BS EN ISO 15186-3:2010

Acoustics — Measurement of sound insulation in buildings and of building elements using sound intensity —

Part 3: Laboratory measurements at low frequencies

ICS 91.120.20

British Standards

National foreword

This British Standard is the UK implementation of EN ISO 15186-3:2010. It is identical to ISO 15186-3:2002. It supersedes BS ISO 15186-3:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EH/1/6, Building acoustics.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Health and Environment Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 22 November 2002

ISBN 978 0 580 71779 6

Amendments/corrigenda issued since publication

Amd. No.	Date	Comments
	30 November 2010	This corrigendum renumbers BS ISO 15186-3:2002 as BS EN ISO 15186-3:2010

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 15186-3

September 2010

ICS 91.120.20

English Version

Acoustics - Measurement of sound insulation in buildings and of building elements using sound intensity - Part 3: Laboratory measurements at low frequencies (ISO 15186-3:2002)

Acoustique - Mesurage par intensité de l'isolation acoustique des immeubles et des éléments de construction - Partie 3: Mesurages en laboratoire à de basses fréquences (ISO 15186-3:2002)

Akustik - Bestimmung der Schalldämmung in Gebäuden und von Bauteilen aus Schallintensitätsmessungen - Teil 3: Messungen bei niedrigen Frequenzen im Prüfstand (ISO 15186-3:2002)

This European Standard was approved by CEN on 5 August 2010.

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 CEN Management Centre 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 CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN ISO 15186-3:2010: E

Foreword

The text of ISO 15186-3:2002 has been prepared by Technical Committee ISO/TC 43 “Acoustics” of the International Organization for Standardization (ISO) and has been taken over as EN ISO 15186-3:2010 by Technical Committee CEN/TC 126 “Acoustic properties of building elements 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 March 2011, and conflicting national standards shall be withdrawn at the latest by March 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 15186-3:2002 has been approved by CEN as a EN ISO 15186-3:2010 without any modification.

Contents

Page

Annexes

This page deliberately set blank

Acoustics — Measurement of sound insulation in buildings and of building elements using sound intensity —

Part 3: Laboratory measurements at low frequencies

1 Scope

1.1 General

This part of ISO 15186 specifies a sound intensity method to determine the sound reduction index and the element-normalized level difference of building elements at low frequencies. This method has significantly better reproducibility in a typical test facility than those of ISO 140-3, ISO 140-10 and ISO 15186-1. The results are more independent of the room dimensions of the laboratory and closer to values that would be measured between rooms of volume greater than 300 m^3. This part of ISO 15186 is applicable in the frequency range 50 Hz to 160 Hz but is mainly intended for the frequency range 50 Hz to 80 Hz.

NOTE For elements faced with thick, porous absorbers, the recommended frequency range is 50 Hz to 80 Hz.

The main differences between the methods of ISO 15186-1 and ISO 15186-3 are that in ISO 15186-3

a) the sound pressure level of the source room is measured close to the surface of the test specimen, and

b) the surface opposite the test specimen in the receiving room is highly absorbing and converts the room acoustically into a duct with several propagating cross-modes above the lowest cut-on frequency.

The results found by the method of ISO 15186-3 can be combined with those of ISO 140-3 and ISO 15186-1 to produce data in the frequency range 50 Hz to 5 000 Hz.

1.2 Precision

The reproducibility of this intensity method is, for all frequencies, estimated to be equal to or better than that found with the method of ISO 140-3 at 100 Hz.

Some comparisons of data obtained with the methods of this part of ISO 15186 and ISO 140-3 are given in annex B.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 15186. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 15186 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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 140-10, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 10: Laboratory measurement of airborne sound insulation of small building elements*

ISO 9614-1:1993, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points*

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61043:1993, *Electroacoustics — Instruments for the measurement of sound intensity — Measurement with pairs of pressure sensing microphones*

3 Terms and definitions

For the purposes of this part of ISO 15186, the following terms and definitions apply.

3.1
average sound pressure level on a test surface
$L_{p\mathrm{S}}$
ten times the common logarithm of the ratio of the surface and the time average of the sound pressure squared to the square of the reference sound pressure

NOTE The surface average is taken over the entire test surface in the source room, including reflecting effects from the test specimen.

3.2
sound reduction index
R
ten times the common logarithm of the ratio of the sound power, W_1, incident on the test specimen to the sound power, W_2 transmitted through the specimen

$$R = 10\,\mathrm{lg}\left(\frac{W_1}{W_2}\right)\,\mathrm{dB} \tag{1}$$

NOTE The expression "sound transmission loss" is also in use.

3.3
sound intensity
I
time-averaged rate of flow of sound energy per unit area oriented normal to the local particle velocity

NOTE This is a vectorial quantity which is equal to

$$\vec{I} = \frac{1}{T}\int_0^T [p(t) \cdot \vec{u}(t)]\,\mathrm{d}t\ \frac{\mathrm{W}}{\mathrm{m}^2} \tag{2}$$

where

$p(t)$ is the instantaneous sound pressure at a point, in pascals;

$\vec{u}(t)$ is the instantaneous particle velocity at the same point, in metres per second;

T is the averaging time, in seconds.

3.4
normal sound intensity
I_n
component of the sound intensity in the direction normal to a measurement surface defined by the unit normal vector $\vec{n}$

$$I_\text{n} = \vec{I} \cdot \vec{n} \tag{3}$$

where $\vec{n}$ is the unit normal vector directed out of the volume enclosed by the measurement surface

3.5
normal sound intensity level
$L_{I\text{n}}$
ten times the common logarithm of the ratio of the unsigned value of the normal sound intensity to the reference intensity I_0

$$L_{I\text{n}} = 10 \lg \left(\frac{I_\text{n}}{I_0} \right) \text{ dB} \tag{4}$$

where $I_0 = 10^{-12}$ W/m^2

3.6
surface-pressure intensity indicator
F_{pI}
difference between the sound pressure level, L_p, and the normal sound intensity level, $L_{I\text{n}}$, on the measurement surface, both being time and surface averaged

$$F_{pI} = (L_p - L_{I\text{n}}) \text{ dB} \tag{5}$$

NOTE This notation is according to ISO 9614-2. In ISO 9614-1 the notation F_2 is used.

3.7
residual-pressure intensity index
δ_{pI0}
difference between the indicated sound pressure level, L_p, and the indicated sound intensity level, L_I, when the intensity probe is placed and oriented in a sound field such that the sound intensity is zero

NOTE 1 It is expressed in decibels.

NOTE 2 Details for determining δ_{pI0} are given in IEC 61043:

$$\delta_{pI0} = (L_p - L_I) \text{ dB} \tag{6}$$

3.8
intensity sound reduction index
R_I
for one source room and one receiving room with an absorbing back wall, index defined by

$$R_I = L_{p\text{S}} - 9 - \left[L_{I\text{n}} + 10 \lg \left(\frac{S_\text{m}}{S} \right) \right] \text{ dB} \tag{7}$$

where

$L_{p\text{S}}$ is the average sound pressure level over the surface of the test specimen in the source room, in decibels;

$L_{I\text{n}}$ is the average normal sound intensity level over the measurement surface in the receiving room, in decibels;

S_m is the total area of the measurement surface(s), in square metres;

S is the area of the test specimen under test, in square metres.

NOTE Equation (7) is valid for a test specimen with a reflecting surface in the source room. It will also work satisfactorily for moderately absorbing surfaces (e.g. surfaces covered with 100 mm thick porous absorbers). For 100 mm to 200 mm thick absorbers, it is recommended to restrict the frequency range to 50 Hz to 80 Hz. For even thicker absorbers, the equation is no longer valid.

3.9
intensity element normalized level difference
$D_{I\text{n,e}}$
difference given by

$$D_{I\text{n,e}} = L_{p\text{S}} - 9 - \left[L_{I\text{n}} - 10 \lg \left(\frac{A_0}{S_\text{m}} \right) - 10 \lg N \right] \tag{8}$$

where

$L_{p\text{S}}$ is the average sound pressure level over the surface of the test specimen in the source room, in decibels;

$L_{I\text{n}}$ is the average normal sound intensity level over the measurement surface in the receiving room, in decibels;

A_0 $=$ 10 m^2;

S_m is the total area of the measurement surface(s), in square metres;

N is the number of small building element units installed within the measurement surface.

NOTE Equation (8) is valid for a test specimen with a reflecting surface in the source room. It will also work satisfactorily for moderately absorbing surfaces (e.g. surfaces covered with 100 mm thick porous absorbers). For 100 mm to 200 mm thick absorbers, it is recommended to restrict the frequency range to 50 Hz to 80 Hz. For even thicker absorbers, the equation is no longer valid.

3.10
measurement surface
surface totally enclosing the test specimen on the receiving side, scanned or sampled by the probe during the measurements

3.11
measurement distance
d
distance between the measurement surface and the specimen in a direction normal to the specimen

3.12
measurement sub-area
part of the measurement surface being measured with the intensity probe, using one continuous scan or discrete positions

4 Instrumentation

4.1 General

The intensity measuring instrumentation shall be capable of measuring intensity levels with reference to 10^{-12} W/m^2 in decibels in one-third-octave bands. The intensity shall be measured in real time when the scanning procedure is used. The instrument, including the probe, shall comply with IEC 61043:1993, class 1.

The residual-pressure intensity index δ_{pI0} of the microphone probe and analyser shall be higher than $F_{pI} + 10$ dB.

For most intensity probes, a 50 mm spacer is recommended.

The equipment for sound pressure level measurements shall meet the requirements of ISO 140-3.

4.2 Calibration

Verify compliance with IEC 61043 either at least once a year in a laboratory making calibrations in accordance with appropriate standards, or at least every 2 years if an intensity calibrator is used before each measurement series.

The following procedure shall be followed before each use of a sound intensity instrument to check that an instrument which has undergone type test and verification is still operating correctly.

a) Allow the instrument to warm up according to the manufacturer's instructions.

b) Set the instrument to the sound pressure mode and apply a class 0 or 1 or 0L or 1L sound pressure calibrator in accordance with IEC 60942 to the two microphones in turn or simultaneously, and adjust the instrument to the correct sound pressure indication in both channels.

c) Apply the residual intensity testing device to the two microphones and measure the pressure-residual intensity index and ensure that the instrument is within the requirements for its class in the range over which the residual intensity testing device operates. Phase compensation and any other procedures recommended by the manufacturer for performance enhancement may be applied. Phase compensation and pressure-residual intensity testing should preferably be done at a sound intensity and sound pressure level close to the levels of use.

d) If a sound intensity calibrator is available, use this to check the sound intensity indication.

5 Test arrangement

5.1 Rooms

Test rooms and test procedure shall be qualified as described in annex A.

Source and receiving rooms shall meet the room dimension requirements of ISO 140-1. The reverberation time of the source room shall meet the requirements of ISO 140-1.

The receiving room shall meet the requirements of the surface-pressure intensity indicator, F_{pI}, and the background noise; see 6.4.2 and 6.5 respectively. The wall in the receiving room opposite the test specimen shall be covered with an efficient sound- absorbing material. The other surfaces of the receiving room shall not be sound absorbing in the frequency range under consideration.

NOTE As sound absorber, use for example a 600 mm to 900 mm thick layer of fibrous material with a specific flow resistivity of approximately 10 kPa · s/m^2. The surface of the absorber can be covered by, for example, thin plastic film, less than 0,3 mm thick.

The filler wall in which windows, doors, etc. are mounted shall be dense (at least 300 kg/m^2). On the receiving room side the filler wall shall consist of another dense wall or a light covering. Thus, the filler wall forms a double construction. The mass-spring-mass resonance frequency should be less than 30 Hz.

5.2 Test specimen

The test specimen shall meet the requirements of ISO 140-3 or, for small building elements, ISO 140-10.

5.3 Mounting conditions

Mount the test specimen according to the requirements of ISO 140-3 or, for small building elements, according to ISO 140-10. If one side is sound absorbing, mount this side towards the source room. The distance between small building elements measured simultaneously shall be at least 2,4 m (i.e. twice the minimum distance given in ISO 140-10).

6 Test procedure

6.1 General

Measure the average sound pressure level over the surface of the test specimen in the source room and the average sound intensity level on a measurement surface in the receiving room. Provided that the surface-pressure intensity indicator is satisfactory, then calculate the intensity sound reduction index or, alternatively, the intensity element-normalized level difference.

6.2 Generation of sound field

Excite the source room by at least one corner loudspeaker or one continuously moving loudspeaker. If a corner loudspeaker is used, the surfaces forming the corner shall not be acoustically reactive; i.e. the constructions shall be solid and without loose layers near the surfaces. Any corner qualifying according to annex A may be used.

NOTE A corner loudspeaker can consist of a 30,48 cm (12 inch) unit in a closed triangular cabinet that fits into a corner and has an edge length of approximately 0,75 m. Smaller units and cabinets can also be used.

A moving loudspeaker shall meet the requirements of ISO 140-3 and travel along a straight line over a length of at least 2 m. The distance between the loudspeaker and the surfaces of the room shall be at least 0,7 m. The test object shall be outside the direct field. The line shall not be parallel to any surface of the room. Instead of a moving loudspeaker, at least five fixed positions along the line may be used. It is permissible to use multiple sound sources simultaneously, provided that they are of the same type and are driven at the same level by similar, but uncorrelated, signals.

The sound shall meet the requirements of ISO 140-3.

6.3 Measurement of the average sound pressure level over the surface of the test specimen in the source room

Measure the average sound pressure level over the surface of the test specimen in the source room by multiple fixed microphone positions evenly but asymmetrically distributed over the entire surface of the test specimen, including parts close to the edges and corners. The distance between the test specimen and microphone shall be less than 50 mm. Minimum numbers of microphone positions are given in Table 1.

Table 1 — Minimum number of fixed microphone positions on the test surface of the source room

Test specimen	Minimum number of microphone positions
Small building elements as defined in ISO 140-10	2 for each element mounted in the test wall
Other elements up to 3 m^2	6
Others	12

For each microphone position, the integration time shall be at least 30 s. Furthermore, if a moving loudspeaker is applied, the integration time shall cover a whole number of traverses.

If two or more fixed loudspeaker positions are used sequentially, the energy average of all loudspeaker and microphone positions shall be taken.

6.4 Measurement of the average sound intensity level on the receiving side

6.4.1 Measurement surface

On the receiving side, use a measurement surface totally enclosing the test specimen. If the test specimen is mounted in a niche, the measurement surface is normally the flat surface of the niche opening. If the test specimen is not mounted in a niche or if the depth of the niche is less than 0,1 m, use a box-shaped measurement surface. This will be the most common condition for small building elements.

NOTE For small building elements a hemispherical measurement surface could also be applicable.

Initially select a measurement distance, normally between 0,1 m and 0,3 m. Avoid measurement distances shorter than 0,1 m because of the near field of the vibrating element. In the near field the intensity tends to change sign very often. The sound field is also normally more uniform in the niche opening than inside the niche. When using box-shaped measurement surfaces, avoid measurement distances longer than 0,3 m.

6.4.2 Qualification of the measurement surface

Measure the time- and space-integrated normal sound intensity level $L_{I\mathrm{n}}$. If possible, measure the time- and space-integrated sound pressure level L_p simultaneously. Then calculate the surface-pressure intensity indicator from equation (5):

$$F_{pI} = (L_p - L_{I\mathrm{n}})\ \mathrm{dB}$$

If the measured intensity is negative or if F_{pI} is not satisfactory (i.e. if $F_{pI} > 10$ dB for a sound-reflecting test specimen or if $F_{pI} > 6$ dB for a test specimen with a sound-absorbing surface in the receiving room), improve the measurement environment (only for two absorbing sides, because elements with one absorbing side are mounted with this side towards the source room; see 5.3). First try to increase the measurement distance by 5 cm to 10 cm. If this fails it may be necessary to decrease the flanking transmission or improve the absorption of the surface opposite the test specimen in the receiving room. For scanning, the sound field indicator requirement is valid for each scan and each loudspeaker position. However, it is only valid for the total measurement surface and not for individual measurement sub-areas. For discrete positions, it is valid for the surface average.

6.4.3 Scanning procedure

Always hold the probe normal to the measurement surface while scanning and direct it to measure the positive intensity outwards from the building element under test.

The measurement surface shall consist of one area or several sub-areas. The scanning time of each sub-area shall be proportional to the size of the area. Keep the scan speed constant. Select a speed between 0,1 m/s and 0,3 m/s. Interrupt the measurements when going from one sub-area to another. Avoid other stops.

Scan each area or sub-area using parallel lines, turning at each edge as shown in Figure 1. The required scanning line density depends on how irregular the sound radiation is. A large amount of irregularities such as leakages requires a higher line density. Normally select the line distance between scan lines to be equal to the measurement distance.

If the measurement surface is box-shaped as shown in Figure 2, give particular care to the areas close to the intersection between the box surface and the partition wall in which the test specimen is mounted. Attempts shall be made to ensure that all radiated sound intensity is measured by scanning the measurement surface properly. In particular, scan as close as possible to the partition wall.

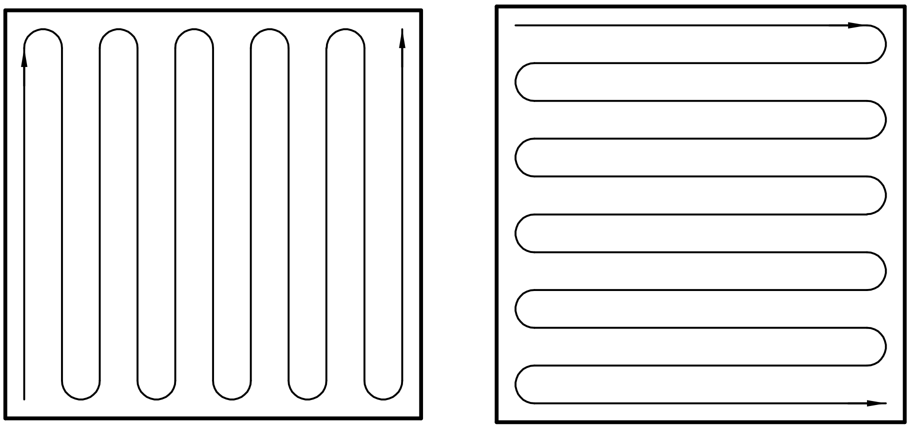

Figure 1 — Scanning patterns for the two scans

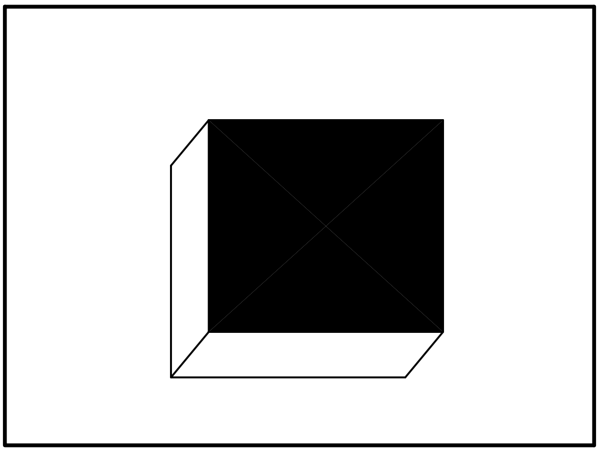

Figure 2 — Box-shaped measurement surface

6.4.4 Procedure for discrete positions

As an alternative to scanning, fixed positions may be used on the measurement surface described in 6.4.3. Initially select the distance between probe positions to be approximately d m, where d is the measurement distance from the test object. For test specimens having strong sound leaks or inhomogeneous sound flow, use a denser measurement grid but keep the measurement distance constant. For the measurements, follow the procedures of a grade 2 method as specified in ISO 9614-1:1993. Check the adequacy of the chosen array of measurements positions using annex B of ISO 9614-1:1993. Measure for at least 10 s in each probe position. If a moving loudspeaker is used, the minimum number of loudspeaker traverses, for the complete set of probe positions, shall be two for doors, windows and small building elements and eight for walls.

6.4.5 One measurement area by scanning

For each fixed loudspeaker position, once the measurement environment is satisfactory, carry out two complete scans, one for each pattern, and compare the results. Turn the scanning path 90° between the two scans. If the difference between the two measurements is less than 2,0 dB in the frequency range 50 Hz to 80 Hz and less than 1,0 dB in the frequency range 100 Hz to 160 Hz, the measurement result is given by the arithmetic average of the two measurements. If the difference is larger than these values, the measurements are not valid. Repeat the two scanning patterns until the requirement is fulfilled. If the requirement cannot be fulfilled, change the scanning line density, scanning time, or measurement surface or measurement environment, and repeat the measurements until the requirement is fulfilled. If, despite these efforts, it turns out to be impossible to comply with this requirement, the results may still be given in the test report providing that all deviations from the requirements of this method are clearly stated.

If two or more corner loudspeaker positions are used sequentially, carry out a pair of scans for each loudspeaker position. Each pair of scans shall comply with the above requirement. Give all results, including sound reduction index and field indicator, as the energy average of all scans carried out.

If a moving loudspeaker is used, the time of each scan shall cover a whole number of traverses. Scan the measurement surface using the two different scanning patterns. Evaluate the averages of the two patterns as for a fixed loudspeaker position.

If, for example, five fixed loudspeaker positions are used as an alternative to a moving loudspeaker, a total set of five horizontal and five vertical scans may be carried out before the difference between the average intensity levels for the two scanning patterns need be checked. The result of each set of patterns is the energy average of the scans.

For each scanning pattern, the total scanning/traverse time shall be at least 60 s for windows, doors and small building elements, and at least 300 s for walls.

6.4.6 Several measurement sub-areas

For each sub-area apply the procedures of 6.4.3 or 6.4.4.

If the measurement surface is divided into several sub-areas, each with the area $S_{\mathrm{m}i}$ and each being scanned individually, evaluate the average normal sound intensity $L_{I\mathrm{n}}$ from

$$L_{I\mathrm{n}} = 10 \lg \left[\frac{1}{S_\mathrm{m}} \sum_i S_{\mathrm{m}i} 10^{0{,}1 L_{I\mathrm{n}i}} \right] \mathrm{dB} \tag{9}$$

where i indicates the sub-area i, and the total area S_m is given by

$$S_\mathrm{m} = \sum_i S_{\mathrm{m}i} \tag{10}$$

If the sound intensity for a measurement sub-area has a negative direction (i.e. if the flow of energy is in the direction towards the test object), a minus sign shall be inserted before the respective $S_{\mathrm{m}i}$ in equation (9).

Calculate the surface pressure-intensity indicator from the following equation:

$$F_{pI} = 10 \lg \left[\frac{1}{S_\mathrm{m}} \sum_i S_{\mathrm{m}i} 10^{0{,}1 L_{pi}} \right] - L_{I\mathrm{n}} \ \mathrm{dB} \tag{11}$$

where L_{pi} is the surface-averaged sound pressure level over $S_{\mathrm{m}i}$, in decibels.

6.5 Background noise

Both the sound pressure level and sound intensity level shall be at least 10 dB higher than the background noise.

These requirements may be tested by applying the following procedure.

If the field indicator $F_{pI} < 10$ dB, then lower the source level by 10 dB. If F_{pI} is changed less than 1 dB then the requirements are fulfilled.

6.6 Frequency range of measurements

Measure the sound pressure level and the sound intensity level using one-third-octave band filters having at least the following centre frequencies in hertz:

50; 63; 80

Measurements may also be carried out using one-third-octave band filters with the following centre frequencies in hertz:

100; 125; 160

Octave band values, if needed, shall be calculated from one-third-octave levels as specified in ISO 140-3.

7 Expression of results

For the statement of the airborne sound insulation of the test specimen, the intensity sound reduction index R_I shall be given at all frequencies of measurement to one decimal place in tabular form and/or in the form of a curve together with the surface field pressure-intensity indicator. For graphs with the level in decibels plotted against frequency on a logarithmic scale, the following dimensions shall be used:

5 mm for a one-third-octave band, 20 mm for 10 dB.

8 Test report

Results obtained with this part of ISO 15186 may be reported separately or together with results obtained with ISO 140-3, ISO 140-10 or ISO 15186-1. The test report shall clearly state the frequency range over which this method has been used.

With reference to this part of ISO 15186, the test report shall state:

a) name of organization that has performed the measurements;

b) identification of test site;

c) name of client;

d) date of test;

e) description of the test specimen, including mounting, sealing and mass per unit area;

f) volume and description of measurement rooms;

g) area of test object, S, and of total measurement surface, S_m;

h) intensity sound reduction index as a function of frequency;

i) surface-pressure intensity indicator, F_{pI}, and residual-pressure intensity index, δ_{pI0} as a function of frequency;

j) measurement distance and shape and area of measurement surface, description of measurement segments, if more than one;

k) information regarding the measurement equipment, including probe (microphone diameter, spacings);

l) information about which test method has been used.

Annex A
(normative)

Qualification

A.1 General

The test facility and the test procedure shall be checked by measuring the sound reduction index of a limp panel with area $S > 1$ m^2, the sound reduction of which shall be calculated using the following equations. Deviations between the measured and calculated values shall not be more than 4,0 dB within the frequency range 50 Hz to 160 Hz.

According to reference [5], the sound reduction index for a limp panel is related to forced transmission only and can be calculated theoretically by:

$$R = R_0 - 10 \lg 2\sigma_\mathrm{d} \qquad \text{(A.1)}$$

where R_0 is calculated according to the mass law

$$R_0 = 20 \lg \frac{\pi f m}{\rho c} \qquad \text{(A.2)}$$

The radiation efficiency σ_d for a plate excited by a diffuse sound field is calculated using the following approximation:

$$\sigma_\mathrm{d} = \frac{1}{2}\left[0{,}20 + \ln\left(2\pi \frac{f}{c}\sqrt{S}\right)\right] \qquad \text{(A.3)}$$

In equations (A.2) and (A.3), f is the frequency (Hz), m is the surface mass (kg/m^2), ρ is the density of air (kg/m^3), c is the speed of sound in air (m/s), and S is the surface area of the test specimen (m^2). Equation (A.3) is valid for the frequency range of this part of ISO 15186 if the area of the test specimen is at least 1 m^2.

In equation (A.2) ρc shall be calculated from (see reference [6]):

$$\rho c = 427\sqrt{\frac{273}{273 + \theta}} \cdot \frac{B}{B_0} \qquad \text{(A.4)}$$

where

θ is the temperature, in degrees Celsius;

B is the static pressure, in pascals;

B_0 is the reference static pressure 1 013 hPa.

In equation (A.3), c shall be calculated using

$$c = 331 + 0{,}6\theta \qquad \text{(A.5)}$$

A.2 Examples

For a window opening with dimensions 1,25 m × 1,50 m, a single leaf sheet like the one recommended in C.2.4 of ISO 140-3:1995 consists of a 2,2 mm thick steel sheet/resin/steel sheet sandwich leaf with surface mass 17 kg/m^2, fixed to a channel section frame by screws in rivets and elastoplastic sealant. The dimensions of the free part of the panel are 1,162 m × 1,412 m. The calculated sound reduction index is given in Table A.1.

For a wall opening with an area 10 m^2 and a test specimen of 12,5 mm thick plaster board with surface mass 10 kg/m^2, the calculated values of the sound reduction index are listed in Table A.1.

Table A.1 — Calculated sound reduction index (at 1 013 hPa and 23 °C)

Values in decibels

Frequency Hz	**Steel sandwich leaf** 17 kg/m^2 Test opening 1,25 m × 1,50 m	**Plaster board** 10 kg/m^2 Test opening 10 m^2
50	21,3	10,7
63	21,2	11,9
80	21,7	13,4
100	22,7	14,8
125	23,8	16,3
160	25,1	17,9

If the result of the qualification test is not satisfactory, try to change the position or type of the sound source, improve the absorber opposite the test specimen in the receiving room, decrease the reverberation time of the source room, or modify the geometry of one of the test rooms, for example with a wooden plate.

Annex B
(informative)

Estimated precision of the method

An example of the precision of the test method is given in Table B.1. It should be noted that the reproducibility depends on the dimensions and construction of the test specimen.

Table B.1 — Estimated reproducibility standard deviation for the intensity sound reduction index

Frequency Hz	Standard deviation of R_I dB
50	2,5
63	2,5
80	2,5
100	2,0
125	2,0
160	2,0

The estimated average differences between results with this part of ISO 15186 and with ISO 140-3 respectively are given in Table B.2.

Table B.2 — Estimated average differences between intensity sound reduction index with this part of ISO 15186 (R_I) and results with ISO 140-3 (R')

Frequency Hz	Average difference $R_I - R'$ dB
50	−4
63	−3
80	−2
100	−1
125	0
160	1

NOTE The values in Tables B.1 and B.2 are based on 16 measurements on windows and plaster board walls carried out in four different European laboratories using the methods of this part of ISO 15186 and ISO 140-3 respectively (see reference [3]).

Bibliography

[1] ISO 3741:1999, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for reverberation rooms*

[2] ISO 9614-2:1996, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning*

[3] ISO 15186-1, *Acoustics — Measurement of sound insulation in buildings and of building elements using sound intensity — Part 1: Laboratory measurements*

[4] PEDERSEN D.B., et al. Measurement of the low-frequency sound insulation of building components. *ACOUSTICA – acta acoustica*, **86**, 2000, pp. 495-505

[5] RINDEL J.H. Sound transmission through single layer walls. *Noise-93, St Petersburg 1993*, **5**, pp. 279-282

[6] HÜBNER G. Sound power related to normalized meteorological conditions. *Internoise 99*

This page deliberately set blank

BSI - British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001 Email: orders@bsigroup.com You may also buy directly using a debit/credit card from the BSI Shop on the Website http://www.bsigroup.com/shop

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact Information Centre. Tel: +44 (0)20 8996 7111 Fax: +44 (0)20 8996 7048 Email: info@bsigroup.com

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002 Fax: +44 (0)20 8996 7001 Email: membership@bsigroup.com

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsigroup.com/BSOL

Further information about BSI is available on the BSI website at http://www.bsigroup.com

Copyright

Details and advice can be obtained from the Copyright and Licensing Manager. Tel: +44 (0)20 8996 7070 Email: copyright@bsigroup.com

BSI Group
Headquarters 389
Chiswick High Road,
London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/
standards