BS EN 14366-1:2023

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Laboratory measurement of airborne and structure-borne sound from service equipment

Part 1: Application rules for waste water installations

bsi.

National foreword

This British Standard is the UK implementation of EN 14366-1:2023. It supersedes BS EN 14366:2004+A1:2019, which is withdrawn.

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Laboratory measurement of airborne and structure-borne sound from service equipment - Part 1: Application rules for waste water installations

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Bauakustik - Messung von Luftschall und Körperschall von gebäudetechnischen Anlagen im Prüfstand - Teil 1: Anwendungsregeln für Abwasserinstallationen

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European foreword

This document (EN 14366-1:2023) 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of an identical text or by endorsement, at the latest by January 2024, and conflicting national standards shall be withdrawn at the latest by January 2024.

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

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Introduction

Noise from waste water installations is generated by the flow 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 or hidden by an enclosure. It seems advisable, therefore, to define measuring methods for both structure-borne and airborne sound. The first standard on laboratory sound measurements of waste water installations (EN 14366) was published in 2004. The present standard is a revision of EN 14366:2004+A1:2019, and is still focused on laboratory characterization of waste water installations for both airborne and structure-borne sound, but now uses the same characterization methods as for building service equipment, i.e. EN 15657. In particular, structure-borne sound is now characterized by vibration measurements and therefore only one test room is required in the standard for airborne sound measurement.

NOTE The room is particularly necessary to keep the former standard configuration, where the piping system mounting conditions in a room are similar to the ones in buildings. A method based on acoustical intensity could be used with no room at all; such a method is not precisely defined and validated yet, but could be standardized in a future revision of the standard.

Important noise sources are bends after vertical sections, bends for pipe deviation, but also discontinuities, e.g. inlets, couplings and sleeves. The revised standard keeps the standard configuration specified in the former one (straight pipe system connected to walls), but also considers vertically deviated pipes connected to walls and horizontal pipes connected to ceilings.

In addition, the revised standard includes measuring the performance of mitigation measures such as pipe enclosures (technical shaft) and pipe lining.

The title and numbering of the revised document have been changed, now opened to other application standards for equipment systems such as water supply installations.

1 Scope

This document characterizes waste water or rain water piping systems as airborne sound source and structure-borne sound source using the same method as the one described in EN 15657 for characterizing building service equipment. It therefore applies to equipment installed in any type of buildings (heavy or lightweight).

This document:

— specifies laboratory measuring methods for determining the input data required for both comparing products and materials, and predicting sound levels in buildings using EN 12354-5. These input quantities are the piping system sound power level for airborne sound and three quantities for structure-borne sound (piping system free velocity, blocked force and mobility), from which the piping system installed power, source input for EN 12354-5, is determined;

— specifies the method for the measurement of the equipment airborne sound power*;*

— only considers piping systems connected to one supporting building element in a first step;

NOTE Simultaneous structure-borne transmissions to wall and floor are more difficult to handle. In the configurations proposed in this document, the piping system is only connected to one supporting element and mechanically decoupled from the other elements.

— includes configurations of vertical pipes with offset (deviated horizontally) connected to walls and horizontal pipes connected to ceilings, for which the measuring method is the same as the one defined for straight vertical pipes connected to walls. These complementary configurations are described in (normative) Annex A;

— specifies laboratory test procedures for determining the performance of mitigation measures such as pipe enclosures (technical shaft) and pipe lining. The corresponding specifications are given in (normative) Annex B;

— defines the expression of the results for use in comparing products and materials and for use as input data for prediction; however, the Single Number Quantities used to compare products cannot be used as a prediction or proof of compliance with requirements in a building;

— indicates a method to transform the quantities measured according to EN 14366:2004+A1:2019, to the quantities used in this document; however, the calculated values cannot be used as certified values obtained by test, but only for comparison with new tests. This method is given in (informative) Annex C.

This document is applicable to waste water piping systems and parts thereof, but not to the actual sources of waste water, e.g. lavatories, toilets and bathtubs or any active units, which are considered separately in EN 12354-5 and are characterized separately. It applies to pipes with natural ventilation and made of any common material in commonly used diameters (up to 160 mm).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12354-5:2023, *Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 5: Sounds levels due to the service equipment*

EN 15657:2017, *Acoustic properties of building elements and of buildings — Laboratory measurement of structure-borne sound from building service equipment for all installation conditions*

EN ISO 10140-4, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 4: Measurement procedures and requirements (ISO 10140-4)*

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

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

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

ISO 5348, *Mechanical vibration and shock — Mechanical mounting of accelerometers*

3 Terms and definitions

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

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

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

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

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

3.2
waste water installation
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
simple waste water installation system with a single path of water flow

Note 1 to entry: A specimen is the object of tests according to this document.

Note 2 to entry: Any combination of commercial elements (or prototype elements) may be assembled and installed according to the instructions given by the producer or distributor of the installation to form a specimen.

3.4
test room
room used for both airborne and structure-borne sound measurements

Note 1 to entry: The specimen is mounted inside the test room.

3.5
standard configuration
mandatory form of specimen used for comparison

3.6
test element
wall or floor on which the specimen is mounted

3.7
contact
point where pipe and receiving element are connected

4 Symbols

Index j	Indicates that the quantity is obtained from a source applied at the contact j or is measured at contact *j*	-
Index cal	Indicates, that the quantity is obtained using a calibrated source	-
Index enclosed	Indicates that the quantity is obtained with an enclosure around the specimen	-
Index lining	Indicates that the quantity is obtained with a lining around the specimen	-
Index A	A-weighted quantity	-
$D_{\mathrm{A,k}}$	Set of attenuation values for the A-weighting	dB
N	Number of one-third octave measured	-
D_{WA}	Airborne sound power insertion loss of an enclosure around the specimen	dB
D_{Ws}	installed power insertion loss of a pipe lining	dB
h	Falling height	m
d	distance	m
Δl	Pipe offset length	m
α	Deviation angle of the pipe offset bend	degree
$L_{\mathrm{p,total}}$	Sound pressure level measured in the test room	dB re 20 µPa
$L_{\mathrm{n,total}}$	Normalized sound pressure level measured in the test room	dB re 20 µPa
T_{r}	Reverberation time of the test room	s
V	Volume of the test room	m^3
$L_{\mathrm{Wa,total}}$	Total sound power level measured in the test room	dB re 10^{-12} Watt
L_{Wa}	Airborne sound contribution to the total sound power level measured	dB re 10^{-12} Watt
$L_{\mathrm{Wa,struc}}$	Structure-borne sound contribution to the total sound power level measured	dB re 10^{-12} Watt
$L_{\mathrm{Ws,i}}$	Installed power level of a vibration source connected to the receiving element	dB re 10^{-12} Watt
$L_{\langle v \rangle}$	Space average vibration velocity level of the receiving element	dB re 10^{-9} m/s
$L_{\mathrm{vf,j}}$	Free velocity level of the specimen at contact *j*	dB re 10^{-9} m/s

$L_{vf,eq}$	Single equivalent free velocity level of the specimen	dB re 10^{-9} m/s
$L_{Fb,eq}$	Single equivalent blocked force level of the specimen	dB re 10^{-6} m/s
$Re\left(Y_{R,low,j}\right)$	Real part of the mobility of the receiving element at contact *j*	m/sN
$Re\left(Y_{R,low,eq}\right)$	Real part of the single equivalent mobility of the receiving element	m/sN
$\left\|Y_{S,eq}\right\|$	Magnitude of the single equivalent mobility of the specimen	m/sN
L'_{ni}	*In situ* apparent impact sound pressure level in a receiving room due to the specimen mounted on element *i*	dB re 20 µPa
$L'_{ne,s,i}$	Structure-borne contribution of the apparent normalized sound pressure level in a receiving room due to the specimen mounted on element *i*	dB re 20 µPa
$L'_{ne,s,0,i}$	Structure-borne contribution of the apparent normalized sound pressure level in a receiving room due to a unit power source mounted on element *i*	dB re 20 µPa

5 Measuring method

5.1 Airborne sound measurements

No airborne sound power measurement method is defined in EN 15657, which refers to EN ISO 3740 to 3747 [2–4]. However, measurements in the present standard are very particular, involving all together small rooms (at least 50 m^3), low frequencies (range down to one-third octave 50 Hz) and both stationary and non-stationary sources; consequently, they are fully described here.

The specimen is mounted on the test wall inside the test room (see Figure 2). Appropriate openings in the upper and lower floors are provided. A steady flow of tap water is applied. The total sound power level $L_{Wa,total}$ in the test room, produced as airborne sound radiated directly from the specimen but also as structure-borne sound radiated by the test wall (and the other walls with smaller contributions) is measured according to the following method:

— the specimen shall be mounted in accordance with Clause 8;

— the following values are measured in one-third octave bands and according to EN ISO 10140-4: (i) the sound pressure level in the room with the source operating, (ii) the sound pressure level of the back-ground noise (water flow stopped) and (iii) the reverberation time T_r of the room;

— the measured level is corrected for background noise according to EN ISO 10140-4 (leading to $L_{p,total}$) and normalized to an equivalent absorption area of 10 m^2 (leading to $L_{n,total}$):

$$L_{n,total} = L_{p,total} - 10 \lg T_r + 10 \lg \left(0{,}16V / 10\right) \tag{1a}$$

where

V is the volume of the test room in cubic metres.

— the total sound power level $L_{Wa,total}$ simply follows from:

$$L_{Wa,total} = L_{n,total} + 4 \text{ dB} \tag{1b}$$

The structure-borne contribution $L_{\mathrm{Wa,struc}}$, measured according to 5.2, is then subtracted to obtain the airborne sound power level L_{Wa} of the piping system:

$$L_{\mathrm{Wa}} = 10\lg\left(10^{\frac{L_{\mathrm{Wa,total}}}{10}} - 10^{\frac{L_{\mathrm{Wa,struc}}}{10}}\right) \quad (1c)$$

Formula (1c) is applicable only if $L_{\mathrm{Wa,total}}$ is greater than $L_{\mathrm{Wa,struc}}$; otherwise, L_{Wa} is negligible; this case should then be mentioned in the test report.

NOTE In this document, the power levels are expressed in dB ref. 10^{-12} Watt.

5.2 Structure borne sound measurements

5.2.1 General

The test wall (see 7.1.2) shall be a low mobility wall compared to the specimen mobility, as specified in EN 15657:2017, C.4. To check the above assumption, the following applicability test can be performed: with the wall mechanically excited by a calibrated source according to 5.2.2, the velocity is measured on the wall at contact points with the specimen and without (before installing the specimen), and normalized to the excitation expressed in terms of installed power; a difference of less than 3 dB between the two normalized velocity levels obtained at each fixing point indicates a low mobility wall compared to the source mobility.

The required structure-borne sound measurements can be performed in two steps: a calibration of the test facilities (see 5.2.2), which can be done once and checked periodically, and the actual testing of the specimen considered (see 5.2.3 and 5.2.4).

5.2.2 Calibration of the test facilities

The test wall is mechanically excited using a calibrated vibration source (instrumented hammer or shaker as suggested in EN ISO 10848-1) successively applied on the side opposite to the test room at each contact *j* between the specimen and the test wall.

The following three quantities are then measured for each excitation location:

— the installed power level $L_{\mathrm{Ws,cal},j}$ of the calibrated vibration source determined according to EN ISO 10848-1,

— the sound power level $L_{\mathrm{Wa,struc,cal},j}$ radiated with the calibrated source (operating), measured in the test room as in 5.1 and

— the space average vibration velocity of the test wall $L_{\langle v\rangle,\mathrm{cal},j}$ measured according to EN 15657:2017, C.3.

NOTE In this document, the velocity levels are expressed in dB ref. 10^{-9} m/s.

The calibrated source shall be powerful enough so that $L_{\langle v\rangle,\mathrm{cal},j}$ is well above the background noise.

There should be no significant difference if the above measurements are performed with or without the specimen connected to the wall.

5.2.3 Indirect procedures for testing the specimen

5.2.3.1 Blocked force measurements

The piping system single equivalent blocked force is indirectly obtained using the power substitution method according to EN 15657:2017, Annex C as follows:

a) with the specimen mounted on the test wall inside the test room, a steady flow of tap water is applied and the space average vibration velocity level of the test wall $L_{\langle v \rangle}$ is measured according to EN 15657:2017, C.3. The water flow is stopped in order to measure the background noise and $L_{\langle v \rangle}$ is corrected for background noise.

   The contribution of the airborne excitation of the test wall due to the pipe near field is taken into account when measuring the blocked force; this contribution is indeed not taken into account anywhere else and should be included. Note that, in the 2004 version of the standard, this contribution was subtracted.

b) The specimen installed power level L_{Ws} is calculated from the installed power levels of the calibrated vibration source $L_{\mathrm{Ws,cal},j}$ (see 5.2.2) applied successively at the contacts *j* corrected for the difference in velocity level of the test wall between the two excitation cases (using respectively the specimen and the calibrated vibration source):

$$L_{\mathrm{Ws}} = 10\lg\left(\sum_j 10^{\frac{L_{\mathrm{Ws,cal},j}}{10}}\right) + L_{\langle v \rangle} - 10\lg\left(\sum_j 10^{\frac{L_{\langle v \rangle,\mathrm{cal},j}}{10}}\right) \quad (2)$$

c) direct measurements of the test wall point mobility $Y_{\mathrm{R,low},j}$ are performed at each contact *j* between the specimen and the test wall according to EN 15657:2017, 6.2, from which the wall real part of the single equivalent mobility is calculated as:

$$\mathrm{Re}\left(Y_{R,low,eq}\right) = \frac{1}{2}\sum_j \mathrm{Re}\left(Y_{R,low,j}\right) \quad (3)$$

   NOTE The test wall can be pre-calibrated as in 5.2.2 by measuring the wall point mobility on a grid of points regularly distributed over the wall and by using in Formula (3) the two points on the grid the closest to the specimen contacts.

   There should be no significant difference if the mobility measurements are performed with or without the specimen connected to the wall.

d) the source single equivalent blocked force level in dB ref. 10^{-6} N is calculated as:

$$L_{\mathrm{Fb,eq}} \approx L_{\mathrm{Ws}} - (10\lg(\mathrm{Re}(Y_{\mathrm{R,low,eq}})/Y_0))\mathrm{dB} \;;\; Y_0 = 1\mathrm{m/sN} \quad (4)$$

5.2.3.2 Structure-borne contribution to the specimen total sound power

The structure-borne sound power $L_{\mathrm{Wa,struc}}$ radiated in the test room with the test wall excited by the specimen, is obtained indirectly using the (installed) power substitution method: $L_{\mathrm{Wa,struc}}$ is obtained from the sound power levels $L_{\mathrm{Wa,struc,cal},j}$ radiated by the calibrated source applied successively at the contacts *j*, corrected for the difference in installed power level between specimen and calibrated source:

$$L_{\text{Wa,struc}} = 10\lg\left(\sum_j 10^{\frac{L_{\text{Wa,struc,cal},j}}{10}}\right) + L_{Ws} - 10\lg\left(\sum_j 10^{\frac{L_{\text{Ws,cal},j}}{10}}\right) \quad (5)$$

5.2.4 Specimen free velocity direct measurement

The specimen free velocity is directly measured at the piping system two fixing points according to EN 15657:2017, 6.1, the piping system being disconnected from the test wall. Measurements are located on clamps as shown in Figure 1, either rigidly or elastically fixed to pipe. The measurements are corrected for background noise if any.

Key

1 Receiving wall
2 Waste water pipe
3 Clamp
4 Arrows indicating the position and direction of the velocity measurements (preferred position encircled)

Figure 1 — Free velocity measurement locations

NOTE If clamps are resiliently fixed to the test wall using elastic sleeves, these sleeves are then part of the source, which becomes a force source, only characterized by its single equivalent blocked force level; free velocity measurements are in this case no longer required.

The single equivalent specimen free velocity level is obtained from the velocity levels measured at each clamp as:

$$L_{\text{vf,eq}} = 10lg\left(\sum_j 10^{L_{\text{vf,j}}/10}\right) \quad (6)$$

5.2.5 Specimen single equivalent mobility estimation

The specimen single equivalent mobility magnitude is approximated according to EN 15657:2017, 7.4 from the specimen single equivalent free velocity and the specimen single equivalent blocked force as:

$$\left|Y_{S,eq}\right|^2 \approx 10^{\frac{(L_{vf,eq} - L_{Fb,eq})}{10}} \cdot 10^{-6} \quad (7)$$

where

$\left|Y_{\text{S,eq}}\right|$ is the specimen single equivalent mobility, in m/sN.

6 Equipment

6.1 Requirements for the frequency range of measurement

The measurements and calculation shall be performed using the one-third octave bands having the following centre frequencies in Hz:

Table 1 — Centre frequencies in Hz

50	63	80	100	125	160
200	250	315	400	500	630
800	1 000	1 250	1 600	2 000	2 500
3 150	4 000 [a]	5 000 [a]	-	-	

[a] Measurements at least up to 3 150 Hz, extended up to 5 kHz for airborne sound measurements.

NOTE This document characterizes waste water installations as possible cause for annoying neighbours in buildings; sounds above 5 kHz are assumed attenuated enough by transmission through the building structure.

The frequency bands where measured values show signal to noise ratio problems, shall be reported in the test report.

6.2 Requirements for the acoustic equipment

The equipment shall comply with the requirements of EN ISO 10140-4.

6.3 Requirements for the hydraulic equipment

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 the table below. The flow rate shall be controlled and kept within ±5 % of the stated value during measuring time.

Table 2 — Flow rate limits

Pipe internal diameter mm	70–80	100–125	150–160
Maximum flow rate l/s	1	4	8

6.4 Requirements for the vibration measuring equipment

According to EN 15657, 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 lower and upper floors are provided for the installation of the test objects.

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

7.1.2 Test wall

Any wall can be used as test wall, as long as the applicability test specified in 5.2.1 is fulfilled. In the case of a wall made of reinforced concrete, a range of wall thickness from 10 cm to 23 cm is usually appropriate.

7.2 Acoustic requirements

According to EN ISO 10140-5.

8 Test specimen

8.1 Geometry

8.1.1 Components

The objects tested according to this document are parts of a wastewater installation with a single path of the water flow and consist of:

— an inlet, part of the test object according to Figure 2;

— any combination of straight pipes, tees, bends, joints and inlets, mounted with clamps on the test wall;

— a basement bend of totally approximately 90° angle, being part of the specimen.

8.1.2 Falling height *h*

The falling height *h* shall be in the range from 5,8 m to 7,5 m, measured between the inlet point and the impact point. (Figure 3). 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.

8.1.3 Standard configuration

For comparison purposes, the following standard configuration is used:

The standard configuration consists 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° bends of the same material as the test object. The horizontal evacuation pipe shall be supported without connection to the test room floor and its slope similar as in buildings.

Key

1 silencer for preventing any airborne sound leak to the outside
2 angle close to 90° (depending on inlet tee)
3 limit of the system
4 25 cm minimum
5 inlet point
6 water flow inlet

Figure 2 — Inlet configuration

Key

1 inlet
2 fixing device

Figure 3 — Standard configuration

8.1.4 Other configurations considered

The scope of this document includes configurations of vertical pipes with offset (deviated horizontally) connected to walls and horizontal pipes connected to floors, for which the measuring method is the same as the one use for the standard configuration. These configurations are described in Annex A (normative annex).

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 waste water installation. It shall be described in full detail in the test report.

The test object is mounted in the restricted area of the test wall, as specified in Figure 4. 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 3). It shall be fixed rigidly but avoiding any direct transmission of structure-borne sound to the test room. Above the test room, the upper installation is fixed, avoiding also any direct transmission of structure-borne sound to the test room.

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 so that the structure borne sound contribution of the lower and upper floors can be assumed negligible.

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 sleeves shall be used. Clamp type and locations shall be described in the test report. The weight of the system shall be secured by at least one of the two clamps.

Key

1 Test wall

2 Forbidden area

Figure 4 — Forbidden area for mounting the test object on the test wall (AA view in Figure 3)

9 Expression of the results

9.1 General

This document defines the expression of the results for use in comparing products and materials in terms of performance, for which single number quantities are required, and for use in predicting service equipment sound levels in buildings, for which one-third octave spectra are required as input data for the prediction method being defined in EN 12354-5. These quantities are defined in this clause and summarized in Table 3 below.

9.2 For use in comparing products and materials

9.2.1 General

When considering service equipment sound in buildings and choosing products, practitioners should differentiate airborne sound performances from structure-borne sound performances and should be aware, that the structure-borne sound performances greatly depend on the type of building on which the equipment is mounted: heavy buildings (with elements of type A as defined in EN ISO 10848-1) usually with low mobility elements or lightweight buildings (with elements of type B). As a result, it is useful to consider the following three quantities for comparing products:

— for airborne sound, the airborne sound power, which can be A-weighted, shall be used, expressed in terms of single number value (see 9.2.2);

— for structure-borne sound, there is no standard defining the quantity and procedure for calculating single number values in order to compare sources characterized according to EN 15657 in general and EN 14366-1 in particular. The source input quantities for prediction (blocked force level for low mobility receiver and installed power for the other cases) cannot be A-weighted and the apparent structure-borne sound pressure level $L'_{\mathrm{ne,s}}$, generated in any building structures, only quantity that could be A-weighted, depends on the transmission paths to the receiving room. Reference building structures should therefore be standardized, from which the apparent sound pressure level generated by any source could be calculated using EN 12354-5 and expressed as single number value. Since such reference building structures don't exist yet, it is suggested for the time being to use the building configurations given in EN 12354-5:2023, G.4, and take the A-weighted sound pressure level obtained as an example of single number value (see 9.2.3).

The Single Number Quantities can only be used to compare products but not at all as a prediction or proof of compliance with requirements in a building.

9.2.2 Single number descriptor for airborne sound

The A-weighted single number descriptor is calculated from the measured airborne sound power level spectrum as:

$$L_{Wa,A} = 10lg\left(\sum_{k=1}^{N}\left(10^{L_{Wa,k}/10} + D_{A,k}\right)\right) \quad (8)$$

where

$D_{\mathrm{A,k}}$ set of attenuation values of the A-weighting filter in the frequency range used (EN 61672-1:2013);

N number of one-third octave measured (at least 19, see Table 1).

9.2.3 Single number descriptor for structure-borne sound

Two examples of building structures are specially given in EN 12354-5:2023, G.4 for application to products characterized using EN 14366-1: one example with a low mobility receiver in a heavy building and the other in a lightweight building.

— for the heavy building with low mobility receiver (G.4.2), the performance of the building is given in terms of apparent impact sound pressure level L'_{n} obtained when the equipment is replaced by the tapping machine. Then the apparent structure-borne sound pressure level generated by the equipment considered shall be calculated using the prediction method defined in EN 12354-5:2023, 5.3.3 and A-weighted using the same procedure as in 9.2.2. The only input data required is the source single equivalent blocked force level.

— for lightweight structures (G.4.3), the performance of the building is given in terms of apparent unit power sound pressure level $L'_{\mathrm{ne,s,0}}$ obtained when the equipment is replaced by a unit power source; the single equivalent mobility magnitude of the receiver, required for calculating the source installed power, is also given. Then the apparent structure-borne sound pressure level generated by the equipment considered shall be calculated using the prediction method defined in EN 12354-5:2023, 5.3.2.2 and A-weighted using the same procedure as in 9.2.2. The input data required is the source installed power level, which shall be calculated according to EN 12354-5:2023, 5.3.2.1 from the source single equivalent blocked force or free velocity level and the source single equivalent mobility magnitude.

9.3 For use in predicting equipment sound pressure levels in buildings

The method predicting sound levels due to service equipment in buildings is defined in EN 12354-5. Calculations are performed in one-third octave bands. For airborne sound, the input data are the equipment airborne sound power, measured using EN 14366-1. For structure-borne sound, as explained in 9.2.3, two different methods are defined depending on the building type considered: heavy building with low mobility receiver or lightweight building:

— for heavy buildings with low mobility receivers, the prediction method is defined in EN 12354-5:2023, 5.3.3 and the only input data required is the source single equivalent blocked force level, measured using EN 14366-1. An example of calculation is given in EN 12354-5:2023, G.2.

— for lightweight structures, the prediction method is defined in EN 12354-5:2023, 5.3.2.2 and the input data required is the source installed power level, which shall be calculated according to EN 12354-5:2023, 5.3.2.1 from the source single equivalent blocked force or free velocity level and the source single equivalent mobility magnitude, all measured using EN 14366-1. Examples of calculation are given in EN 12354-5:2023, G.3.

9.4 Summary

Table 3 summarizes the quantities for use in prediction and in comparing product.

Table 3 — Quantities for use in prediction and in comparing products

	Airborne sound	**Structure-borne sound**	
		Low mobility receiver	**General case**
Measured quantities for prediction (in one-third octave bands)	L_{Wa}	$L_{Fb,eq}$	$L_{Fb,eq}$ or $L_{vf,eq} \left\| Y_{S,eq} \right\|$
Quantities for comparing products	$L_{Wa,A}$	$L'_{ne,s,A}$ [a]	$L'_{ne,s,A}$ [a]

[a] Example of single number value, obtained if the building structure examples given in EN 12354-5:2023, G.4 are used.

10 Accuracy

For waste water pipe measurements, the accuracy is expressed in terms of the following quantities:

— for the *airborne sound power:* the measurement procedure is particular and its accuracy differs from the one indicated in EN ISO 3743-1 [3], where measurements are not performed in one-third octave bands and don’t include frequency bands down to 50 Hz. In this document, the same measurement procedure as in EN 14366:2004+A1:2019 is used. However, since no Round Robin has been performed on the former standard, it is recommended that different organizations perform comparison measurements based on the present standard using the same test specimen to check the repeatability and reproducibility of the test procedure (see Note 3). Some information on accuracy related to airborne sound in rooms can also be found in ISO 12999-1:2020;

— for *the specimen structure-borne sound characteristics:* according to the Round Robin performed on standard EN 15657 using a reference source [6], the following averaged standard deviation of reproducibility is obtained for each source characteristics per one-third octave band:

  — single blocked force level: 3 dB,

  — single free velocity level: 4 dB,

  — single equivalent source mobility: ratio to mean value of 1,2 if linear values (in m/sN) are used on a log scale (corresponding to 1 dB).

NOTE 1 The standard deviation of reproducibility given by the Round Robin might differ from the one of real sources, the reference source tested being not representative of every source, particularly in terms of mounting and operating conditions.

Some information on accuracy related to structure-borne sound sources can also be found in [7].

NOTE 2 Detailed methods such as GUM seems complicated when applied to structure-borne sound source characterization, as shown in a paper on the “two stage reception plate method” [8]; however, in the case of waste water pipes, the pipe free velocity is measured directly, which should simplify the GUM calculation.

NOTE 3 For a better accuracy estimation, the testing laboratories that have participated to the development of this document have made the decision of performing a Round Robin based on this document for both airborne and structure-borne sound, as soon as the document is published.

11 Test report

The test report shall include:

a) reference to this European Standard, including its year of publication;

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 the manufacturer or supplier of the test;

f) description of the tested object stating the configuration tested (vertical pipe, vertical pipe with offset installed according to Annex A, A.2 or horizontal pipe installed according to A.3), the material and size of the parts, the methods used for joining and sealing the parts, the detailed plan of the mounting configuration, including the materials, size and locations of the clamps, and the type of elements used (commercial or prototype);

g) identification of the test specimen and instruments used;

h) description of the test facilities, especially of the test wall and/or test floor;

i) environmental data (temperature, static pressure, back ground noise);

j) test results for the bare installation: the report shall, according to EN 15657, include the spectra of the following quantities, obtained for the different flow rates:

  — airborne sound power L_{Wa} and corresponding single number value $L_{\mathrm{Wa,A}}$,

— single equivalent free velocity level $L_{vf,eq}$,

— single equivalent blocked force level $L_{Fb,eq}$,

— single equivalent mobility magnitude $\left|Y_{S,eq}\right|$.

For structure-borne sound, the examples of single number values given in EN 12354-5:2023, G.4 especially for application to EN 14366-1 and useful for manufacturers to compare products, can be added to the test results. However, the Single Number Quantities cannot be used as a prediction or proof of compliance with requirements in a building.

k) test results according to Annex B, B.4 for the mitigated installation, if tested;

l) any deviation from the procedure and any unusual features observed;

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

Annex A
(normative)

Cases of vertical pipes with offset and horizontal pipes

A.1 General

The scope of this document includes configurations of vertical pipes with offset (deviated horizontally) connected to walls and horizontal pipes connected to floors, for which the measuring method and the test report are the same as the ones used for the standard configuration. Schematics of the geometry of these configurations are given and compared to the standard configuration specified in the main text (see Figures A.1 to A.3).

A.2 Vertical pipes with offset

In the case of waste water installations with offset (vertically deviated) connected to walls, the geometry of the corresponding configuration can be specified by two parameters: the pipe offset Δl (in metre) and the deviation angle α (see Figure A.2); these two parameters shall be indicated in the report. All the other requirements for geometry given in 8.1 are still valid.

Requirements for the test facilities and the mounting of the system are the same as the ones for vertical pipes, given respectively in Clause 7 and 8.2, including 8.2.3; measuring method and test procedure are also the same.

A standard configuration for such installations has been specified, corresponding to the following parameter values: Δl = 0,75 m and α = 45°.

If α is close to 90°, the horizontal part of the piping system might be close to the ceiling and connected to it as shown in Figure A.3; the corresponding configuration is described in A.3).

A.3 Horizontal pipes

In the case of waste water installations with horizontal pipes connected to ceilings, the two 45° bend at the bottom can be located either outside or inside the test room as shown in Figure A.3. The requirement for falling height *h* given in 8.1.2 and shown in Figure 2 is still valid.

For the test facilities, any upper floor/ceiling can be used, as long as the applicability test specified in 5.2.1 is fulfilled. In the case of reinforced concrete, a range of ceiling thickness from 10 cm to 23 cm is usually appropriate.

Requirements for the test facilities are the same as the ones for vertical pipes, given in Clause 7. The necessary entrance and exit openings in the test room follow the same requirements for airborne sound measurements as in 8.2.2.

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 ceiling, as specified in Figure A.3, is provided for mounting of the test object. At least two fixing point shall be used to fasten the system to the test ceiling. No further restrictions are made concerning the location of clamps, clips and other fixing devices.

The standard configuration for horizontal pipes is the following: Two clamps shall be used to fasten the system to the test ceiling and the bottom two 45° bend should be located inside the test room (worst case). If not otherwise specified by the manufacturer, metal plugs shall be used. Clamp type and locations shall be described in the test report. The mandatory basement bend shall be mounted below the ceiling of the test room, at a distance d_1 of (15 ± 5) cm from the ceiling (see Figure A.3). Above the test room, the upper installation is fixed, avoiding any direct transmission of structure-borne sound to the test room.

If outside the test room, the basement bend could be mounted either at a distance d_2 of (15 ± 5) cm from the test room wall (see Figure A.3) or far away (distance to be determined), so that the bend has no influence on the pipe performance; but these configurations are no longer considered as standard configurations.

Key

1 inlet configuration similar to Figure 1
2 inlet tees
3 fixing devices
4 two 45° bend
h as in Figure 3
d As in Figure 3

Figure A.1 — Standard configuration; (left) schematic laboratory installation; (right) AA view of installation

Key

1 inlet configuration similar to Figure 1
2 inlet tees
3 fixing devices
4 two 45° bends
h as in Figure 3
d as in Figure 3
Δl Distance between the pipe axis

Offset parameter values for standard configuration: Δl = 0,75 m and ɿ = 45° (offset bends made of three 45° bends)

Figure A.2 — Vertical piping system with offset; (left) schematic laboratory installation; (right) AA view of installation

Key

1 inlet configuration similar to Figure 1

2 inlet tee

3 fixing devices

4 two 45° bend

5 Forbiden area: width: 50 cm

h as in Figure 3

d_1 Distance between upper floor and bend 4 (similar to d in Figure 3)

d_2 Distance between wall and bend 4 (similar to d in Figure 3)

Figure A.3 — Configurations for horizontal pipes: (upper right) bottom two 45° bend outside the test room; (upper left) bottom two 45° bend inside the test room (standard configuration); (lower right) forbidden area (top view of ceiling)

Annex B
(normative)

Test procedures for piping system mitigation measures

B.1 General

The performance of piping systems can be improved with mitigation measures such as pipe enclosures (technical shaft) or pipe lining. If such mitigation measures are tested, then the Laboratory test procedures for determining their performance shall be performed according to this annex.

B.2 Mitigation measure characterization

B.2.1 Pipe enclosure (technical shaft)

The piping system is mounted on the test wall inside the test room and disconnected from the test wall; the enclosure is then built around (usually the same way as in buildings) according to the instructions given by the manufacturer (see Figure B.1). The highest water flow rate (see 6.3) is applied and the enclosed source airborne sound power level $L_{\text{Wa,enclosed}}$ is measured according to 5.1.

Structure-borne sound is not measured in this case and predictions can only be approximated assuming a bare receiving wall (without enclosure) and using the results obtained without enclosure.

The pipe enclosure airborne sound power insertion loss D_{Wa} is calculated as:

$$D_{\text{WA}} = L_{\text{Wa}} - L_{\text{Wa,enclosed}} \tag{B.1}$$

where

L_{Wa} is the airborne sound power of the specimen without enclosure measured according to 5.1.

NOTE 1 The insertion loss D_{Wa} measured using the (heavy) test wall is considered as an acceptable approximation of the enclosure insertion loss in the case of a lightweight supporting wall.

If the sound generated in the room by the highest flow rate is too low to be measured with the enclosure (case of enclosure with high performance), then the water flow excitation shall be replaced by an acoustic excitation generated inside the piping system. A sufficiently powerful source shall be obtained by mounting a loudspeaker at the pipe inlet (see Figure B.2), which generates airborne sound inside the pipe [9]. The air gap between loudspeaker and pipe has to be filled with resilient material in order to prevent any airborne sound leak to the outside.

NOTE 2 The insertion loss obtained should not depend on the flow rate, nor on the piping type tested, nor on the excitation type (water flow or airborne sound in the pipe).

Key

1 inlet configuration similar to Figure 1
2 inlet tees
3 enclosure
4 two 45° bend

Figure B.1 — Standard configuration with enclosure; (left) schematic laboratory installation; (right) AA section of installation

Key

1 Inlet pipe disconnected (at dotted line) with plug put on inlet tee
2 angle close to 90° (depending on inlet tee)
3 loudspeaker

Figure B.2 — Airborne sound excitation setup

B.2.2 Pipe lining

The piping system is mounted on the test wall inside the test room (standard configuration) and the pipe lining installed according to the instructions given by the manufacturer. A steady flow of tap water is applied. The lining is likely to have an effect on both airborne sound and structure-borne sound.

— the airborne sound power of the piping system with lining $L_{\mathrm{Wa,lining}}$ is measured using the same procedure as in 5.1, leading to an airborne sound power insertion loss D_{Wa} calculated as:

$$D_{\mathrm{Wa}} = L_{\mathrm{Wa}} - L_{\mathrm{Wa,lining}} \tag{B.2}$$

where

L_{Wa} is the airborne sound power of the specimen without lining measured according to 5.1.

— the structure-borne sound performance obtained for a receiving element *i* is also expressed in terms of a power-based insertion loss $D_{\mathrm{Ws},i}$:

— *Case of low mobility receivers*: the single equivalent blocked force level $L_{\mathrm{Fb,eq,lining}}$ of the piping system with lining is the only characteristic required, measured according to *5.2.3.1*. The structure-borne sound power insertion loss $D_{\mathrm{Ws,low}}$ can then be calculated as

$$D_{\mathrm{Ws,low}} = L_{\mathrm{Fb,eq}} - L_{\mathrm{Fb,eq,lining}} \tag{B.3}$$

where

$L_{\mathrm{Fb,eq}}$ is the single equivalent blocked force level of the specimen without lining measured according to 5.2.3.1.

NOTE $D_{\mathrm{Ws,low}}$ does not depend on the receiving element *i* considered.

— *Other cases (usually in lightweight structures)*: The structure-borne sound power insertion loss $D_{\mathrm{Ws,high},i}$ is calculated in terms of installed power and depends on the receiving element *i* considered:

$$D_{\mathrm{Ws,high},i} = L_{\mathrm{Ws},i} - L_{\mathrm{Ws},i,\mathrm{lining}} \tag{B.4}$$

where

$L_{\mathrm{Ws},i}$ and $L_{\mathrm{Ws},i,\mathrm{lining}}$ are the installed power levels of the specimen without and with lining calculated according to EN 12354-5:2023, 5.3.2.1.

In this case, the characteristics $L_{\mathrm{Fb,eq,lining}}$ or $L_{\mathrm{fv,eq,lining}}$ and $\left|Y_{\mathrm{S,eq,lining}}\right|$ of the piping system with lining, as well as the receiver mobility, are required to calculate the installed power.

The above airborne and structure-borne sound measurements should be repeated for each flow rate (see Table 2), each corresponding to a particular sound source. The results obtained are only valid for the tested system.

B.3 Single number descriptor for mitigation measures

— The single number value for the pipe enclosure performance is calculated from the difference in airborne sound power levels of the installation with and without enclosure, each expressed in dB(A).

$$D_{\text{Wa,A}} = L_{\text{Wa,A}} - L_{\text{Wa,A,enclosed}} \quad \text{(B.5)}$$

— The single number value for the pipe lining airborne sound performance, only relevant for a given installation at a given flow rate, is calculated from the difference in airborne sound power levels of the installation with and without lining, each expressed in dB(A).

$$D_{\text{Wa,A}} = L_{\text{Wa,A}} - L_{\text{Wa,A,lining}} \quad \text{(B.6)}$$

— For the pipe lining structure-borne sound performance, relevant for a given installation at a given flow rate, only examples of single number values in terms of A-weighted sound pressure levels can be given as explained in 9.2.1. The sound pressure levels can be calculated using the examples specially given in EN 12354-5:2023, G.4 for application to EN 14366-1, first without pipe lining and then with pipe lining; in the latter case, the installed power is simply modified by adding the insertion loss $D_{\text{Ws},i}$ to the installed power of the bare pipe.

B.4 Test results for mitigation measures

B.4.1 Pipe enclosure

The report shall include the spectra of the following quantities and a description of the source used (water flow with maximum flow rate or loudspeaker):

— airborne sound power without enclosure L_{Wa},

— airborne sound power with enclosure $L_{\text{Wa,enclosed}}$,

— insertion loss D_{Wa} calculated according to (Formula (B.1) and corresponding single number value $D_{\text{Wa,A}}$ calculated according to (Formula (B.5).

B.4.2 Pipe lining

a) Airborne sound

Similar to Pipe enclosure above, replacing “enclosure” and “enclosed” by “lining”.

b) Structure-borne sound

The report shall include the spectra of the following quantities, obtained for a given installation at the different flow rates:

— single equivalent blocked force $L_{\text{Fb,eq}}$;

— single equivalent blocked force with lining $L_{\text{Fb,eq,lining}}$;

— insertion loss $D_{\text{Ws,low}}$ using Formula (B.3);

— single equivalent free velocity $L_{vf,eq}$;

— single equivalent free velocity with lining $L_{vf,eq,lining}$;

— single equivalent mobility magnitude $\left|Y_{S,eq}\right|$;

— single equivalent mobility magnitude with lining $\left|Y_{S,eq,lining}\right|$;

— insertion loss $D_{Ws,high,i}$ using Formula (B.4);

Examples of single number values, useful for manufacturers, can be obtained for structure-borne sound according to the calculation procedure described in B.3 using the examples specially given in EN 12354-5:2023, G.4 for application to EN 14366-1.

Annex C
(informative)

Link from EN 14366:2004+A1:2019 to EN 14366-1

In EN 14366:2004+A1:2019, the report includes the following three quantities: the normalized airborne sound level L_{an}, the normalized structure borne sound level L_{sn} and the test wall structural sensitivity L_{SS}.

The airborne sound power L_{Wa} of the specimen measured according to Clause 5 can be calculated from the airborne sound pressure level L_{an} as:

$$L_{Wa} = L_{an} + 4\ \text{dB} \quad \text{(C.1)}$$

The structure-borne contribution to the total sound power $L_{Wa,struc}$ of the specimen measured according to 5.2.3.2 can be calculated from structure-borne sound pressure level L_{sn} as:

$$L_{Wa,struc} = L_{sn} + 4\ \text{dB} \quad \text{(C.2)}$$

The single equivalent blocked force level $L_{Fb,eq}$ of the specimen measured according to 5.2.3.1 can then be calculated as:

$$L_{Fb,eq} = L_{Wa,struc} - L_{SS} + 10\ \lg(\rho_0 c_0 W_0 / F_0^2 k^2) \quad \text{(C.3)}$$

where

$L_{Wa,struc}$	is calculated using Formula (C.2);
$\rho_0 c_0$	is the characteristic impedance of air (ρ_0 in kg/m^3 and c_0 in m/s); $\rho_0 c_0$ = 400 Ns/m^3
L_{SS}	is the test wall structural sensitivity;
k	is the wave number in air (m^{-1}); $k = 2\pi f / c_0$
W_0	is the reference power ($W_0 = 10^{-12}$ Watt);
F_0	is the reference force ($F_0 = 10^{-6}$ N).

The calculated values cannot be used as certified values obtained by test, but only for comparison with new tests. However, such comparisons are relevant only if the same information on the test object and its mounting conditions is given in the two test reports (the old and the new one).

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