system or electrical cross-talk between the source and the receiving systems all contribute to the background noise level. The background noise level shall be at least 6 dB (and preferably more than 15 dB) below the level of signal and background noise combined at each frequency band.

If the difference in levels is smaller than 15 dB but greater than 6 dB, calculate corrections to the signal level according to Formula (4):

$$L = 10 \lg(10^{L_{sb}/10} - 10^{L_b/10}) \tag{4}$$

where

L is the adjusted signal level, in decibels;

L_{sb} is the level of signal and background noise combined, in decibels;

L_b is the background noise level, in decibels.

If the difference in levels is less than or equal to 6 dB in any of the frequency bands, use the 1,3 dB correction. For each frequency band where this is the case, it shall be clearly indicated in the report that a 1,3 dB correction has been made and these values are the limit of measurement.

To check the electrical noise in the receiving system or electrical cross-talk between the source and the receiving systems, replace the microphone by a dummy microphone or replace the loudspeaker by an equivalent impedance.

4.4 Measurement of airborne sound insulation

4.4.1 General

Sound shall be generated in the source room using loudspeakers in at least two positions or a single loudspeaker moved to at least two positions or a moving loudspeaker. The qualification procedure for loudspeakers and loudspeaker positions specified in ISO 10140-5:—, Annex D shall be used to determine the minimally required number of loudspeakers and their most suitable position for a given source room/receiving room combination. The sound pressure level shall be measured using microphones in fixed positions or using moving microphones.

4.4.2 Measurements with fixed microphone positions

a) When using more than one loudspeaker at the same time or a moving loudspeaker, a minimum of five microphone positions shall be used in each room. These shall be distributed within the maximum permitted space throughout each room. No two microphone positions shall lie in the same plane relative to the room boundaries.

b) When using a single loudspeaker, a minimum of five microphone positions shall be used in each room for each loudspeaker position (additional sets of microphone positions may be different from the first set of positions). Each set of microphone positions shall be distributed within the maximum permitted space throughout each room. No two microphone positions shall lie in the same plane relative to the room boundaries and the positions shall not be in a regular grid.

4.4.3 Measurements with a continuously moving microphone

a) When using more than one loudspeaker at the same time or a moving loudspeaker, at least one measurement with a continuously moving microphone shall be used. The sweep radius shall be at least 1 m. The plane of the traverse shall be inclined in order to cover a large proportion of the permitted room space and shall not lie in any plane that is less than 10° to any room surface (wall, floor or ceiling). The duration of a traverse period shall be not less than 15 s.

b) When using a single loudspeaker, a minimum of one measurement using a continuously moving microphone shall be used for each loudspeaker position. The sweep radius shall be at least 1 m. The plane of the traverse shall be inclined to cover a large proportion of the permitted room space and shall not lie in any plane that is less than 10° to a room surface (wall, floor or ceiling). The duration of a traverse period shall be not less than 15 s.

The location of the fixed point about which the continuously moving microphone moves may be changed for each loudspeaker position. The same number of measurements shall be taken at each location.

4.5 Measurement of impact sound insulation

4.5.1 General

Sound shall be generated using the standard tapping machine. Requirements for the tapping machine are specified in ISO 10140-5:—, Annex E. Not less than four tapping machine positions shall be used for any measurement.

4.5.2 Measurements with fixed microphone positions

The number of microphone positions shall equal the number of tapping machine positions or integer multiples of the number of tapping machine positions.

The same number of microphone positions shall be used for each tapping machine position.

If four or five tapping machine positions are used, at least two measurements of impact sound pressure level shall be made for each tapping machine position. Measurements shall be made in at least two microphone positions for each tapping machine position.

If six or more tapping machine positions are used, at least one measurement of impact sound pressure level shall be made for each tapping machine position. Measurements shall be made at a different microphone position for each tapping machine position.

4.5.3 Continuously moving microphone

The same number of measurements shall be taken for each tapping machine position and at least one measurement shall be made for each tapping machine position. The sweep radius shall be at least 1 m. The plane of the traverse shall be inclined to cover a large proportion of the permitted room space and