BRITISH STANDARD

BS EN 14366:2004

Laboratory measurement of noise from waste water installations

The European Standard EN 14366:2004 has the status of a British Standard

ICS 17.140.20; 91.140.80

British Standards

National foreword

This British Standard is the official English language version of EN 14366:2004.

The UK participation in its preparation was entrusted by Technical Committee EH/1, Acoustics, to Subcommittee EH/1/6, Building acoustics, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

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EN 14366

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English version

Laboratory measurement of noise from waste water installations

Mesurage en laboratoire du bruit émis par les installations d'évacuation des eaux usées

Messung der Geräusche von Abwasserinstallationen im Prüfstand

This European Standard was approved by CEN on 23 September 2004.

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Contents

Foreword

This document (EN 14366:2004) has been prepared 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of an identical text or by endorsement, at the latest by May 2005, and conflicting national standards shall be withdrawn at the latest by May 2005.

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Introduction

Noise from wastewater installations is generated by the flow and fall of water in the piping system. There are many different ways to install such systems in buildings, depending on national building codes. They may be firmly cemented into walls and floors, fixed by clips in walls and covered slabs, or hung exposed in the plenum above a suspended ceiling. It seems advisable, therefore, to define measuring methods for both structure-borne and airborne sound.

Important noise sources are bends after vertical sections, but also discontinuities, e.g. inlets, couplings and sleeves. Apart from that the noise impact on the inhabitants of a building strongly depends on the material properties of the pipes, on the methods used in joining and fastening them and on the local building practice.

1 Scope

This document:

— specifies methods for the measurement of airborne and structure-borne sound produced in waste water and rain water installations under laboratory conditions;

— defines the expression of the results.

It is applicable to waste water piping systems and parts thereof, but not to the actual sources of the wastewater, e.g. lavatories, toilets and bathtubs or any active units. It applies to pipes with natural ventilation and made of any common material in commonly used diameters (up to 150 mm).

The results obtained can be used for the comparison of products and materials. It may serve in estimating the behaviour of waste water systems in a building under certain conditions. Nevertheless, this standard does not provide a normalized procedure for calculating the acoustical properties of such installations in a building.

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 61672-1, *Electroacoustics - Sound level meters - Part 1: Specifications (IEC 61672-1:2002)*.

EN 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 140-3:1995).*

EN ISO 354, *Acoustics – Measurement of sound absorption in a reverberation room (ISO 354:2003).*

EN ISO 6926, *Acoustics – Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels (ISO 6926:2000).*

ISO 5348, *Mechanical vibration and shock – Mechanical mounting of accelerometers.*

ISO 16063-21, *Methods for the calibration of vibration and shock transducers -- Part 21: Vibration calibration by comparison with a reference transducer.*

3 Terms and definitions

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

3.1
waste water
any type of water including rainwater evacuated from buildings into the sewer system

3.2
waste water installation
the total of pipes and all fixing components, used to evacuate waste water, but excluding the actual sources of the waste water, e.g. sinks, toilets, bathtubs, gutter or any active units (pumps…)

3.3
specimen
object of tests according to this standard. Specimens are simple wastewater installation systems with a single path of water flow. Any combination of commercial elements may be assembled to form a specimen

3.4
source room
test room used for airborne sound measurement; the specimen is mounted inside the test room

3.5
receiving room
test room used for structure-borne sound measurement; the specimen is mounted outside the test room

3.6
standard configuration
a mandatory form of specimen used for comparison

3.7
standard mounting
mandatory mounting conditions for the standard configuration

3.8
standard test wall
mandatory test wall used for comparison

3.9
wall structural sensitivity
normalised ratio between a point force exciting the test wall and the sound power radiated by the test wall. The wall structural sensitivity is measured according to a reciprocity method described in Annex A

3.10
reference wall
standardized wall of 250 kg/m^2 used for normalisation of the measurement results and described by a reference structural sensitivity spectrum (given in clause 9)

3.11
frequency range of measurement
range in 1/3 octave bands over which measurements are carried out

4 Notations

f	frequency in Hz
T_e	reverberation time measured in the source (emission) room, in seconds (according to EN ISO 354)
T_r	reverberation time measured in the receiving room, in seconds
V_e	volume in the source room in cubic metres
V_r	volume in the receiving room in cubic metres
L'_s	average sound pressure level due to structure-borne sound measured in the receiving room (according to EN ISO 140-3) before correction for background noise, in decibels
L'_t	average total sound pressure level measured in the source room (according to EN ISO 140-3) including airborne and structure-borne sound, before correction for background noise, in decibels
L_B	measured background sound pressure level, in decibels
L_s	structure-borne sound pressure level after correction for background noise, in decibels
L_t	total sound pressure level after correction for background noise, in decibels
L_{sn}	structure-borne sound pressure level normalized to an equivalent absorption area of 10 m^2, in decibels
L_{tn}	total sound pressure level normalized to an equivalent absorption area of 10 m^2, in decibels
L_{an}	airborne sound pressure level normalized to an equivalent absorption area of 10 m^2, in decibels
$L_{s,A}$	A-weighted structure-borne pressure level, in decibels
$L_{a,A}$	A-weighted airborne sound pressure level, in decibels
D_A	attenuation values of the A-weighted filter, in decibels
T_m	measuring time, in seconds
L_{SS}	wall structural sensitivity level, in decibels
L_{SSR}	structural sensitivity level of the reference wall, in decibels
ΔL_{SS}	structural sensitivity correction in decibels : $\Delta L_{SS} = L_{SS} - L_{SSR}$
L_{sc}	structure-borne sound characteristic level, in decibels : $L_{sc} = L_{sn} - \Delta L_{SS}$
L_W	sound power level (ref 10^{-12} watts) of the sound reference source, in decibels
L'_v	vibration velocity level (ref 10^{-9} m/s) at the clamp fixing, in decibels, before correction for background vibration
L_v	vibration velocity level (ref 10^{-9} m/s) at the clamp fixing, in decibels, after correction for background vibration

5 Principle of the test method

5.1 Structure-borne sound measurements (index s)

The specimen is mounted outside the test room (receiving room), connected as in practice to the test wall using the fixing material specified by the manufacturer of the system. A steady flow of tap water is applied and the total sound transmitted into the test room is measured (L'_s). The specimen is then disconnected from the test wall and the water system operated in order to measure the background noise. The values L'_s are then corrected for background noise giving the values L_s. These values are then normalized (see 9.5) to an equivalent absorption area of 10 m^2 using the measured reverberation time T_r of the receiving room giving the values L_{sn}.

After the last step, the results are corrected for the difference in structural sensitivity between the test wall used and the reference wall (correction given in clause 9).

5.2 Airborne sound measurement (index a)

The specimen is mounted on a test wall inside the test room (source room). Appropriate openings in the ceiling and in the floor are provided. A steady flow of tap water is applied. The sound in the test room, produced as airborne sound radiated directly from the object but also as structure-borne sound radiated by the wall is measured (L'_t). The water flow is stopped in order to measure the background noise. The values L'_t are then corrected for background noise giving the values L_t and normalized to an equivalent absorption area of 10 m^2 using the measured reverberation time T_e of the source room giving the values L_{tn}.

Later in the progress of calculation the structure-borne contribution is subtracted giving the values L_{an}.

6 Equipment

6.1 Requirements for the frequency range of measurement

Throughout this standard the frequency range is limited to the eighteen 1/3 octave bands with mid-frequencies from 100 Hz to 5 000 Hz. If additional information is required in the low frequency range, measurements at 1/3 octaves 50 Hz, 63 Hz and 80 Hz can be made; guidance for such additional measurements is given in EN ISO 140-3:1995 Annex F.

6.2 Requirements for the acoustic equipment

The equipment shall comply with the requirements of EN ISO 140-3:1995 clause 4.

6.3 Requirements for the hydraulic equipment

The hydraulic equipment shall be able to generate flow rates between 0,5 l/s and an upper limit depending on the inner diameter of the tested specimen (given in 9.2). The equipment shall be able to measure the flow with an accuracy of 5 %.

6.4 Requirements for the wall structural sensitivity measuring equipment

The reciprocity method requires the use of a reference sound source calibrated according to EN ISO 6926. The vibration transducer used shall be calibrated according to ISO 16063-21 and fixed according to ISO 5348.

7 Test facilities

7.1 Construction requirements

7.1.1 Test room

The test room shall have a volume of at least 50 m^3 and an interior height of (3,0 ± 0,5) m. The test wall shall not be less than 3,5 m wide. Openings in the ceiling and in the floor are provided for the installation of the test objects.

A combination of two adjacent test rooms may be advantageous, allowing the simultaneous measurement of the airborne and the structure-borne sound.

Additional space above and below the test room is required to ensure the standardised falling height of the measured system of about 6 m (see 8.1.2.).

7.1.2 Test wall

A single wall built of bricks, blocks or poured concrete shall be defined as the standard test wall; hollow bricks or blocks are not allowed. Its mass per unit area, including a coat of mineral based plaster on both sides, shall be (200 ± 50) kg/m^2.

Any other mass per unit area can be used, as long as the applicability condition defined in Annex A.2 is fulfilled.

7.2 Acoustic requirements

According to EN ISO 140-3, the reverberation time shall be in the range 1s – 2s.

8 Test specimen

8.1 Geometry

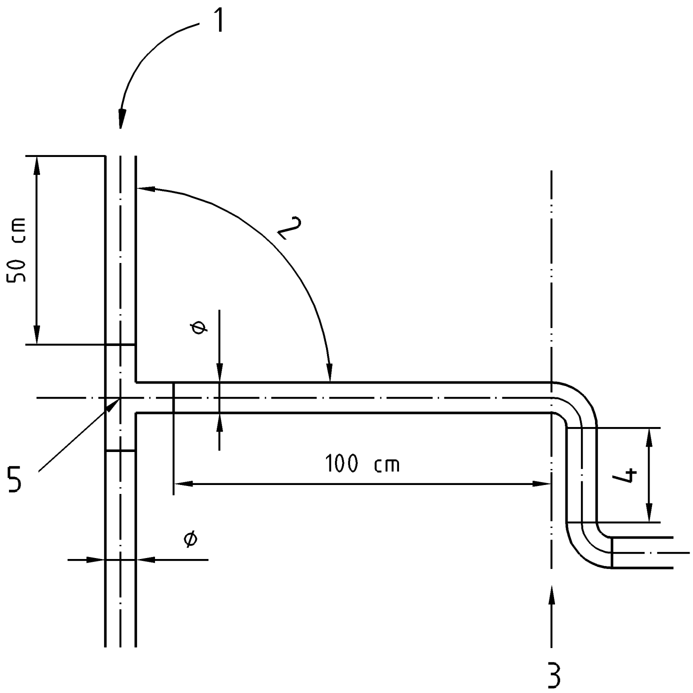
8.1.1 Components

The objects tested according to this standard consist of systems of wastewater installations with a single path of the water flow. They consist of:

- an inlet, part of the test object according to Figure 1;
- any combination of straight pipes with tees, bends, joints and inlets, mounted on the test wall;
- a basement bend of totally approximately 90 degree angle, being part of the specimen.

8.1.2 Falling height h

The falling height h shall be in the range 5,8 m – 7,5 m, measured between the inlet point and the impact point (Figure 2). The inlet point is given as the intersection of the axis of the inlet tube with the axis of the vertical pipe; the impact point is defined by the intersection of the vertical pipe axis with the wall of the basement bend.



Key

1 Silencer when required as part of the test installation

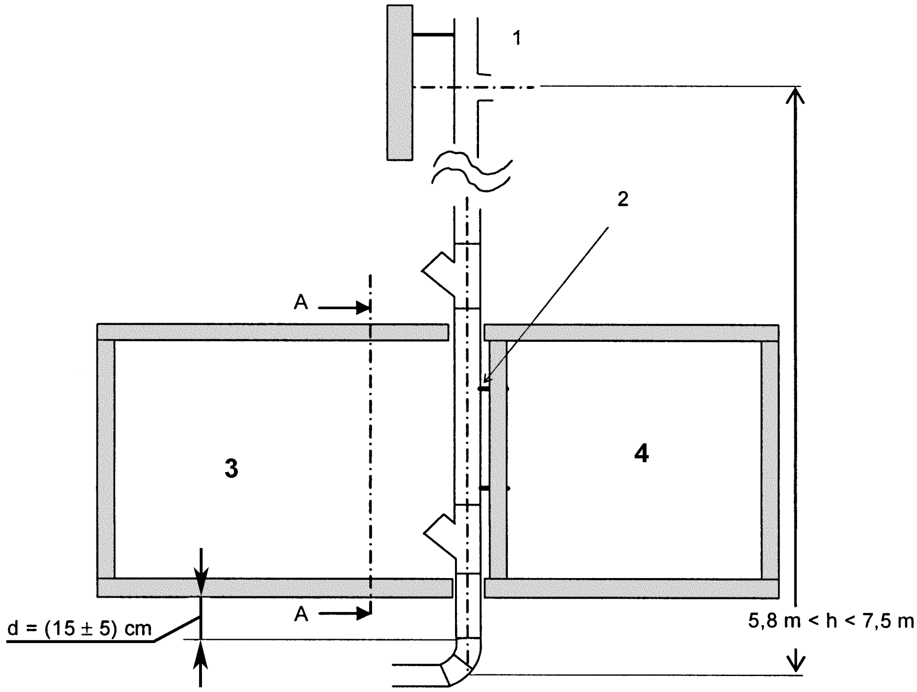
2 Close to 90° (depending on product)

3 Limit of the system

4 25 cm minimum

5 Inlet point

Figure 1 — Inlet configuration



Key

1 Inlet

2 Fixing device

3 Source room

4 Receiving room

Figure 2 — Standard configuration

8.1.3 Standard configuration

For comparison purposes a standard configuration is used, consisting of a straight vertical pipe with an inlet tee within the measuring room and an inlet tee above the test room, both closed by an accessory of the manufacturer. In the standard configuration the basement bend is made of two 45 degree bends of the same material as the test object.

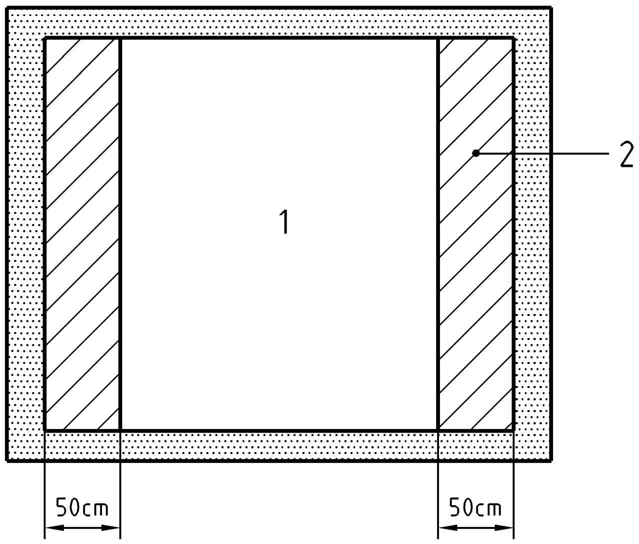
8.2 Mounting of the specimen

8.2.1 General

The mounting is performed exactly according to the instructions given by the manufacturer or distributor of the pipe system. It shall be described in full detail in the test report.

A restricted area of the test wall, as defined by Figure 3, is provided for mounting of the test object. At least one fixing point shall be used to fasten the system to the test wall. No further restrictions are made concerning the location of clamps, clips and other fixing devices.

The mandatory basement bend shall be mounted below the floor of the test room, at a distance of (15 ± 5) cm from the floor (see Figure 2). It shall be fixed rigidly, but avoiding any direct transmission of structure-borne sound to the test room. Above the test room, the upper system is fixed, avoiding also any direct transmission of structure-borne sound to the test room.



Key

1 Test wall

2 Restricted area

Figure 3 — Restricted area for mounting the test object on the test wall (AA view in Figure 2)

8.2.2 Requirements for airborne sound measurement

The air gaps between tube and floor in the entrance and exit openings have to be carefully filled with porous absorbent material and covered with plastic sealant in order to prevent any airborne sound from the outside influencing the measurement. The seal shall remain sufficiently flexible to avoid mechanical clamping of the pipe.

8.2.3 Requirements for the standard configuration

Two clamps shall be used to fasten the system to the test wall. If not otherwise specified by the manufacturer, metal plugs shall be used.

9 Test procedure and evaluation

9.1 Wall structural sensitivity measurement

The wall structural sensitivity level shall be measured, according to the procedure described in Annex A, at each fixing location (L_{SS1} and L_{SS2}) with the pipe in place and then averaged energetically for each frequency band:

$$L_{SS} = 10 \lg \left(\left(10^{L_{SS1}/10} + 10^{L_{SS2}/10} \right) / 2 \right) \qquad (1)$$

A wall structural sensitivity correction is then calculated from the difference:

$$\Delta L_{SS} = L_{SS} - L_{SSR} \qquad (2)$$

where

L_{SSR} is the structural sensitivity level of the reference wall, given in Figure 4, in decibels and calculated from;

$$L_{SSR} = \left(-28 \lg f + 11{,}2 \right) \text{ rounded to the nearest integer} \quad (3)$$

9.2 Flow rate

The test shall be performed at the following constant flow rates: 0,5 l/s; 1 l/s ; 2 l/s ; 4 l/s and 8 l/s, up to a limit depending on the pipe internal diameter and given in Table 1. The flow rate shall be controlled and kept within ± 5 % of the stated value during measuring time T_m.

Table 1 — Flow rate limits

Pipe internal diameter D mm	70 ≤ D < 100	100 ≤ D ≤ 125	125 < D ≤ 150
Upper flow rate l/s	1	4	8

9.3 Measurements

Both the sound pressure levels L'_t and L'_s and the reverberation times T_e and T_r are measured in 1/3-octave bands according to EN ISO 140-3.

A complete set of primary quantities comprises the levels L'_t and L'_s for each flow rate, the reverberation times T_e and T_r of the source and receiving room respectively and the wall structural sensitivity correction ΔL_{SS}.

9.4 Correction for background noise

The measured levels L'_t and L'_s are corrected for background noise according to EN ISO 140-3 giving the values L_t and L_s respectively. Levels at the limit of measurement shall be clearly indicated in the test report.

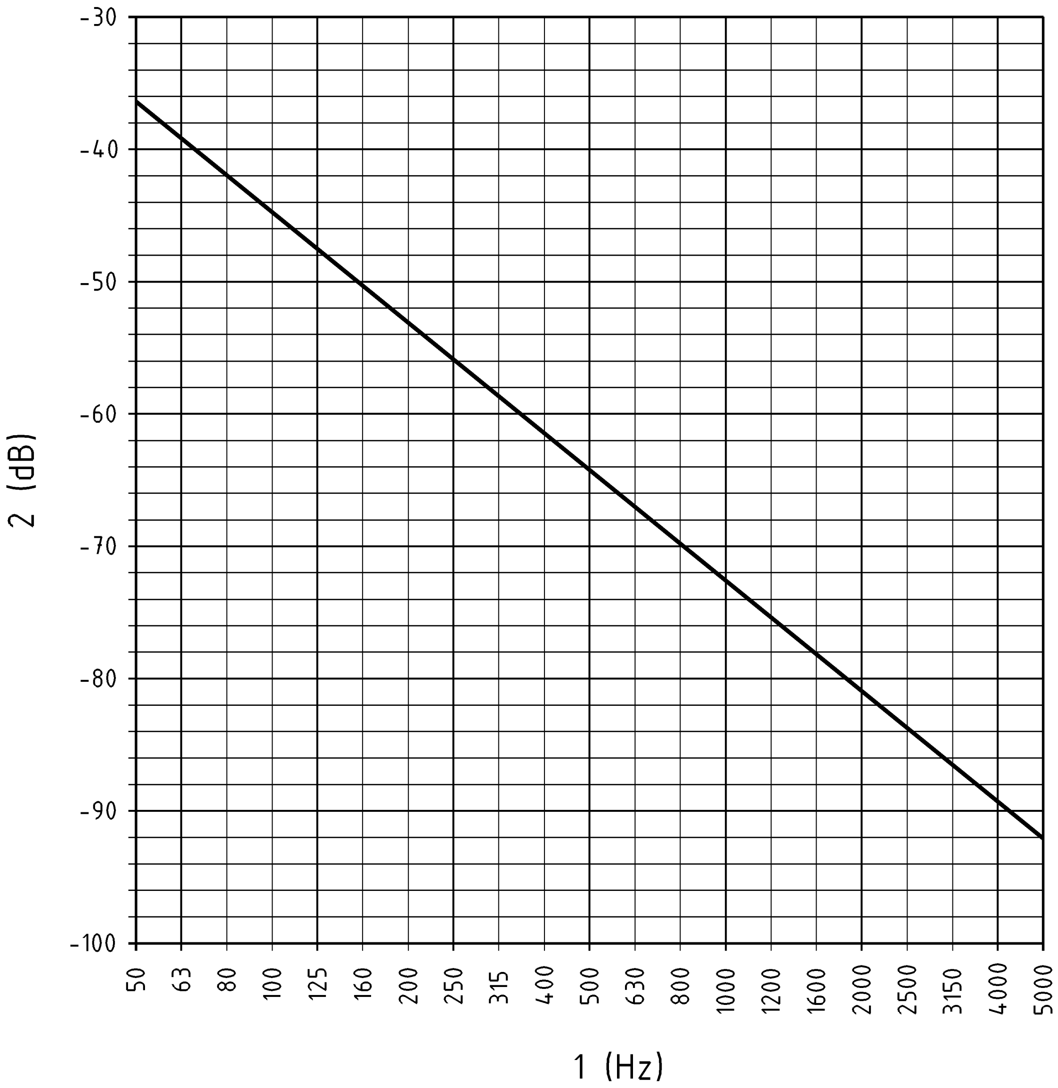


Figure 4 — Reference structural sensitivity spectrum

9.5 Normalisation

The values L_t and L_s are normalized to an equivalent absorption area of 10 m^2 using

$$L_{tn} = L_t - 10\lg\left(T_e\right) + 10\lg\left(0{,}16V_e/10\right) \tag{4}$$

$$L_{sn} = L_s - 10\lg\left(T_r\right) + 10\lg\left(0{,}16V_r/10\right) \tag{5}$$

where

V_e and V_r are the volume of the source and receiving room respectively, in cubic metres.

9.6 Calculation of structure-borne sound level L_{sn} and normalisation with respect to the acoustic properties of the wall

The structure-borne sound level L_{sn} is calculated and the wall structural sensitivity correction ΔL_{SS} is subtracted from L_{sn} in order to normalize L_{sn} with respect to the acoustic properties of the wall compared with the properties of a reference wall:

$$L_{sc} = L_{sn} - \Delta L_{SS} \tag{6}$$

The level L_{sc} is characteristic of the pipe system tested.

NOTE The level obtained in any configuration (laboratory or field) can then be calculated by adding L_{sc} to the correction $\Delta L_{ss,situ}$ corresponding to the configuration considered.

9.7 Calculation of the airborne level L_{an}

The airborne sound is calculated from L_{tn} by energetically subtracting the structure-borne sound for each frequency band:

$$L_{an} = 10 \lg\left(10^{L_{tn}/10} - 10^{L_{sn}/10}\right) \tag{7}$$

10 Calculation of single number quantities

10.1 Single number descriptor for structure-borne sound

The A-weighted single number descriptor is calculated by:

$$L_{sc,A} = 10 \lg \left(\sum_{i=1}^{18} 10^{(L_{sci} + D_{Ai})/10}\right) \tag{8}$$

where

D_{Ai} are the attenuation values of the A-weighting filter in the frequency range used (EN 61672-1).

10.2 Single number descriptor for airborne sound

The A-weighted single number descriptor is calculated by:

$$L_{a,A} = 10 \lg \left(\sum_{i=1}^{18} 10^{(L_{ani} + D_{Ai} / 10)}\right) \tag{9}$$

11 Precision

11.1 Repeatability

NOTE It is not currently possible to define repeatability. This will be added once experience with this test method has been gained.

11.2 Reproducibility

NOTE It is not currently possible to define reproducibility. This will be added once experience with this test method has been gained.

12 Expression of results

The 1/3 octave spectra L_{sc} and L_{an} obtained for the different flow rates shall be given in a table where the flow rates are clearly stated. Levels at the limit of measurement (see 9.4) shall be clearly indicated.

13 Test report

The test report shall include:

a) reference to this document;

b) name and address of the testing laboratory;

c) identification number of the test report;

d) name and address of the organization or the person who ordered the test;

e) name and address of manufacturer or supplier of the tested object;

f) a description of the tested object stating the material and size of the parts, the methods used for joining and sealing the parts and the detailed plan of the mounting configuration;

g) identification of the test equipment and instruments used;

h) a description of the test facility, especially of the test wall;

i) environmental data (temperature, static pressure, background noise);

j) test results : the main page of the report shall include a table giving the single number descriptors $L_{sc,A}$ and $L_{a,A}$ obtained for the different flow rates. The report shall include the noise spectra L_{sn} and L_{an} obtained for the different flow rates and the test wall structural sensitivity spectrum L_{SS};

k) date of the test and signature of the person responsible.

Annex A
(normative)

Wall structural sensitivity measurement

A.1 Measurement procedure

The sound reference source shall be located in the receiving room as described in EN ISO 140-3 for loudspeakers, not close to the test wall (minimum distance: 2 m from the test wall and 1 m from other walls) and at a minimum of 3 positions.

Accelerometers shall be located as close as possible to the clamp fixing points (maximum distance : 5 cm).

The sound reference source (of sound power level L_W) is operated and the velocity levels at the clamp fixing points are measured (L'_v). The sound reference source is stopped in order to measure the background vibration level. The values L'_v are then corrected for background vibration with the same procedure as for sound pressure level giving the values L_v. Levels at the limit of measurement shall be clearly indicated in the test report. The wall structural sensitivity level L_{SS} is then calculated for each clamp fixing point using the following equation in decibels:

$$L_{SS} = L_v - L_W + 10 \lg \frac{V_r}{T_r} - 59 \text{dB} \quad \text{(A.1)}$$

where

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

T_r is the reverberation time of the receiving room in seconds.

A.2 Applicability of the method

The vibration levels at the specimen fixing points shall be measured with and without the pipe in place; the method is applicable if the difference between the two levels obtained at each fixing point is less than 3 dB. This condition shows that the internal mobility of the pipe is much higher than the input mobility of the wall and that the pipe is a force source.

Annex B
(informative)

Background ; application of reciprocity for calibrating the test wall

Detailed information on the chosen measuring procedure is given in [1]. If the test wall is excited by a point force F, the transmission behavior of the wall can be described by a wall structural sensitivity α_F , defined as:

$$\alpha_F = \frac{\rho c}{k^2} \times \frac{W}{F^2} \quad \text{(B.1)}$$

where

ρc is the characteristic impedance of air (ρ in kg/m^3 and c in ms^{-1});

k is the wave number (m^{-1}) ;

W is the sound power radiated by the test wall to the receiving room behind the wall, in watts;

F^2 is the mean square value of force F, in Newtons.

A wall structural sensitivity level L_{SS} can be defined as

$$L_{SS} = 10 \lg (\alpha_F) \quad \text{(B.2)}$$

In the reciprocal direction, the transmission behaviour of the test wall can also be characterized by the transfer function α_p , which is given by:

$$\alpha_p = \rho^2 c^2 \times \frac{v^2}{p^2} \quad \text{(B.3)}$$

In this case, a reverberant sound field is generated by a loudspeaker in the room behind the test wall. The space averaged mean square sound pressure p^2 in Pascal^2 is measured, as well as the mean square velocity v^2 in (ms^{-1})^2 of the test wall at the same location and the same direction as the excitation force.

Under reciprocity conditions the following relation can be written:

$$\frac{\alpha_p}{\alpha_F} = 4\pi \quad \text{(B.4)}$$

and thus:

$$\alpha_F = \frac{\rho^2 c^2}{4\pi} \times \frac{v^2}{p^2} \quad \text{(B.5)}$$

Equation (B.5) can be expressed by a reciprocal measurement using the excitation of an airborne reverberant sound field and measuring the velocity of the test wall at a point of interest. This may be e.g. a point where the waste water pipe system is fixed to the test wall. The transfer functions α_F and α_p depend on the location of the chosen points.

Using the described method, it is assumed that the following requirements are fulfilled:

— reciprocal and linear behavior of all proceedings;

— diffuse sound field in the room behind the test wall;

— point forces;

— identical directions of force and velocity at the same point.

According to the relation between sound pressure p and sound power W in a reverberant sound field:

$$p^2 = \frac{4\rho c}{A} \times W \qquad \text{(B.6)}$$

equation (B.5) can be transformed into:

$$\alpha_F = \frac{\rho c A}{16\pi} \times \frac{v^2}{W} \qquad \text{(B.7)}$$

where

A is the equivalent absorption area of the room behind the test wall, in m^2

and expressed in decibels as:

$$L_{SS} = L_v - L_W + 10\lg\frac{V_r}{T_r} + 10\lg\frac{\rho c v_0^2}{\pi W_0} - 20\,\mathrm{dB} \qquad \text{(B.8)}$$

where

v_0 is the vibration velocity of reference used to calculate the level v, in metres per second ; $v_0 = 10^{-9}$ m/s ;

W_0 is the sound power reference used to calculate the level L_W, in watts; $W_0 = 10^{-12}$ watts.

In this standard this relation is used for calibrating the test wall. The quantities T_r (reverberation time in the room behind the wall, which has the volume V_r) and the velocity v on the wall have to be determined by measurement. Using a calibrated reference sound source with defined sound power *W*, the quantity W can be taken as known; investigations have shown that the accuracy of the calibration procedure is then increased (see Bibliography [3]).

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