INTERNATIONAL STANDARD

ISO 10052

First edition
2004-12-15

Acoustics — Field measurements of airborne and impact sound insulation and of service equipment sound — Survey method

Acoustique — Mesurages in situ de l'isolement aux bruits aériens et de la transmission des bruits de choc ainsi que du bruit des équipements — Méthode de contrôle

Reference number
ISO 10052:2004(E)

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Published in Switzerland

Foreword

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Throughout the text of this document, read “...this European Standard...” to mean “...this International Standard...”.

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Foreword

This document (EN ISO 10052:2004) has been prepared by Technical Committee CEN/TC 126 "Acoustic properties of building products and of buildings", the secretariat of which is held by AFNOR, in collaboration with Technical Committee ISO/TC 43 "Acoustics".

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of an identical text or by endorsement, at the latest by June 2005, and conflicting national standards shall be withdrawn at the latest by June 2005.

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

Introduction

This document describes survey test methods which can be used for surveying the acoustic characteristics of the airborne sound insulation, impact sound insulation and of the sound pressure levels from service equipment. The methods may be used for screening tests of the acoustical properties of buildings. The methods are not intended to be applied for measuring acoustical properties of building elements.

The approach of the survey methods is to simplify the measurement of sound pressure levels in rooms by using a hand-held sound level instrument and by manually sweeping the microphone in the room space. The correction for reverberation time can be either estimated by usage of tabular values or be based on measurements. The measurement of airborne and impact sound insulation is carried out in octave bands. For measuring sound from domestic service equipment, A - or C -weighted sound pressure levels are recorded.

Measurements are performed with specified operation conditions and operation cycles. The operating conditions and operating cycles given in Annex B are only used if they are not opposed to national requirements and regulations.

The measurement uncertainty of the results obtained using the survey method is a priori larger than the uncertainty inherent in the corresponding test methods on engineering level.

NOTE Engineering methods for field measurements of airborne and impact sound insulation are dealt with in EN ISO 140-4 and EN ISO 140-7. Engineering methods for field measurements of airborne sound insulation of façade elements and façades are dealt with in EN ISO 140-5. An engineering method for measurement of service equipment sound is dealt with in EN ISO 16032.

1 Scope

This document specifies field survey methods for measuring:

a) airborne sound insulation between rooms;

b) impact sound insulation of floors;

c) airborne sound insulation of façades; and

d) sound pressure levels in rooms caused by service equipment.

The methods described in this document are applicable for measurements in rooms of dwellings or in rooms of comparable size with a maximum of 150 m^3.

For airborne sound insulation, impact sound insulation and façade sound insulation the method gives values which are (octave band) frequency dependent. They can be converted into a single number characterising the acoustical performances by application of EN ISO 717-1 and EN ISO 717-2. For service equipment sound the results are given directly in A - or C -weighted sound pressure levels.

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.

EN 20140-2, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 2: Determination, verification and application of precision data (ISO 140-2:1991).*

EN 61260, *Electroacoustics - Octave-band and fractional-octave-band filters (IEC 61260:1995).*

EN 60651, *Sound level meters (IEC 60651:1993).*

EN 60804, *Integrating-averaging sound level meters (IEC 60804:2000).*

EN ISO 140-7:1998, *Measurements of sound insulation in buildings and of building elements — Part 7: Field measurements of impact sound insulation of floors (ISO 140-7:1998).*

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

EN ISO 717-2, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 2: Impact sound insulation (ISO 717-2:1996).*

EN ISO 3822-1, *Acoustics - Laboratory tests on noise emission from appliances and equipment used in water supply installations - Part 1: Method of measurement (ISO 3822-1:1999)*

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 $\overline{L}$

ten times the logarithm to the base 10 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 (wall, etc.) is of significant influence. It is expressed in decibels as:

$$\overline{L} = 10 \lg \frac{\frac{1}{T_m} \int_0^{T_m} p^2(t)\, dt}{p_0^2} \text{ dB} \tag{1}$$

where

p is the sound pressure level, in Pascal, p_0 = 20 μPa is the reference sound pressure;

T_m is the integration time in seconds

3.2

level difference D

difference in the space and time average sound pressure levels produced in two rooms by one sound source in one of them. It is expressed in decibels as:

$$D = \overline{L}_1 - \overline{L}_2 \quad \text{dB} \tag{2}$$

where

$\overline{L}_1$ is the average sound pressure level in the source room, in decibels;

$\overline{L}_2$ is the average sound pressure level in the receiving room, in decibels

3.3

reverberation index k

ten times the logarithm to the base 10 of the ratio of the actual reverberation time T of the receiving room to the reference reverberation time T_0. It is expressed in decibels. This quantity is denoted by:

$$k = 10 \lg \frac{T}{T_0} \text{ dB} \tag{3}$$

where

T_0 = 0,5 s

3.4

standardized level difference D_{nT}

level difference corresponding to a reference value of the reverberation time in the receiving room. It is expressed in decibels as:

$$D_{nT} = D + k \quad \text{dB} \tag{4}$$

where

D is the level difference (see equation (2)), in decibels;

k is the reverberation index (see equation (3)), in decibels

3.5
normalized level difference D_n
level difference D corresponding to the reference absorption area in the receiving room. It is expressed in decibels as:

$$D_n = D + k + 10\ \lg \frac{A_0\ T_0}{0{,}16\ V}\ \text{dB} \tag{5}$$

where

k is the reverberation index;

T_0 is the reference reverberation time (T_0 = 0,5 s);

V is the volume of the receiving room, in cubic metres;

A_0 is the reference equivalent absorption area, in square metres, (A_0 = 10 m^2);

0,16 has the unit s/m

3.6
apparent sound reduction index *R*’
ten times the logarithm to the base 10 of the ratio of the sound power W_1 which is incident on a partition under test to the total sound power transmitted into the receiving room, if, in addition to the sound power W_2 transmitted through the separating element, the sound power W_3, transmitted through flanking elements or by other components, is significant.

It is expressed in decibels as:

$$R' = 10 \lg \frac{W_1}{W_2 + W_3}\ \text{dB} \tag{6}$$

NOTE 1 The expression "apparent sound transmission loss" is also in use in English-speaking countries. It is equivalent to "apparent sound reduction index".

Under the assumption of diffuse sound fields in the two rooms, the apparent sound reduction index in this document is calculated from:

$$R' = D + k + 10\ \lg \frac{S\ T_0}{0{,}16\ V}\ \text{dB} \tag{7}$$

where

D is the sound pressure level difference, in decibels;

k is the reverberation index;

S is the area of the partition, in square metres;

V is the volume of the receiving room, in cubic metres;

T_0 is the reference reverberation time (T_0 = 0,5 s);

0,16 has the unit s/m.

In the case of staggered or stepped rooms, S is that part of the area of the partition common to both rooms. If the common area between the stepped or staggered rooms is less than 10 m^2, this shall be indicated in the test report. If V/7,5 is larger than S, insert this value for S where V is the volume in m^3 of the receiving room which should be the smaller room.

In the case that no common area exists the normalized level difference D_n shall be determined.

NOTE 2 In the apparent sound reduction index, the sound power transmitted into the receiving room is related to the sound power incident on the common partition irrespective of actual conditions of transmission.

The apparent sound reduction index is independent of the measuring direction between the rooms if the sound fields are diffused in both rooms

3.7
impact sound pressure level L_i

average sound pressure level in the receiving room when the floor under test is excited by the standardized tapping machine. It is expressed in decibels. If more than one position of the tapping machine is used, the impact sound pressure level is calculated by averaging the sound pressure levels $L_{i,n}$ at N positions according to:

$$L_i = 10 \lg \left(\frac{1}{N} \sum_{n=1}^{N} 10^{L_{i,n}/10} \right) \text{ dB} \quad (8)$$

3.8
standardized impact sound pressure level L'_{nT}

impact sound pressure level L_i reduced by the reverberation index k, and expressed in decibels:

$$L'_{nT} = L_i - k \text{ dB} \quad (9)$$

3.9
normalized impact sound pressure level L'_n

impact sound pressure level L_i reduced by a correction term which is given in decibels, being ten times the logarithm to the base 10 of the ratio between the reference equivalent absorption area and the actual equivalent sound absorption area A of the receiving room. The actual equivalent absorption area is calculated from the reverberation index, the reference reverberation time and the room volume:

$$L'_n = L_i - 10 \lg \frac{A_0}{A} \ dB = L_i - k - 10 \lg \frac{A_0 \ T_0}{0{,}16 \ V} \ dB \quad (10)$$

where

V is the volume of the receiving room in cubic metres;

k is the reverberation index;

T_0 is the reference reverberation time (T_0 = 0,5 s);

A_0 is the reference absorption area (A_0 = 10 m^2);

0,16 has the unit s/m

3.10
average sound pressure level on a test surface $L_{1,s}$
ten times the logarithm to the base 10 of the ratio of the surface and time average of the sound pressure squared to the square of the reference sound pressure, the surface average being taken over the entire test surface including reflecting effects from the test specimen and façade; it is expressed in decibels

3.11
façade level difference D_{2m}
difference between the outdoor sound pressure level 2 m in front of the façade, $L_{1;2m}$, and the space and time averaged sound pressure level, L_2, in the receiving room. It is expressed in decibels as:

$$D_{2m} = L_{1,2m} - L_2 \quad \text{dB} \tag{11}$$

It is also possible to measure in the plane of the façade. In this case the denotation is $L_{1,s}$ instead of $L_{1;2m.}$

If road traffic sound has been used as sound source the notation is $D_{tr,2m}$ and if a loudspeaker has been used it is $D_{ls,2m}$ and is expressed in decibels

3.12
standardized façade level difference $D_{2m,nT}$
façade level difference D_{2m} corresponding to a reference value of the reverberation time in the receiving room. It is expressed in decibels as

$$D_{2m,nT} = D_{2m} + k \quad \text{dB} \tag{12}$$

where

k is the reverberation index

3.13
normalized façade level difference $D_{2m,n}$
façade level difference D_{2m} corresponding to the reference equivalent absorption area in the receiving room:

$$D_{2m,n} = D_{2m} + k + 10 \lg \frac{A_0 \, T_0}{0{,}16 \, V} \text{ dB} \tag{13}$$

where

V is the volume of the receiving room in cubic metres;

k is the reverberation index;

T_0 is the reference reverberation time (T_0 = 0,5 s);

A_0 is the reference equivalent absorption area in square metres (A_0 = 10 m^2);

0,16 has the unit s/m

3.14
service equipment sound pressure level
the average sound pressure level in the room obtained by the procedure described in 6.3.3 indexes 1 and 2 relate to the position of the measuring points

$$L_{\mathrm{XY}} = 10\lg\left(\frac{1}{3}\times 10^{L_{\mathrm{XY},1}/10} + \frac{2}{3}\times 10^{L_{\mathrm{XY},2}/10}\right)\ \mathrm{dB} \qquad (14)$$

where

$L_{\mathrm{XY,i}}$ is the weighted sound pressure level at position 1 being the corner position

$L_{\mathrm{xy,2}}$ is the weighted sound pressure level measured at the position 2 being in the reverberant field of the room.

Index x relates to frequency weighting used (x = A or C).

- Index y characterizes there the temporal weighting (y = F, S or equivalent continuous level L_{eq})

NOTE The different measures L_{XY} are not comparable. Only measurement results obtained with the same measuring parameters should be compared

3.15
standardized service equipment sound pressure level
sound pressure level corresponding to a reference of the reverberation time in the receiving room. This quantity is denoted by $L_{\mathrm{XY,nT}}$

$$L_{\mathrm{XY,nT}} = L_{\mathrm{XY}} - k \quad \mathrm{dB} \qquad (15)$$

where

L_{XY} is the service equipment sound pressure level;

k is the reverberation index

in this case, k is calculated from the arithmetic average of the reverberation times measured for the octave-bands 500Hz, 1kHz and 2kHz.
K = 10lg 1/3 [(T_{500} + T_{1000} + T_{2000})/T_0]

3.16
normalized service equipment sound pressure level
service equipment sound pressure level corresponding to the reference equivalent absorption area in the receiving room. This quantity is denoted by $L_{\mathrm{XY,n}}$

$$L_{\mathrm{XY,n}} = L_{\mathrm{XY}} - k - 10\lg\frac{A_0\ T_0}{0{,}16\ V}\ \mathrm{dB} \qquad (16)$$

where

L_{XY} is the service equipment sound pressure level;

V is the volume of the receiving room in cubic metres;

k is the reverberation index;

in this case, k is calculated from the arithmetic average of the reverberation times measured for the octave-bands 500Hz, 1kHz and 2kHz.
K = 10lg 1/3 [(T_{500} + T_{1000} + T_{2000})/T_0]

T_0 is the reference reverberation time (T_0 = 0,5 s);

A_0 is the reference absorption area (A_0 = 10 m^2);

0,16 has the unit s/m

4 Single number quantities

The single number quantities of service equipment noise which can be determined according to this document are given in Table 1. When reporting measurement results the notation in Table 1 shall be used. The different quantities can be combined according to e.g. requirements in national building code regulations. Single number quantities of airborne and impact sound insulation can be obtained according to EN ISO 717-1.

Table 1 — Quantities for service equipment sound pressure level

	A-weighted value	*C*- weighted value
Maximum sound pressure level, time weighting «*S*»	L_{ASmax} [1] $L_{ASmax,nT}$ [2] $L_{ASmax,n}$ [3]	L_{CSmax} [1] $L_{CSmax,nT}$ [1] $L_{CSmax,n}$ [3]
Maximum sound pressure level, time weighting «*F*»	L_{AFmax} [1] $L_{AFmax,nT}$ [2] $L_{AFmax,n}$ [3]	L_{CFmax} [1] $L_{CFmax,nT}$ [2] $L_{CFmax,n}$ [3]
Equivalent sound pressure level	L_{Aeq} [1] $L_{Aeq,nT}$ [2] $L_{Aeq,n}$ [3]	L_{Ceq} [1] $L_{Ceq,nT}$ [2] $L_{Ceq,n}$ [3]

1 No standardization/normalization.

2 Standardization to a reverberation time of 0,5 s.

3 Normalization to an equivalent sound absorption area of 10 m^2.

5 Instrumentation

The measuring service equipment shall comply with the requirements of Clause 6.

The sound source for measuring sound insulation between rooms shall be as omnidirectional as practicable. In façade measurement, the opening angle shall cover the whole façade. The directivity of the sound source and the distance to the façade must be such that the variations between pressure levels measured in front of the façade, for each frequency band of interest, are less 5 dB.

The tapping machine shall comply with the requirements given in Annex A of EN ISO 140-7:1998.

The accuracy of the sound pressure level measurement equipment shall comply with the requirements of accuracy classes 0 or 1 defined in EN 60651 and EN 60804. The complete measuring system including the microphone shall be adjusted before each measurement to enable absolute values of sound pressure levels to be obtained.

For all measurements diffuse field microphones are required. For sound level meters with free field microphones corrections for accounting the diffuse sound field shall be applied.

Filters shall comply with the requirements defined in EN 61260.

NOTE For pattern evaluation (type testing) and regular verification tests recommended procedures for sound level meters are given in OIML R58 and R88, for the tapping machine requirements are given in Annex A of EN ISO 140-7:1998.

6 Test procedure and evaluation

6.1 General

The measurements of airborne sound insulation and of impact sound insulation are made in octave bands. The measurements of service equipment sound pressure levels are made in A-weighted or C-weighted sound pressure levels. The measurements shall be performed with doors and windows closed and shutters normally open. Operating cycles and operating conditions for measuring of service equipment noise are given in Annex B. They shall only be used if they are not opposed to national requirements and regulations.

6.2 Generation of sound field

6.2.1 General

If the difference between the signal level and the background noise level is less than 6 dB, the measured signal level shall be recorded in the report. A note shall be added to say that the measured receiving room level was affected by background noise and the corresponding level difference has been underestimated or than the measurement level (service equipment) has been overestimated by an unknown amount.

No correction for background noise shall be applied.

For measurements of the airborne sound insulation between rooms and the airborne sound insulation of façades using the loudspeaker method, the sound power of the source should be adjusted so that the sound pressure level in the receiving room (in each frequency band) is at least 6 dB higher than the background noise level. This shall be checked by switching the source on and off before starting the measurement.

When measuring the airborne sound insulation of façades by the traffic sound method, the background noise level in the receiving room cannot easily be assessed. Because of this, steps should be taken to ensure that the noise level in the receiving room due to sources within the building is as low as practicable. Excessive background noise from internal sources will lead to an underestimate of the façade insulation. A comment shall be made in the report if this is thought to have occurred.

6.2.2 Airborne sound insulation between rooms

The sound generated in the source room shall be steady and have a continuous spectrum in the frequency range considered. Filters with a bandwidth of one octave may be used. When using broad-band noise, the spectrum of the sound source may be shaped to ensure an adequate signal-to-noise ratio at high frequencies in the receiving room.

If the sound source enclosure contains more than one loudspeaker operating simultaneously, the loudspeakers shall be driven in phase. Multiple sound sources may be used simultaneously providing they are of the same type and are driven at the same level by similar, but uncorrelated, signals.

Place the sound source in a corner of the room opposite the separating element. The distance from the walls shall be at least 0,5 m. If the source is a single loudspeaker system it should be placed facing the corner.

When testing rooms in a vertical direction, use the lower room as the source room. When testing rooms of unequal size in a horizontal direction, use the larger room as the source room unless it has been previously agreed that the test should be in the other direction.

6.2.3 Impact sound insulation between rooms

The impact sound shall be generated by the standard tapping machine (see EN ISO 140-7). The tapping machine shall be placed in the source room on the diagonal near the centre of the floor. This single position is sufficient if the floor is isotropic.

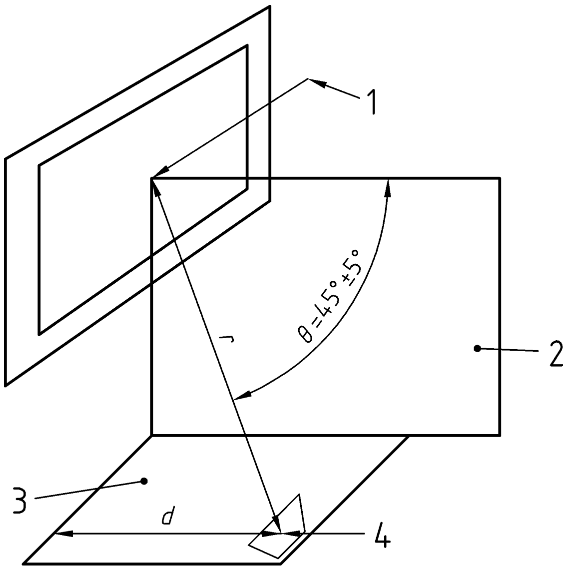
In the case of anisotropic floor constructions (with ribs, beams, etc.) add two positions so that the three positions are randomly distributed over the floor area. The hammer connecting line should be orientated at 45° to the direction of the beams or ribs. In these cases, the distance of the tapping machine from the edges of the floor shall be at least 0,5 m.

6.2.4 Airborne sound insulation of façades

The airborne sound insulation of façades is measured by using an outside loudspeaker or road traffic sound. The room behind the façade serves as the receiving room.

6.2.4.1 Loudspeaker method

Place the loudspeaker outside the building at a distance d from the façade with the angle of sound incidence as close as possible to 45° (see Figure 1). Choose the position of the loudspeaker and the distance d to the façade so that the variation of the sound pressure level on the test specimen is minimized. The sound source is preferably placed on the ground. Alternatively place the sound source as high above the ground as practically possible. The distance r from the sound source to the centre of the test specimen shall be at least 7 m ($d > 5$ m) from the façade being tested.



Key

1 Normal to the façade
2 Vertical plane
3 Horizontal plane
4 Loudspeaker

Figure 1 — Geometry of the loudspeaker method

The sound generated shall be steady and have a continuous spectrum in the frequency range considered. Filters with a bandwidth of one octave band may be used. When using broad-band noise the spectrum of the sound source may be shaped to ensure an adequate signal-to-noise ratio at high frequencies in the receiving room.

6.2.4.2 Traffic sound method

The traffic sound method with road traffic as sound source may be used if the sound pressure level is high enough in relation to the background noise in the receiving room. If the sound is incident on the façade from different directions and with varying intensity, such as road traffic sound in busy streets, the façade level difference is obtained from the average sound pressure levels measured simultaneously on both sides of the façade.

NOTE Due to background noise the traffic sound method is normally limited to measure $D_{nT,w} < 40$ dB.

6.3 Measurement of sound pressure levels

6.3.1 Airborne and impact sound insulation between rooms

To determine the insulation against airborne sound, measure in the source and receiving rooms; to determine insulation against impact sound, measure only in the receiving room. In both cases measure the average sound pressure level in each of the specified octave bands using an integrating sound level meter. The measurement time interval shall be approximately 30 s. Stand near the centre of the floor and face away from the loudspeaker in the source room or from the separating element in the receiving room. Hold the sound level meter out at arm's length. Move the microphone four times horizontally through 180°, moving the arm up and down in a gentle movement during the traverse (see Figure 2). Complete the four rotations in a total time of approximately 30 s. If a parallel octave-band or real time octave-band sound level meter is not available, carry out this procedure for each octave band, and read each L_{eq} for 30 s band level from the meter to obtain an estimate of the average octave band levels in the room.

Figure 2 — Example for movement of the sound level meter

The following separating distances are minimum values and shall be exceeded where practicable:

— 0,5 m between any microphone position and room boundaries;

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

NOTE Hearing protectors should be worn by the operator when measuring in the source room.

6.3.2 Airborne sound insulation of façades

Place the outdoor microphone at a distance of (2,0 ± 0,2) m from the plane of the façade or at such a larger distance that the distance to the part of the façade nearest to the road - for instance the balustrade - is at least 1 m. If the sound source is a loudspeaker measure the outdoor sound pressure level with an integration time of 30 s and the level in the receiving room according to 6.3.1.

If the sound source is the prevailing road traffic, measure the outdoor level and the indoor level simultaneously. The integration time shall be 60 s and the indoor level is obtained by repeating the procedure of 6.3.1 during this period. During this measurement period at least 15 vehicles shall have passed.

NOTE Making sound (e.g. of clothes) should be avoided when moving the sound level meter (Figure 2). Sometimes it may be necessary to use 3 or 5 fixed positions.

6.3.3 Service equipment sound pressure level

Measure the service equipment sound pressure level in the room directly using a sound level meter. Two fixed positions are used. One position shall be close to the apparent corner with the acoustically hardest surfaces, preferably in a distance of 0,5 m from the walls. The second position shall be in the reverberant field of the room. The distance to any sound source (for example: ventilation outlets) shall be at least 1,5 m.

In each position the measurement time interval shall be chosen in accordance with at least one cycle of the service equipment working under normal conditions. Use three cycles of the service equipment working under normal conditions. The operation cycles are given in Annex B.

In order to calculate the average sound pressure level according to equation (14) weight the measurement of the two microphone positions as follows: Take the measurement at the corner position once and the measurement in the reverberant field twice.

6.4 Frequency range of measurements

The sound pressure levels measured using octave band filters shall cover at least the following midband frequencies in hertz:

125 Hz	250 Hz	500 Hz	1 000 Hz	2 000 Hz

Sound from service equipment installed is measured in A- or C-weighted sound pressure level with the specific time weighting.

6.5 Reverberation index data

In the survey method described in this document, the reverberation time (the correction for reverberation time) may either be based on measurements or estimated with the aid of Table 2 and Table 3.

To make the estimate for unfurnished rooms, Table 2 shall be used to classify the room according to the type of walls, floor, ceiling and floor covering. Table 3 is then used to find the reverberation index which corresponds to this classification. For furnished rooms Table 2 can be used directly. Reverberation indices are given for octave bands, and also for A- and C-weighted sound pressure levels.

Table 3 takes account of room volume, and is valid for rooms typical of those in dwellings. However, it may also be used for comparable rooms in other types of building.

NOTE 1 The Table is based on a statistical evaluation of reverberation times obtained in dwellings, as typically constructed in several European countries in the period 1960 to 1980. The standard deviation of the reverberation indices calculated from these data is approximately 1 dB. Changed construction methods or habitation habits may give rise to systematic deviations.

Alternatively, the reverberation time may be measured according to the specifications for the survey method described in ISO/CD 3382-2:2003, 5.2 in octave bands and the reverberation index may be calculated by using the measured reverberation times according to equation (3). Measurement of reverberation time can be advantageous if performed only once in a typical room of a building under test which has a large number of identical rooms (for instance in hotels). For noise measurement of service equipment realised in term of global weighted level, for calculation of reverberation index k the reverberation time is the average between the data in the octave bands of 500 Hz, 1 000 Hz and 2 000 Hz.

The tabular values of the reverberation indices are listed in Table 3. Table 3 is valid for a reference reverberation time T_0 = 0,5 s and for room sizes of up to 150 m^3. Furnished rooms like living rooms, sleeping rooms and rooms of similar volume and furniture are considered in one group. Furnished kitchens and bathrooms are considered separately. Concerning unfurnished rooms the reverberation index depends on the type of construction as listed in Table 2.

Table 2 — List of symbols representing the type of construction

Unfurnished	Soft floor covering		Hard floor covering	
Floor type	light	heavy	light	heavy
Light walls/ceiling	a	b	c	d
Heavy walls/ceiling	e	f	g	h

"Light wall" is typically a plasterboard or wooden wall mounted on studs. Heavy walls covered with plasterboard linings shall be considered as light walls.

"Heavy wall" is typically a masonry or concrete block wall without lining.

"Light floor" is typically a floor of wooden planks or boards on timber beams.

"Heavy floor" is typically a concrete slab with or without floating concrete covering.

"Floor covering" is typically carpet (soft), tiles or timber flooring (hard).

If the type of construction is not the same throughout the room, but the areas of different construction are approximately equal, use the average of the values given for the different construction types. For example: if a room has a heavy floor with a carpet, three heavy walls, one light wall and a light ceiling, use the average of b and f. If the areas of different construction are not approximately equal, use the value for the type of construction having the largest area.

NOTE 2 The reverberation indices for A- and C-weighting were derived by averaging the data in the octave bands between 500 Hz and 2 000 Hz. This method is appropriate in the cases of receiving room levels without strong components in the low frequency range. This applies to the measurement of broad-band equipment sound spectra.

Table 3 — Reverberation index data in dB in octave bands and corresponding to *A*- or *C*-weighted sound pressure levels

Volume V in m^3		$V < 15$						$15 \le V < 35$					
Octave bands in Hz		125	250	500	1 000	2 000	*A*, *C*	125	250	500	1 000	2 000	*A*, *C*
Furnished rooms:													
kitchens		0	0	0	0	0	0	0	0,5	0	0	0	0
bathrooms		1	1	0	0	-0,5	0	1,5	1,5	0,5	0,5	0	0,5
others		0	0	- 0,5	- 0,5	- 1	- 0,5	0	0	0	0	- 0,5	0
Unfurnished rooms:													
type:	a	0	1	1	1	0	0,5	1	1,5	1,5	1	0,5	1
	b	1	2,5	3	2,5	2	2	1	3	3,5	3	2,5	2,5
	c	0	2,5	3,5	4	4	4	1	3	4	4,5	4	4,5
	d	0	2,5	3	4	4	4	1	3	3,5	4,5	4	4,5
	e	3,5	3,5	3,5	3,5	1,5	3,5	3,5	4	4	4	2	4
	f	4,5	4,5	4,5	3,5	2,5	3,5	4,5	4,5	4,5	4	3	4
	g	3,5	4	4,5	5	5	5	4	5	5	5	5	5,5
	h	4	4,5	5	5	4,5	5	4,5	5	5,5	5,5	5	5
Mixed type:	a+e	2	2,5	2,5	2,5	1	2	2,5	3	3	2,5	1,5	2,5
	b+f	3	3,5	4	3	2,5	3	3	4	4	3,5	3	3,5
	c+g	2	3,5	4	4,5	4,5	4,5	2,5	4	4,5	5	4,5	5
	d+h	2	3,5	4	4,5	4,5	4,5	3	4	4,5	5	4,5	5

Volume V in m^3		$35 \le V < 60$						$60 \le V < 150$					
Octave bands in Hz		125	250	500	1 000	2 000	*A*, *C*	125	250	500	1 000	2 000	*A*, *C*
Furnished rooms (except bathrooms and kitchens)		0,5	0,5	0,5	0	0	0	0,5	0,5	0,5	0,5	0	0,5
Unfurnished rooms:													
type:	a	1	2	2	1,5	1	1,5	1	2,5	2,5	2	1,5	2
	b	2	3,5	4	3,5	2,5	3	2,5	4	4,5	3,5	2,5	3,5
	c	1,5	3,5	4,5	5	4,5	5	2	4	5	5,5	5	5,5
	d	1,5	3,5	4	5	5	5	2	4	4,5	5,5	5,5	5,5
	e	4	4	4,5	4	2,5	4	4	4	5	4,5	3	4,5
	f	4,5	4,5	4,5	4	3	5	4,5	5	5	4	3	5
	g	4,5	5	5,5	5,5	5,5	5,5	5	5,5	6	6	6	6
	h	5	5,5	6	5	5,5	5,5	5,5	6	6,5	5,5	6	6
mixed type:	a+e	2,5	3	3,5	3	2	3	2,5	3,5	4	3,5	2,5	3,5
	b+f	3,5	4	4,5	4	3	4	3,5	4,5	5	4	3	4,5
	c+g	3	4,5	5	5,5	5	5,5	3,5	5	5,5	6	5,5	6
	d+h	3,5	4,5	5	5	5,5	5,5	4	5	5,5	5,5	6	6

6.6 Precision

It is required that the measurement procedure gives satisfactory reproducibility. This can be determined in accordance with the method shown in EN 20140-2 and shall be checked from time to time, particularly when a change is made in procedure or instrumentation.

NOTE Numerical requirements for reproducibility of the engineering methods for airborne and impact sound insulation are given in EN 20140-2. It is estimated that the results from the survey test method and the corresponding engineering method differ within ± 2 dB.

7 Expression of results

7.1 Airborne sound insulation

For the statement of the airborne sound insulation, the values of the standardized level difference D_{nT}, the normalized level difference D_n or the apparent sound reduction index R', $R'_{45°}$, $R'_{tr,s}$ shall be given at all frequencies of measurement, to one decimal place, in tabular form and in the form of a curve. Graphs in the test report shall show the value in decibels plotted against frequency on a logarithmic scale, and the following dimensions shall be used:

— 15 mm for an octave band;

— 20 mm for 10 dB.

The use of a form in accordance with Annex A is preferred. Being a short version of the test report it shall include all information of importance regarding the test object, the test procedure and the test results.

For the evaluation of single-number ratings from the octave-band results, see EN ISO 717-1. It shall be clearly stated that the evaluation has been based on a result obtained by a field survey method.

7.2 Impact sound insulation

For the statement of the impact sound insulation, the values of the standardized impact sound pressure level L'_{nT} or the normalized impact sound pressure level L'_n shall be given at all frequencies of measurement, to one decimal place, in tabular form and in the form of a curve. Graphs in the test report shall show the value in decibels plotted against frequency on a logarithmic scale, and the following dimensions shall be used:

— 15 mm for an octave band;

— 20 mm for 10 dB.

The use of a form in accordance with Annex A is preferred. Being a short version of the test report it shall include all information of importance regarding the test object, the test procedure and the test results.

For the evaluation of single-number ratings from the octave-band results, see EN ISO 717-2. It shall be clearly stated that the evaluation has been based on a result obtained by a field survey method.

7.3 Service equipment sound pressure level

For the statement of the sound pressure level from housing service equipment quantities given in Table 1 shall be given A- or C-weighted rounded to one dB.

Being a short version of the test report it shall include all information of importance regarding the test object, the test procedure and the test results.

8 Test report

The test report shall state:

a) reference to this document;

b) name of the organization which has performed the measurements;

c) name and address of the organization or person who ordered the test (client);

d) date of test;

e) identification (location of the building, identification of the rooms, description of the test arrangement);

f) description of the building construction;

g) volumes of the rooms tested;

h) room type which was used (the reference reverberation time, if different from 0,5 s);

i) area of the separating element tested (where appropriate);

j) relevant quantity describing the acoustical property of the building:

   i) standardized level difference D_{nT} or the normalized level difference D_n or the apparent sound reduction index R', $R'_{45°}$, $R'_{tr,s}$ as a function of frequency;

   ii) normalized impact sound pressure level L'_n or the standardized impact sound pressure level L'_{nT} as a function of frequency;

   iii) standardized service equipment sound pressure level $L_{XY,nT}$;

   iv) normalized service equipment sound pressure level $L_{XY,n}$;

k) for service equipment:

— description of the relevant aspects of the service equipment and its operating condition (quantitatively and qualitatively);

— location of the corner position;

— note on the check of background noise, if necessary;

l) for water installations:

1) normative:

— position of stop cocks;

— description of all relevant aspects of the water installation and the operating conditions;

2) optional:

— flow pressure (cold and warm water system);

— flow rate / refilling time for cisterns;

- manufacture and destination of the valve or device;
- sound class and flow rate for valves or devices classified according to EN ISO 3822-1;
- flow rate, static pressure and flow pressure of the valves during the test;
- volume and filling time of the flush tank (if possible).

Annex A
(informative)

Forms for the expression of results

This Annex gives examples for the expression of results for the field measurements of airborne and impact sound insulation using the survey method.

The curves of reference values shown in the forms are taken from EN ISO 717-1 and EN ISO 717-2. The reference curves should be supplemented or at least replaced by the shifted reference curves according to the procedure described in EN ISO 717-1 or EN ISO 717-2.

Normalized level difference according to EN ISO 10052

Client:

Date of test:

Description and identification of the building construction and test arrangement, direction of measurement:

Source room volume: m^3

Receiving room volume: m^3

···· Frequency range according to the curve of reference values

— Curve of reference values (EN ISO 717-1)

Frequency f Hz	D_n (octave) dB
125	
250	
500	
1 000	
2 000	

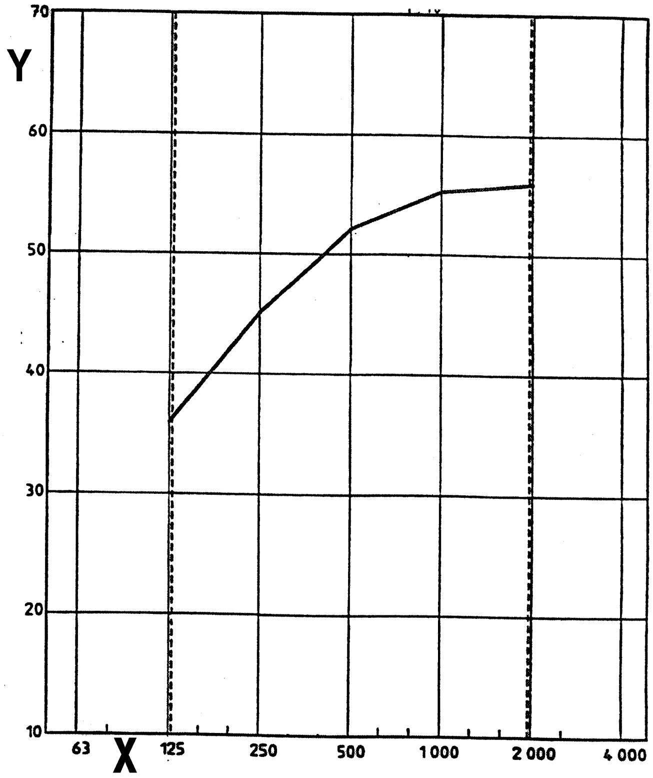


Figure A.1

Key

X Frequency f, Hz

Y Normalized level difference, D_n, dB

Rating according to EN ISO 717-1:

$D_{n,w}$ (C; C_{tr}) = ( ) dB

Evaluation based on field measurement results obtained by a survey method

N° of test report:

Name of test institute:

Date:

Signature:

Standardized level difference according to EN ISO 10052
Field measurements of airborne sound insulation between rooms

Client:

Date of test:

Description and identification of the building construction and test arrangement, direction of measurement:

···· Frequency range according to the curve of reference values

— Curve of reference values (EN ISO 717-1)

Source room volume: m^3

Receiving room volume: m^3

Frequency f Hz	D_{nT} (octave) dB
125	
250	
500	
1 000	
2 000	

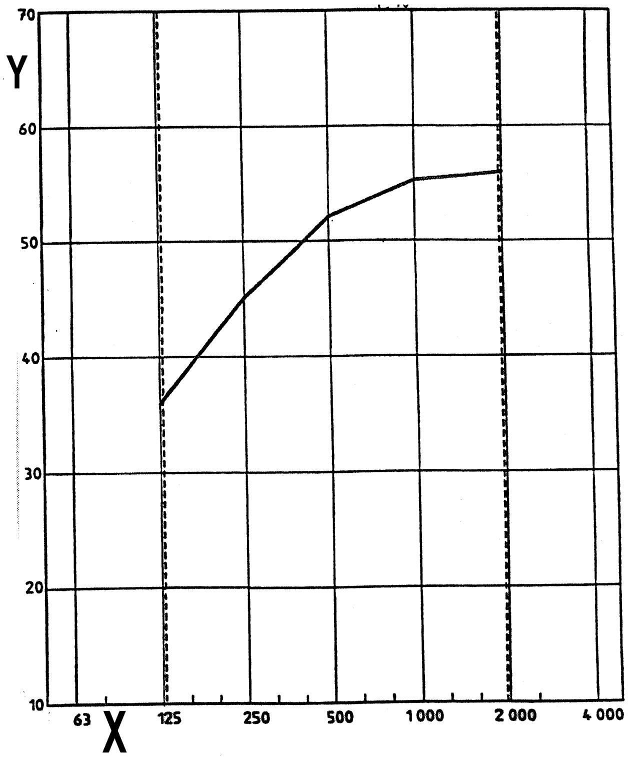


Figure A.2

Key

X Frequency f, Hz

Y Normalized level difference, D_{nT}, dB

Rating according to EN ISO 717-1:

$D_{nT,w}$ (C; C_{tr}) = ( ) dB

Evaluation based on field measurement results obtained by a survey method:

N° of test report:

Name of test institute:

Date:

Signature:

Apparent sound reduction index according to EN ISO 10052
Field measurements of airborne sound insulation between rooms

Client:

Date of test:

Description and identification of the building construction and test arrangement, direction of measurement:

Area *S* of separating element: m^3

Source room volume: m^3

Receiving room volume: m^3

Frequency *f* Hz	*R'* (octave) dB
125	
250	
500	
1 000	
2 000	

···· Frequency range according to the curve of reference values

— Curve of reference values (EN ISO 717-1)

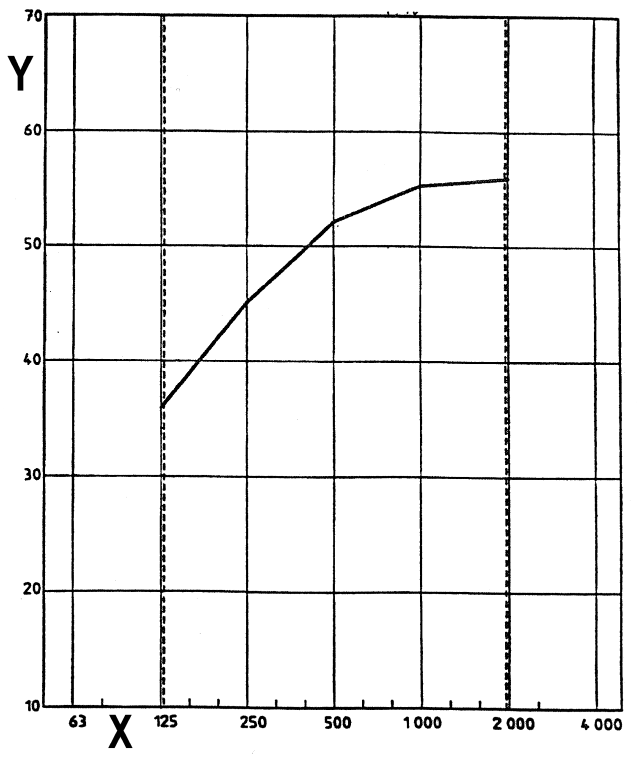


Figure A.3

Key

X Frequency *f*, Hz

Y Apparent sound reduction index, *R'*, dB

Rating according to EN ISO 717-1:

R'_w (C; C_{tr}) = ( ) dB

Evaluation based on field measurement results obtained by a survey method

N° of test report:

Name of test institute:

Date:

Signature:

Normalized impact sound pressure levels according to EN ISO 10052
Field measurements of impact sound insulation of floors

Client:

Date of test:

Description and identification of the building construction and test arrangement:

···· Frequency range according to the curve of reference values

— Curve of reference values $L'_{n,W}$ = 60 dB (EN ISO 717-2)

Receiving room volume: m^3

Frequency f Hz	L'_n (octave) dB
125	
250	
500	
1 000	
2 000	

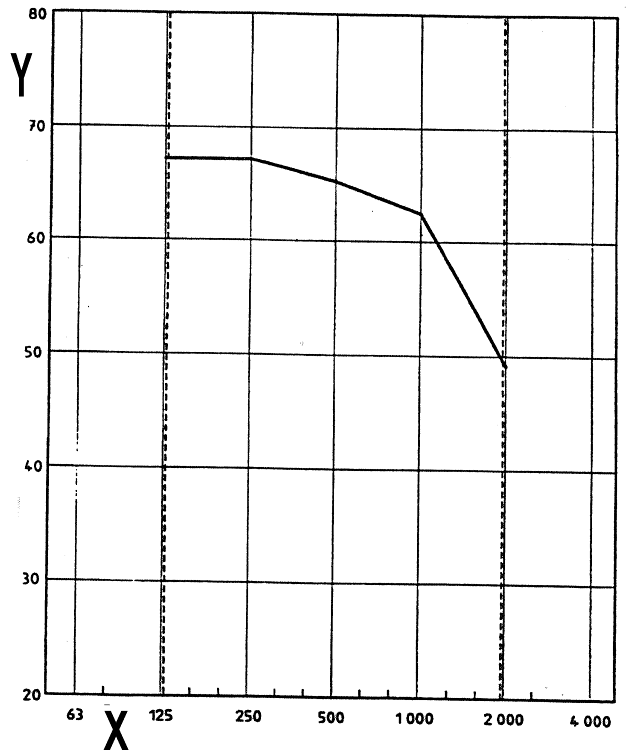


Figure A.4

Key
X Frequency f, Hz
Y Normalized impact sound pressure level, L'_n, dB

Rating according to EN ISO 717-2:

$L'_{n,W}$ (C_1) = ( ) dB

Evaluation based on field measurement results obtained by a survey method:

N° of test report:

Name of test institute:

Date:

Signature:

Standardized impact sound pressure levels according to EN ISO 10052

Client:

Date of test:

Description and identification of the building construction and test arrangement:

Receiving room volume: m^3

···· Frequency range according to the curve of reference values

— Curve of reference values $L'_{nT,W}$ = 60 dB (EN ISO 717-2)

Frequency f Hz	L'_{nT} (octave) dB
125	
250	
500	
1 000	
2 000	

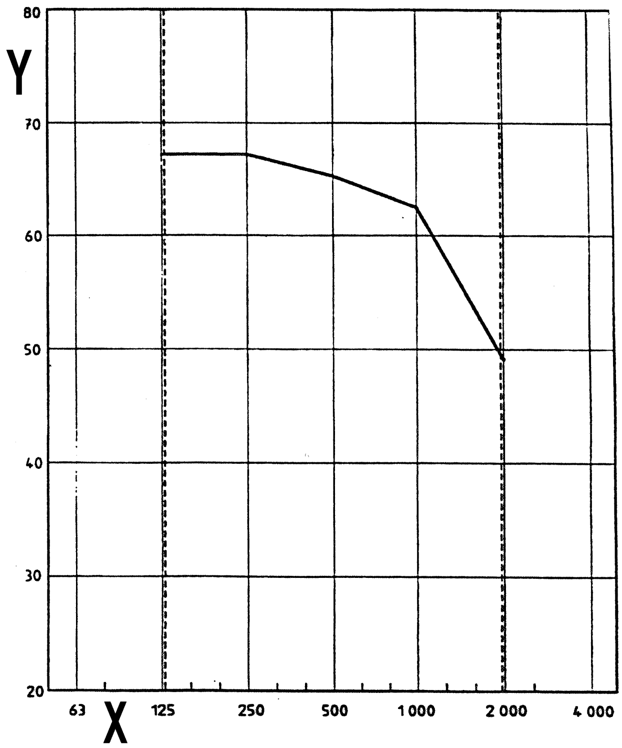


Figure A.5

Key

X Frequency f, Hz

Y Standardized impact sound pressure level, L'_{nT}, dB

Rating according to EN ISO 717-2:

$L'_{nT,W}$ (C_1) = ( ) dB

Evaluation based on field measurement results obtained by a survey method.

N° of test report:

Name of test institute:

Date:

Signature:

Annex B
(normative)

Operating conditions and operating cycles for measuring the maximum sound pressure level and the equivalent continuous sound pressure level

B.1 General principles

B.1.1 General

In the following, operating conditions and operating cycles are given for the most common service equipment in buildings. They shall only be used if they are not opposed to national requirements and regulations. However, service equipment not mentioned in the following can be measured according to the principles stated in this document. The chosen operating conditions and operating cycle shall then be reported in detail.

B.1.2 Maximum sound pressure level (L_{max})

In this Annex L_{max} is used as a general symbol for the respective quantities given in Table 1. The basic principle for measuring the maximum sound pressure level is that the service equipment under test during the measurement is operated - automatically or manually - within the limits of normal practical use. For service equipment with a constant sound level the maximum sound pressure level is determined during a measurement period of approximately 30 s. For service equipment with sound varying with time the maximum sound pressure level is determined for a typical operation, e.g. during the period of opening and closing a water tap.

B.1.3 Equivalent continuous sound pressure level (L_{eq})

In this Annex L_{eq} is used as a general symbol for the respective quantities given in Table 1. The basic principle for measuring the equivalent continuous sound pressure level is that the integration time corresponds to a typical operating cycle of the service equipment under test.

For water taps the equivalent continuous sound pressure level is measured with the tap fixed at the position causing the highest sound pressure level.

B.2 Water installations

B.2.1 General operating conditions

For sound measurements on water taps, normally the water shall be drained off the sink, shower cabin or tub during the measurement.

It shall be ensured that all functions are in normal operation (water pressure, flow rate etc.). For water installations the stop cocks shall be completely open, or when this is not the case the position shall be reported. Measurement and reporting of the flow pressure and the flow rate of the valve are optional.

Normally the sound pressure level from sanitary installations is not measured in the room where the installation is mounted, but exclusively in surrounding rooms (e.g. neighbouring dwellings).

L_{max}:

The maximum sound pressure level at each microphone position is determined for a specified operating condition and operating cycle of the installation under test as prescribed in B.2.2 to B.2.6.

Measurement on water installations starts before the installation is operated and stops after the operating cycle has ended.

L_{eq}:

Concerning water taps the measurement is carried out with the tap fixed in the position causing the highest sound pressure level (see B.2.2, operating cycle for the equivalent continuous sound pressure level).

B.2.2 Water tap

a) Operating conditions

L_{max} **and** L_{eq}:

If the outlet of the tap or valve is movable, it shall be placed in the position closest to the middle of the sink (for further operating conditions, see B.2.1).

b) Operating cycles

L_{max}:

Taps with one inlet: Open the tap completely, wait a few seconds and then turn off the tap.

Mixing valves with similar independent controls for hot and cold water: Open the hot tap completely, open the cold tap, wait a few seconds, close the hot tap and then close the cold tap.

Mixing valves with one dual function control for flow and temperature: Open the control completely at average temperature setting, decrease the temperature to the minimum, and then increase the temperature to the maximum, wait until the maximum temperature has been reached and close the control.

Mixing valves with independent controls for flow and temperature: Open the flow control completely at average temperature setting, decrease the temperature to the minimum and then increase the temperature to the maximum, wait until the maximum temperature has been reached and close the control.

Thermostatic mixing valves: Open the tap completely at average temperature setting, decrease the temperature to the minimum and then increase the temperature to the maximum and close the tap.

L_{eq}:

The integration time is approximately 30 s.

Taps with one inlet: open the tap and find the position causing the highest sound pressure level. The taps shall be fixed in this position during the measurement.

Mixing valves with similar independent controls for hot and cold water: open both the hot tap and the cold tap and find the position causing the highest sound pressure level. The taps shall be fixed in this position during the measurement.

Mixing valves with one dual function control for flow and temperature: open the tap and find the position causing the highest sound pressure level at average temperature setting. The taps shall be fixed in this position during the measurement. The sound pressure level with the taps in hot-water position and cold-water position, respectively, shall be checked. The highest of the three levels is the measurement result.

Mixing valves with independent controls for flow and temperature, and thermostatic valves: open the tap and find the position causing the highest sound pressure level at average temperature setting. The taps shall be fixed in this position during the measurement. The sound pressure level with the tap in hot-water position and cold-water position respectively, shall be checked. The highest of the three levels is the measurement result.

B.2.3 Shower cabin

a) Operating conditions

$L_{\mathbf{max}}$ **and** $L_{\mathbf{eq}}$:

The shower shall be placed in the wall fixture at its highest position above floor level and the shower shall be directed towards the floor of the cabin (for further operation conditions, see B.2.1).

b) Operating cycle

The measurement is performed according to B.2.2.

If a distinction is needed between the sound pressure level originating by the impact sound excitation from the water bouncing on the floor of the cabin and the sound pressure level originating by using the valves, the water shall be drained off soundlessly (measurement of the valves alone).

B.2.4 Bath (tub)

a) Operating conditions

$L_{\mathbf{max}}$ **and** $L_{\mathbf{eq}}$:

If the tap of the bath is a combination of a nozzle exclusively for filling the bath and a separate shower, the two functions shall be regarded separately. If there is no fixture on the wall, the shower shall be held at a height above the bottom of the tub of approximately 1,5 m. Emptying the bath shall take place simultaneously with the measurement (for further operating conditions see B.2.1).

b) Operating cycle

$L_{\mathbf{max}}$ **and** $L_{\mathbf{eq}}$:

The measurement is performed according to B.2.2 and, if the bath is fitted with a shower, according to B.2.3.

If a distinction is needed between the sound pressure level originating by the impact sound excitation from the water bouncing on the bottom of the tub and the sound pressure level originating by using the valves, the water shall be drained off soundlessly (measurement of the valves alone).

B.2.5 Filling and emptying sinks and baths

a) Operating conditions

$L_{\mathbf{max}}$ **and** $L_{\mathbf{eq}}$:

If the sound pressure level from filling and emptying sinks and baths is to be measured separately, the plug is closed and the sink/bath is filled to half of the maximum level during the measurement. Hot and cold water is mixed equally with the tap(s) in fully opened position(s) (for further operating conditions see B.2.1).

The plug is opened and a new measurement is carried out during the emptying period.

b) Operating cycle

L_{max}:

The measurement is carried out first during the filling and then during the emptying period.

L_{eq}:

Integration time is equal to the filling period and emptying period.

B.2.6 Water closet (Toilet)

a) Operating conditions

L_{max} and L_{eq}:

The sound from a water closet (toilet) consists partly of the sound from flushing the water and partly of sound generated when the cistern is refilled. Flushing valves and flushing cisterns shall be operated to the end stop. In case of a flushing cistern the sound pressure level is measured when the supply valve is fully opened and until the supply valve has closed (for further operating conditions see B.2.1).

b) Operating cycle

L_{max}:

The measurement is carried out during a full flushing/refilling cycle.

NOTE 1 The maximum sound pressure level exclusively generated by flushing the water closet (toilet) can be determined by refilling seven litres of water from a bucket directly into the W.C. pan within about 3 s.

L_{eq}:

The integration time shall correspond to a full flushing/refilling cycle.

NOTE 2 For a water closet (toilet) the equivalent continuous sound pressure level should be supplemented by the maximum A-weighted sound pressure level measured according to B.2.6.

B.3 Mechanical ventilation

a) Operating conditions

L_{max} and L_{eq}:

The part of a ventilation system placed in a dwelling normally consists of vents in living rooms and toilets for comfort ventilation, and cooker hoods in kitchens.

Generally, manually operated systems shall be set to the position with the highest sound pressure level, normally the maximum speed and/or the fully opened position of the vent. Before taking measurements it shall be checked that the system has been adjusted to the correct air-flow.

NOTE 1 In building Code regulations it might be stated that manually operated ventilation systems should be measured at a lower setting than maximum for measurement in the dwelling to which the system belongs.

NOTE 2 Cooker hoods connected to a ventilation system common to the whole building can generate a considerable sound when the vent is fully closed. A measurement with the hood in this operating condition might be appropriate.

b) Operating cycle

L_{max}:

Continuous operating. The measurement time is approximately 30 s.

L_{eq}:

The integration time is approximately 30 s.

B.4 Heating and cooling service equipment

a) Operating conditions

L_{max} **and** L_{eq}:

For individual heating systems the measurement has to be carried out during simultaneous working of the burner under full load, circulation pump, fan and fuel delivery pump (maximum normal water flow; maximum normal airflow).

Cooling systems shall be set to the position with the highest sound pressure level.

b) Operating cycle

L_{max}:

For heating systems, start-up from cold conditions. Operate at full load. Open and close slowly each appliance (taps for heating elements; regulators of air devices) and stop.

For cooling systems the measurement time shall be approximately 30 s.

L_{eq}:

The integration time is approximately 30 s.

NOTE For heating systems the equivalent continuous sound pressure level should be supplemented by the maximum A-weighted sound pressure level measured when operating each appliance (taps for heating elements; regulators of air devices) according to B.4.

L_{max} **and** L_{eq}:

For measurements of sound pressure levels from radiators the water flow shall be stabilized in the thermostat position for the highest possible room temperature. After that search for the thermostat position which causes the maximum constant noise level.

B.5 Lift (Elevator)

a) Operating conditions

L_{max} **and** L_{eq}:

The lift (elevator) shall be loaded with 1 or 2 persons. The load and the number of persons in the lift (elevator) during the measurement shall be reported.

b) Operating cycle

L_{max} **and** L_{eq}:

Start the lift (elevator) from the lowest possible level. Stop at each intermediate level. Open and close the door (if by hand without force). When the lift (elevator) has arrived at the highest level of its shaft, call it back directly to the lowest possible level and then open and close the door.

NOTE For measurements on lifts (elevators) the equivalent continuous sound pressure level should preferably be supplemented by at least the maximum A-weighted sound pressure level.

B.6 Rubbish chute

a) Operating conditions

The chute shall be clear of waste.

b) Operating cycle

L_{max}:

From the top storey two objects are dispatched simultaneously.

The objects shall consist of a tube with open ends and a length of 0,1 m made of unplasticized polyvinyl chloride or a material with similar characteristics. The nominal external diameter shall be 50 mm, and the wall thickness 3 mm. The mass per metre length shall be 0,7 kg/m.

Sound from rubbish chutes shall exclusively be determined as the maximum sound pressure level.

B.7 Boilers, blowers, pumps and other auxiliary service equipment

a) Operating conditions

Continuously operating under normal (loaded) conditions.

b) Operating cycle

L_{max} **and** L_{eq}:

For manually, electrically controlled appliances a cycle of start - operate - stop shall be used.

For automatically controlled service equipment a full cycle shall be used (including start/stop if relevant).

The integration time for measurement of the equivalent continuous sound pressure level shall correspond to the duration of the operating cycle.

B.8 Motor driven car park door

a) Operating conditions

L_{max} **and** L_{eq}:

The car park door shall be in normal operation.

b) Operating cycle

L_{max}:

Opening and closing the door.

L_{eq}:

The integration time shall correspond to a full cycle of opening and closing the door.

B.9 Other types of building service equipment

a) Operating conditions

For other types of service equipment that are not mentioned here, the operating conditions for normal use shall be selected for the measurement.

b) Operating cycle

For other types of service equipment that are not mentioned here, the operating cycle for normal use shall be selected for the measurement.

The integration time for measurement of the equivalent continuous sound pressure level shall correspond to the duration of the operating cycle.

Bibliography

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ICS 17.140.20; 91.120.20; 91.140.01

Price based on 30 pages