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Railway applications — Gangway systems between vehicles

Part 2: Acoustic measurements

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Bahnanwendungen - Übergangssysteme zwischen Fahrzeugen - Teil 2: Messung der Akustik

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Foreword

This document (EN 16286-2:2013) has been prepared by Technical Committee CEN/TC 256 “Railway Applications”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by September 2013, and conflicting national standards shall be withdrawn at the latest by September 2013.

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This series of European Standards EN 16286, *Railway applications — Gangway systems between vehicles*, consists of the following parts:

— *Part 1: Main applications*

— *Part 2: Acoustic measurements*

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Introduction

This European Standard presents a measurement method to collect information about the noise insulation of rail bound vehicle gangway systems. These components need their own measurement procedure as the geometrical sound distribution situation is not in line with the basic assumptions of general standards about noise insulation measurements as provided for building elements, etc.

In this standard, a number of different setups are described, which represent possible approaches to the ideal test situation. As the approaches may contradict the ideal sound fields, the standard includes methods to assess the influence of reflections and other difficulties in order to reduce the uncertainties of these test methods to an acceptable amount in Annex A.

1 Scope

This European Standard specifies a measurement method and conditions to obtain reproducible and comparable sound reduction indices of all kinds of rail bound vehicles' gangway systems defined in EN 16286-1. The setup should include all components of the system mounted like this is done between two adjacent car bodies within the train, so that a person will be able to use the gangway system, consisting of e.g:

- the bridge system (footplate);
- side panels;
- flexible components (bellows);
- mounting systems;
- elements to couple parts in case of separable gangway systems.

If separable gangway systems shall be measured, the whole system between two adjacent car bodies should be used.

The method is applicable to type testing of gangways.

This method is not applicable to:

- interior noise measurements in vehicles;
- structure borne noise measurements.

The type testing procedures specified in this European Standard are of engineering grade (grade 2) in the frequency range from 100 Hz up to 5 kHz; that is the preferred range for noise declaration purposes, as defined in EN ISO 12001. If test conditions are relaxed, the results are no longer of engineering grade.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ENV 13005, *Guide to the expression of uncertainty in measurement*

EN 60942, *Electroacoustics — Sound calibrators (IEC 60942)*

EN 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications (IEC 61672-1)*

EN 61672-2, *Electroacoustics — Sound level meters — Part 2: Pattern evaluation tests (IEC 61672-2)*

EN ISO 266, *Acoustics — Preferred frequencies (ISO 266)*

EN ISO 3741, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for reverberation test rooms (ISO 3741)*

EN ISO 9614-1:2009, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points (ISO 9614-1:1993)*

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

EN ISO 10140-4:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 4: Measurement procedures and requirements (ISO 10140-4:2010)*

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

3 Terms and definitions

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

3.1
sound pressure
p
root mean square (RMS) value of a fluctuating pressure superimposed on the static atmospheric pressure measured over a certain time period, expressed in Pa

3.2
sound pressure level
L_p
level given by the formula:

$$L_p = 10 \log (p/p_0)^2 \text{ dB} \quad (1)$$

where

L_p is the sound pressure level in dB;

p is the RMS sound pressure in Pa;

p_0 the reference sound pressure; p_0 = 20 μPa

Note 1 to entry Adapted from ISO 1996-1.

3.3
average sound pressure level in a source room
L_{p1}
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, window, etc.) is of significant influence

Note 1 to entry This quantity is given in decibels.

Note 2 to entry For a complete definition, see EN ISO 10140-2.

3.4
sound reduction index
R
ten times the logarithm to the base 10 of the ratio of the sound power W_1 incident on the test specimen to the sound power W_2 transmitted through the specimen:

$$R = 10 \log \left(\frac{W_1}{W_2} \right) \text{dB} \quad (2)$$

Note 1 to entry The expression "sound transmission loss" is also in use.

3.5
sound intensity
I
time-averaged rate of flow of sound energy per unit area oriented normal to the local particle velocity; this is a vectorial quantity which is equal to:

$$\vec{I} = \frac{1}{T}\int_{0}^{T} p(t) \times \vec{u}(t) \times \mathrm{d}t \tag{3}$$

where

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

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

T is the averaging time, in seconds

Note 1 to entry Sound intensity is measured in watts per square meter.

3.6
normal sound intensity
I_{n}
component of the sound intensity in the direction normal to a measurement surface defined by the unit normal vector $\vec{n}$:

$$I_{\mathrm{n}} = \overline{I} \times \vec{n} \tag{4}$$

where

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

3.7
normal sound intensity level
L_{In}
ten times the logarithm to the base 10 of the ratio of the unsigned value of the normal sound intensity to the reference intensity I_0, as given by:

$$L_{\mathrm{In}} = 10 \log \frac{I_{\mathrm{n}}}{I_0} \ \mathrm{dB} \tag{5}$$

where

$$I_0 = 10^{-12} \ \mathrm{W/m^2} \tag{6}$$

3.8
surface pressure-intensity indicator
F_{pI}
difference between the sound pressure level, L_{p}, and the normal sound intensity level, L_{In}, on the measurement surface, both being time and surface averaged:

$$F_{\mathrm{pI}} = L_{\mathrm{p}} - L_{\mathrm{In}} \tag{7}$$

Note 1 to entry This notation is in accordance with EN ISO 9614-2. In EN ISO 9614-1, the notation F_2 is used.

3.9
pressure-residual intensity index
δ_{pI0}
difference between the indicated sound pressure level, L_{p}, and the indicated sound intensity level, L_{I}, when the intensity probe is placed and oriented in a sound field such that the sound intensity is zero

Note 1 to entry δ_{pI0} is expressed in decibels.

Note 2 to entry Details for determining δ_{pI0} are given in EN 61043:

$$\delta_{\mathrm{pI0}} = \left(L_{\mathrm{p}} - L_{\mathrm{I}}\right)$$

3.10
intensity sound reduction index of a gangway
R_{IG}
index evaluated from Formula (2), assuming that the sound field in the source room is diffuse:

$$R_{\mathrm{IG}} = L_{\mathrm{p1}} + \Delta L_{\mathrm{c}} - 6 - L_{\mathrm{In}} - 10 \log\left(\frac{S_{\mathrm{m}}}{S}\right) \text{(in dB)} \tag{8}$$

where

L_{p1} is the average sound pressure level in the source room;

ΔL_{c} is the indicator for the diffusity of the sound field according to Annex A of this standard;

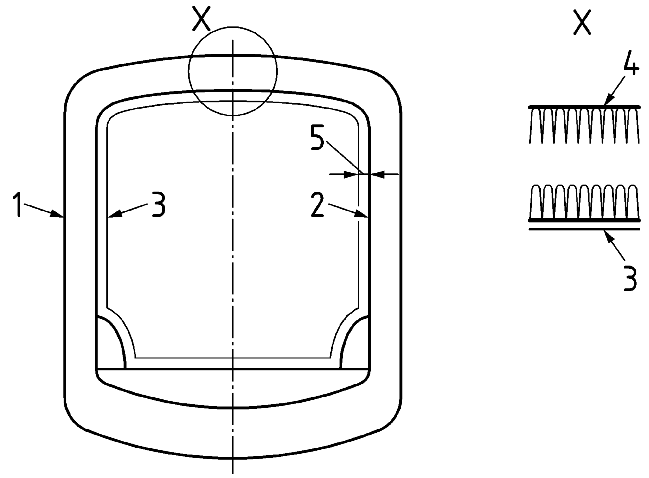
L_{In} is the average sound intensity level over the measurement surface in the receiving room;

S_{m} is the total area of the measurement surface(s);

S is the inner respectively outer contour area of the test specimen at the source side (compare Figure 1 and Figure 2)

3.11
source side area of the test specimen
S
contour area of the test specimen at the source side

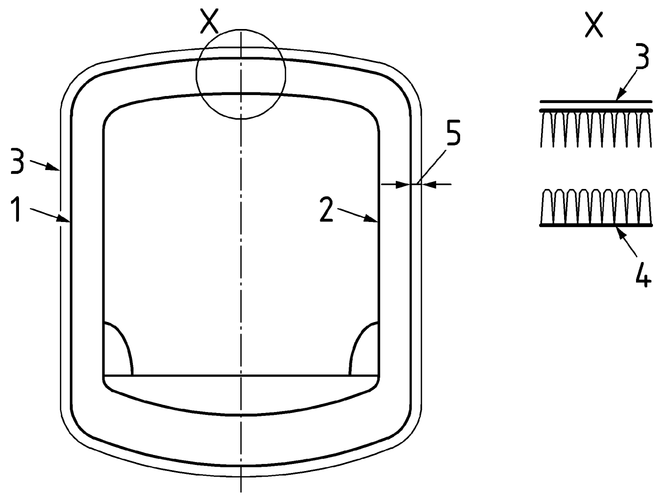
3.12
measurement surface
S_{m}
surface in parallel to the bellow contour totally enclosing the test specimen on the receiving side, scanned or sampled by the probe during the measurements



Key

1 bellow at source side
2 bellow at receiving side
3 measurement surface S_m
4 contour area of the test specimen at the source side S
5 distance d between contour area of the receiving side and the measurement surface S_m

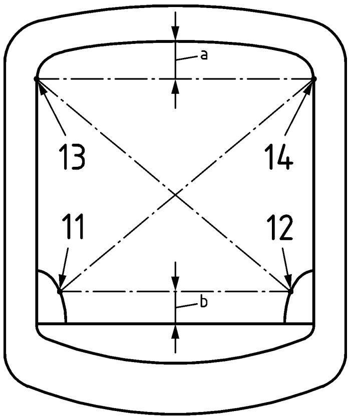
Figure 1 — Measurement surface S_m for intensity measurements inside the gangway and contour area of the outer source side S



Key

1 bellow at receiving side
2 bellow at source side
3 measurement surface S_m
4 contour area of the test specimen at the source side S
5 distance d between contour area of the receiving side and the measurement surface S_m

Figure 2 — Measurement surface S_m for intensity measurements outside the gangway and contour area of the inner source side S



Key

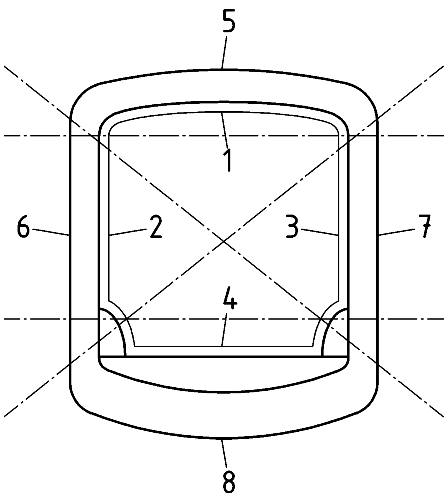
11, 12 intersection points between horizontal line above floor level and inner contour of the gangway system

13, 14 intersection points between horizontal line below ceiling and inner contour of the gangway system

a distance between horizontal line (intersection points 13 and 14) and ceiling level of the gangway system

b distance between horizontal line (intersection points 11 and 12) and floor level of the gangway system

Figure 3 — Procedure to determine areas of floor, sides and ceiling



Key

1 partial measurement surface of the roof $S_{mc, 1}$

2 partial measurement surface of the side 1 $S_{mc, 2}$

3 partial measurement surface of the side 2 $S_{mc, 3}$

4 partial measurement surface of the floor $S_{mc, 4}$

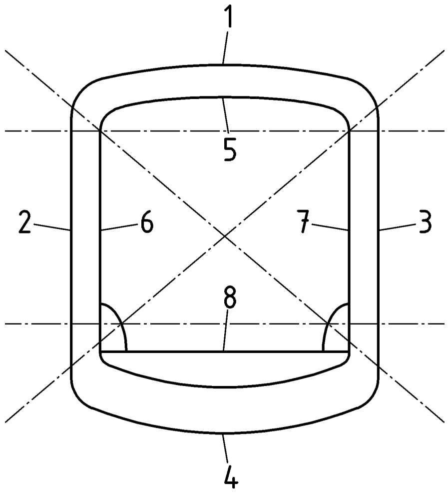
5 partial area of the roof $S_{c, 1}$

6 partial area of the side 1 $S_{c, 2}$

7 partial area of the side 2 $S_{c, 3}$

8 partial area of the floor $S_{c, 4}$

Figure 4 — Procedure to determine partial areas S_c and partial measurement surfaces S_{mc} in the case of an inside measurement surface



Key

1 partial measurement surface of the roof $S_{mc,\,1}$

2 partial measurement surface of the side 1 $S_{mc,\,2}$

3 partial measurement surface of the side 2 $S_{mc,\,3}$

4 partial measurement surface of the floor $S_{mc,\,4}$

5 partial area of the roof $S_{c,\,1}$

6 partial area of the side 1 $S_{c,\,2}$

7 partial area of the side 2 $S_{c,\,3}$

8 partial area of the floor $S_{c,\,4}$

Figure 5 — Procedure to determine partial areas S_c and partial measurement surfaces S_{mc} in the case of an outside measurement surface

3.13
partial area
S_c
inner respectively outer contour area S of the test specimen at the source side is subdivided into the contiguous partial areas S_c, representing the sidewalls, the floor and the ceiling

Note 1 to entry The sum of all partial areas S_c equals the outer contour area S.

Note 2 to entry Partial areas S_c can be combined from any number of contiguous subareas S_{ci}.

$$S_c = \sum_i S_{ci} \tag{9}$$

Note 3 to entry See Figure 3 to Figure 5.

3.14
subarea
S_{ci}
part of the inner respectively outer contour of the test specimen at the source side

Note 1 to entry See Figures 4 and 5.

3.15
partial measurement surface
S_{mc}
measurement surface S_m of the test specimen is subdivided into the contiguous partial measurement surfaces S_{mc}

Note 1 to entry See Figures 4 and 5.

$$S_{\mathrm{mc}} = \sum_{\mathrm{i}} S_{\mathrm{mci}} \tag{10}$$

3.16
measurement subarea
S_{mci}
part of the measurement surface S_{mc} being measured with the intensity probe using one continuous scan or discrete positions

Note 1 to entry No overlap and no gaps are intended between subareas. The measurement subarea S_{mci} is related to the subarea S_{ci}.

Note 2 to entry Figures 4 and 5 give explanation for S_{ci}, S_{mci}, S_{c}, S_{mc}, a, b.

3.17
partial intensity sound reduction index of a gangway
R_{IGc}
index for the partial area c evaluated from Formula (2), assuming that the sound field in the source room is diffuse:

$$R_{\mathrm{IGc}} = L_{\mathrm{p1}} + \Delta L_{\mathrm{c}} - 6\ dB - L_{\mathrm{Inc}} - 10\ \log\left(\frac{S_{\mathrm{mc}}}{S_{\mathrm{c}}}\right)\ \mathrm{dB} \tag{11}$$

where

$$L_{\mathrm{Inc}} = 10 \times \log\left[\frac{1}{S_{\mathrm{mc}}}\sum_{\mathrm{i}} S_{\mathrm{mi}} 10^{\left(\frac{1}{10}L_{\mathrm{Ini}}\right)}\right] \tag{12}$$

Note 1 to entry L_{Inc} is the average sound intensity level over the partial measurement surface S_{mc} at the receiving side.

Note 2 to entry If the sound intensity for a measurement subarea has a negative direction (i.e. if the flow of energy is in the direction towards the test object) a minus-sign will be inserted before the respective S_{mi}.

3.18
overall intensity sound reduction index of a gangway
R_{IG}
index for the overall area S evaluated from Formula (2), assuming that the sound field in the source room is diffuse:

$$R_{\mathrm{IG}} = L_{\mathrm{p1}} + \Delta L_{\mathrm{c}} - 6 - L_{\mathrm{In}} - 10\ \log\left(\frac{S_{\mathrm{m}}}{S}\right)\ \mathrm{dB} \tag{13}$$

where

$$L_{\mathrm{In}} = 10 \times \log\left[\frac{1}{S_m}\sum_{\mathrm{c}} S_{\mathrm{mc}} 10^{\left(\frac{1}{10}L_{\mathrm{Inc}}\right)}\right] \tag{14}$$

Note 1 to entry The overall intensity sound reduction index can also be calculated using the following formula:

$$R_{\mathrm{IG}} = -10 \times \log\left[\frac{1}{S}\sum_{\mathrm{c}} S_{\mathrm{c}} 10^{\left(-\frac{1}{10}R_{\mathrm{IGc}}\right)}\right] \tag{15}$$

Note 2 to entry See also Note 2 of Formula 12.

4 Instrumentation and calibration

4.1 Instrumentation

The compliance of the calibrator with the requirements of EN 60942 shall be verified at least once a year. The compliance of the instrumentation system with the requirements of EN 61672-1 and EN 61672-2 shall be verified at least every two years.

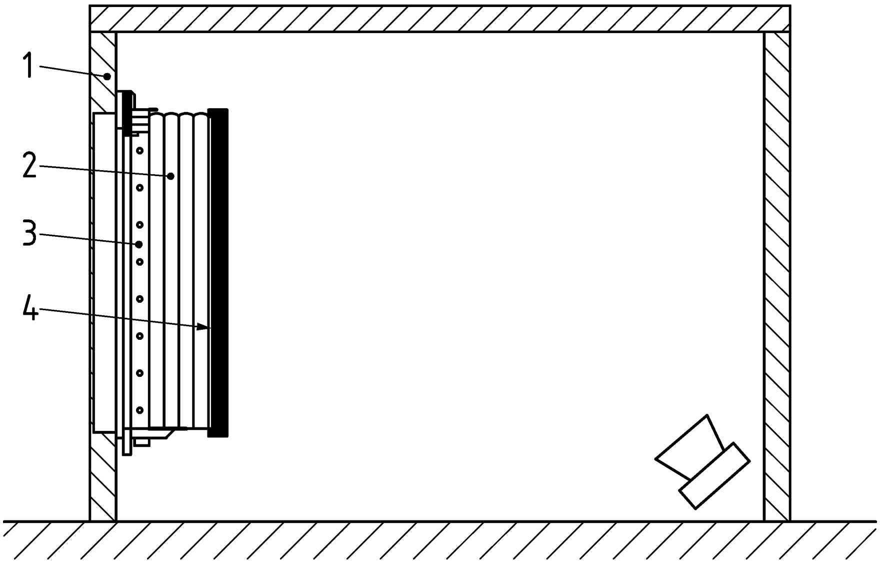
4.2 Calibration

Before and after each series of measurements and at least each time the cabling has been disconnected and reconnected, a sound calibrator meeting the requirements of class 1 according to EN 60942 shall be applied to the microphone(s) for verifying the calibration of the entire measuring system at one or more frequencies over the frequency range of interest. If the results of this process vary by more than 0,5 dB between two consecutive checks, the results collected in between shall be rejected.

5 Measurement setup

The general setup consists of a gangway system to be measured, a source room where a diffuse sound field is provided and a separated receiver room where the transmitted sound intensity is measured. It is possible to apply the diffuse sound field to the inner or outer surface of the gangway system; the transmitted sound intensity is measured at the receiver side.

Possible configurations of this setup are shown in Figure 6 to Figure 9.



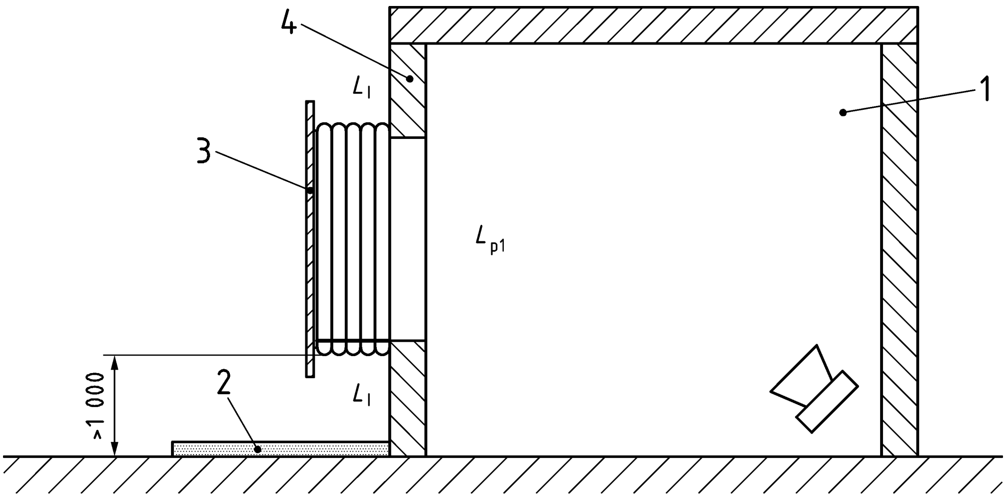
Key

1 solid wall
2 gangway
3 window
4 double panel

NOTE The test object is mounted inside the source room on the dividing wall.

Figure 6 — Configuration example 1

Dimensions in millimetres

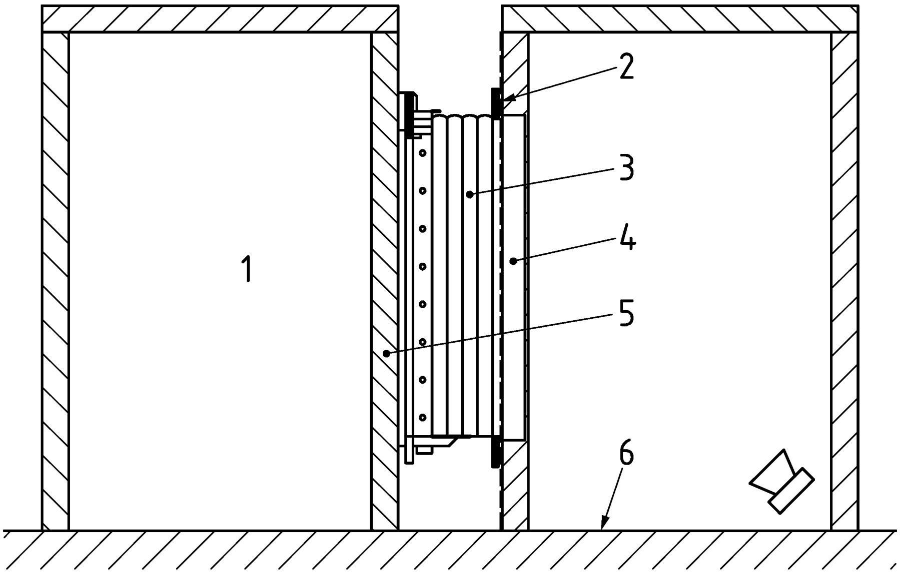


Key

1 source room – diffuse field
2 absorbing mat
3 double panel
4 solid wall

NOTE The test object is mounted outside the source room on the dividing wall.

Figure 7 — Configuration example 2



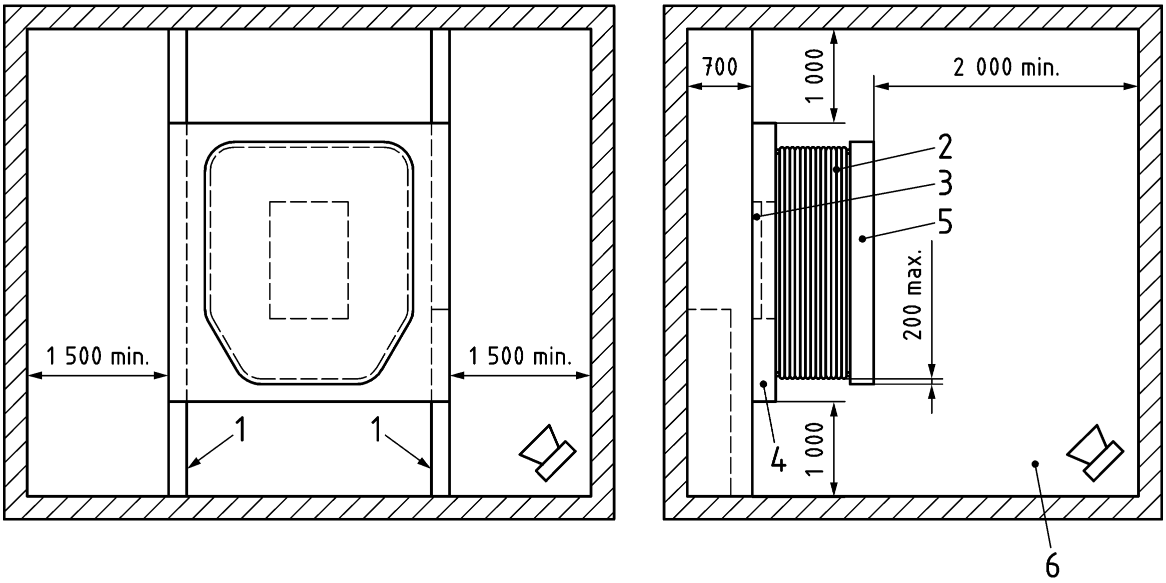
Key

1 reverberant room
2 solid wall
3 gangway
4 door – high sound insulation
5 solid wall
6 floor

NOTE The test object is mounted within the source room between two closing covers.

Figure 8 — Configuration example 3

Dimensions in millimetres



Key

1 solid wall

2 gangway

3 door – high sound insulation

4 panel 1

5 panel 2

6 source room – diffuse field

NOTE The test object is mounted within the source room between a separating wall and a closing cover.

Figure 9 — Configuration example 4

6 Test procedure

6.1 General

The procedure is based on a highly diffuse sound field at the source side of the gangway surface and the transmission to the receiver side which is supposed to be in free field condition.

The main measurement task is a measurement of the average sound pressure level in the diffuse field of the source room and the average sound intensity level on a measurement surface in the receiver room. When the acoustic field indicators as defined in EN ISO 15186-1 fulfil the requirements, then the intensity sound reduction index is calculated.

As the gangway system in terms of the acoustical point of view of this standard does not include doors, if doors are part of the gangway system to be measured, they shall be opened as far as possible. In case of doors covering the bellows in open condition they shall be removed for the measurement.

6.2 Generation of sound field

The characteristics of the sound source, the test signal and the sound source positions shall meet the requirements of EN ISO 10140-2 and EN ISO 10140-4.

A check of the sound field according to Annex A of this standard shall be performed for every setup.

NOTE 1 In certain cases the minimum number of sound source positions will be more than required by EN ISO 10140-4.

Recommended minimum distances of the outer gangway surface or openings to room surfaces, except the dividing wall between source side and receiver side:

— to the floor: 1 m;

— to the sidewalls: 1,5 m;

— to the ceiling: 1 m.

In the case of a gangway mounted to a dividing wall the distance between the gangway closing plate and the backside wall of the measurement room shall be 2 m at least.

In the case of a free standing gangway the covered openings should have a minimum distance of 1,0 m to any wall.

Reverberant rooms should be compliant to the needs of EN ISO 3741. Minimum size of reverberant rooms shall be 200 m^3.

The check of the sound field is still needed in case of conformity to all geometric parameters defined in this note.

In any test frequency the sound reduction of the closing plate shall exceed the sound reduction of the gangway system by at least 10 dB, but preferably more than 15 dB. The size of the closing panel shall not exceed the size of the gangway outer surface by more than 200 mm at any point.

NOTE 2 In the case of separating walls the 200 mm criterion might not be applied to one wall. This will be the case for a test setup as shown in Figure 8.

Additional absorbers inside the gangway system for the purpose of damping are recommended at those surfaces not under test during the measurement of a certain subarea.

Sound source placement shall be done compliant to EN ISO 10140-2.

Measurements shall enable to provide results with sufficient repeatability and accuracy for the frequency range from 100 Hz up to 5 kHz in one-third octave bands. Additional results shall be provided for the low frequency range beginning at 50 Hz (compare with EN ISO 10140-4). The deviation of measurement results in the low frequency range will exceed the tolerances specified before.

6.3 Sound pressure level in the source room

The average sound pressure level in the source room shall be measured according to the procedures given in EN ISO 10140-2, EN ISO 10140-4 and EN ISO 10140-5. Especially Part 4 provides information about loudspeaker positions.

The preferred measurement setup should be chosen according to 4.4.2.a and 4.4.3.a of EN ISO 10140-4:2010.

6.4 Measurement of average sound intensity level on the measurement surface

6.4.1 General

Procedure to define areas of the gangway (see Figure 3 to Figure 5):

— first define a horizontal line 200 mm above the floor level of the gangway system (provides intersection point 11 (left side) and 12 (right side));

— then define a horizontal line 200 mm below the highest point of the gangway ceiling (provides intersection point 13 (left side) and 14 (right side));

— the vertical sections between the intersection points are the right (12/14) and left (11/13) side inner areas;

— the connection between the lower intersection points (11/12) defines the floor inner area;

— the connection between the upper intersection points (13/14) defines the ceiling inner area;

— the corresponding outer areas are found by cutting the overall outer area by the diagonal lines.

There shall be no overlap of partial measurement surfaces as well as no gaps between partial surfaces. The partial measurement surface S_{mc} is related to the partial area S_c.

Partial measurement surfaces S_{mc} can be combined from any number of contiguous sub surfaces S_{mci}.

6.4.2 Measurement surface

On the receiving side, use a measurement surface S_m parallel to the bellow contour totally enclosing the test specimen.

Initially select a constant measurement distance d in the range from 0,1 m to 0,2 m.

Measurement distances shorter than 0,1 m should be avoided because of the near field of the vibrating element. In the near field the intensity tends to change sign very often.

6.4.3 Qualification of the measurement surface

Measure the time averaged sound intensity level L_{In} over the test surface S_m. If possible, measure the sound pressure level L_p simultaneously. Then calculate the surface pressure-intensity indicator from:

$$F_{pI} = L_p - L_{In} \text{ [dB]} \quad (16)$$

If the measured intensity is negative or if F_{pI} is not satisfactory (i.e. if F_{pI} > 10 dB for a sound reflecting test specimen, or if F_{pI} > 6 dB for a test specimen with a sound absorbing surface at the receiving side), improve the measurement environment. First try to increase the measurement distance by 5 cm to 10 cm. If this fails, add sound absorbing material at the receiving side. For scanning, the sound field indicator requirement is valid for each scan and each loudspeaker position. However, it is only valid for the total measurement surface and not for individual measurement subareas. For discrete positions it is valid for the surface average.

NOTE 1 When intensity measurements are done at the outer surface of the specimen, as a rule of thumb, F_{pI} < 10 dB requires S/A < 1,25

where

S is the area of the measurement surface;

A is the sound absorption area of the receiving side (for definition, see EN ISO 10140, all parts); the greater the flanking transmission the more A should be increased.

NOTE 2 When intensity measurements are done at the inner surface of the specimen, a common requirement will be to provide absorbing material with a thickness of > 200 mm and an averaged absorption coefficient α_S > 0,95 at all surfaces apart from the measurement surface.

6.4.4 Scanning procedure

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

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

Scan each area or subarea using parallel lines, turning at each edge as shown in Figure 10. The required scanning line density depends on how irregular the sound radiation is. A large amount of irregularities such as leakages requires a higher line density. The line distance between scan lines shall not exceed 0,1 m.

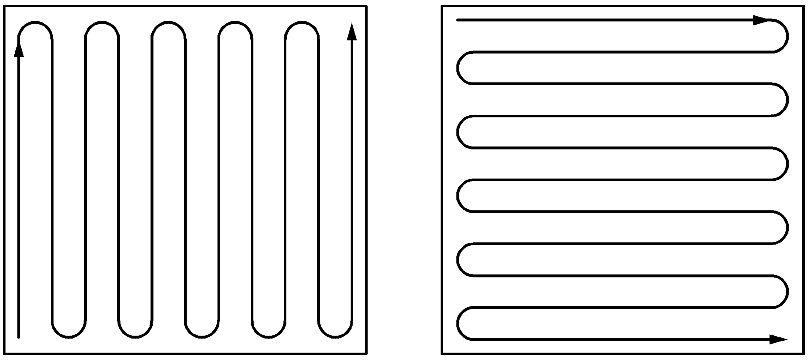


Figure 10 — Scanning patterns for the two scans

6.4.5 Procedure using discrete positions

As an alternative to scanning, fixed positions can be used on the measurement surface described in 6.4.4. Initially select the distance between probe positions to be approximately d m, where d is the measurement distance from the test object. For test specimens having strong sound leaks or inhomogeneous sound flow, use a denser measurement grid but keep the measurement distance constant. For the measurements, follow the procedures of a grade 2 method as specified in EN ISO 9614-1:2009. Check the adequacy of the chosen array of measurements positions using Annex B of EN ISO 9614-1:2009. Measure at least 10 s in each probe position. If a moving loudspeaker is used, the minimum number of loudspeaker traverses, for the complete set of microphone positions, shall be two.

6.4.6 Scanning procedure for one measurement area

For each fixed loudspeaker position, once the measurement environment is satisfactory, carry out two complete scans, one for each pattern, and compare the results. Turn the scanning path 90° between the two scans. If the difference between the two measurements is less than 1,0 dB for any one frequency band, the measurement result is given by the arithmetic average of the two measurements. If the difference is larger than 1,0 dB, the measurements are not valid.

Repeat the two scanning patterns until the requirement is fulfilled. If the requirement cannot be fulfilled, change the scanning line density, measurement surface or measurement environment and repeat the measurements until the requirement is fulfilled. If, despite these efforts, it is impossible to comply with these requirements, the results may still be given in the test report provided that all deviations from the requirements of this method are clearly stated.

If two or more loudspeaker positions are used sequentially, carry out a pair of scans for each loudspeaker position. Each pair of scans shall comply with the requirements above.

Alternatively multiple loudspeakers supplied with non-correlated noise signals may be used. In this case a pair of scans provides sufficient data.

Give all results, including the sound reduction index and field indicator, as the arithmetic mean of all scans carried out. If a moving loudspeaker is used, use, for each scan, at least one loudspeaker traverse. Scan the measurement surface using the two different scanning patterns. Each of these scans shall take place during a single complete loudspeaker traverse. Select a scan direction to avoid having coinciding loudspeaker and microphone positions in the two scans. The result of each set of patterns is the energy average of the scans. Evaluate the averages of the two patterns as for a fixed loudspeaker position.

6.4.7 Scanning procedure for several measurement subareas

For each subarea, apply the procedures of 6.4.5 or 6.4.6.

If the measurement surface is divided into several subareas, each with the area S_{mi}, each being scanned individually, evaluate the normal sound intensity level L_{In} from:

$$L_{In} = 10 \log\left[\frac{1}{S_m}\sum_i S_{mi} 10^{0,1 L_{Ini}}\right] \text{dB} \qquad (17)$$

where

i indicates the subarea i;

S_m is the total area measured and is given by $\Sigma\, S_{mi}$.

If the sound intensity for a measurement subarea has a negative direction (i.e. if the flow of energy is in the direction towards the test object) a minus-sign shall be inserted before the respective S_{mi}in Formula (11).

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

$$F_{pI} = 10 \log\left[\frac{1}{S_m}\sum_i S_{mi} 10^{0,1 L_{pi}}\right] \text{dB} - L_{In} \qquad (18)$$

where

L_{pi} is the surface-averaged sound pressure level over S_{mi}.

6.5 Background noise

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

NOTE These requirements might be tested by applying the following procedure. If the field indicator F_{pI} is < 10 dB, then lower the source level by 10 dB. If F_{pI} is changed less than 1 dB, then the requirements are fulfilled.

6.6 Frequency range of measurements

Measure the sound pressure level and the sound intensity level using one-third octave band filters having at least the centre frequencies from 100 Hz up to 5 kHz, according to EN ISO 266.

Octave band values, if needed, shall be calculated from one-third-octave levels.

7 Presentation of results

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

— 5 mm per one-third octave band,

and

— 20 mm per 10 dB.

8 Quality of the measurements

8.1 Deviations from the requirements

The conditions prescribed for the tests described in Clause 6 shall be complied with as closely as possible. Slight deviations from the specified test conditions for type tests may be unavoidable. In this case, they shall be described in the test report and, in general, will lower the accuracy or reproducibility or both.

8.2 Measurement tolerances

All measurement distances mentioned in the standard shall be considered with a tolerance of ± 20 %.

8.3 Measurement uncertainties

The measurement uncertainty shall be evaluated according to ENV 13005 for both Type A and Type B uncertainty categories. The report shall contain the main assumptions taken for this analysis following the standard.

9 Test report

With reference to this document, the test report shall state the following:

a) name of organisation that has performed the measurements;

b) identification of test site;

c) name of client;

d) date of test;

e) description of the test specimen, including mounting and sealing;

f) volume and description of measurement rooms;

g) measurement distance and area of test object, contour area S, measurement surfaces S_{m} and partial areas S_{c} and partial measurement surfaces S_{mc};

h) description of diffusity test procedure and test result;

i) intensity sound reduction index as a function of frequency (overall area and partial area measurement results);

NOTE Reference to EN ISO 717-1 if required.

j) surface pressure-intensity indicator, F_{pI} for overall area and partial areas and pressure-residual intensity index, δ_{pI0} as a function of frequency;

k) ΔL_c as indicator for the quality of the sound field at the source side;

l) description of the measurement equipment, including probe (microphone diameter, spacing) and data acquisition system. The date of the last verification of the compliance with the relevant European Standards and the required calibration interval shall be recorded.

Annex A
(normative)

Method to qualify the sound field on the surface of the test specimen in the source room

Measurements of the sound transmission require a diffuse and uniform sound field on all partial areas of the test specimen. Nevertheless for practical reasons the ideal sound field conditions will not be met. Therefore this method provides an indicator ΔL_c for the deviation from ideal conditions.

The source room without the test specimen shall meet the reverberation room requirements defined in EN ISO 3741.

For the acceptance of a test setup including the test specimen, the following requirements shall be fulfilled:

— equally distributed sound incidence in terms of directivity on the surface of the test specimen;

— uniformity of sound pressure level at any partial area of the test specimen;

— the test specimen shall be exposed to the diffuse sound field of the room.

The compliance of the test setup with these criteria shall be tested by the following procedure which shall be performed for each partial area S_c:

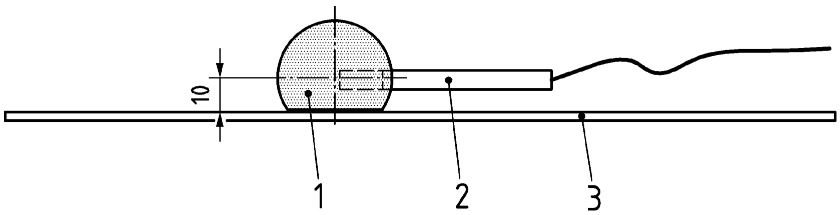
— cover the partial area S_c of the test specimen with a sound reflecting plate with an area specific mass of at least 6 kg/m^2. Possible reflecting plates are made from 1 mm steel or a bituminous foil;

— measure the sound pressure level L_{p1c} of the diffuse field according to 6.3;

— measure the averaged sound pressure level L_{pSc} in a distance of approximately 10 mm to the complete surface of the sound reflecting cover plate. The scanning procedure described in 6.4.4 shall be applied.

Figure A.1 shows a possible setup to achieve a constant distance of 10 mm.

Dimensions in millimetres



Key

1 cropped microphone windscreen ball

2 microphone

3 sound reflecting cover plate

Figure A.1 — Possible setup to achieve a constant distance of 10 mm

Noises caused by the contact of the windball with the surface will be small compared to the measurement signals.

NOTE 1 In the case of an omnidirectional microphone, the microphone can be held in normal direction as well. The distance between microphone and surface can be reduced to 3 mm according to EN ISO 10140-5.

In the case of resonances caused by the covering plate, the distance of the covering plate to the surface of the test area may be increased to maximum 100 mm.

— for each one-third octave band, calculate the level difference between the averaged sound pressure levels near to the covering plate and the diffuse sound pressure level in the room and apply a correction term of –3 dB representing the near field effect. The result is the indicator ΔL_{c} which supplies a value for the deviation from ideal diffuse field condition:

$$\Delta L_{\mathrm{c}} = L_{\mathrm{pSc}} - L_{\mathrm{p1c}} - 3\,\mathrm{dB}$$

NOTE 2 Theoretically it is expected that in an ideal diffuse field the sound pressure level directly on a surface is 3 dB higher than in the diffuse field.

— compare the one-third octave band indicator ΔL_{c} with the acceptable values given in Table A.1:

Table A.1 — Maximum acceptable deviation values ΔL_{c}

Frequency band	**Acceptable deviation values ΔL_{c}**
100 Hz - 400 Hz	± 2,0 dB
500 Hz – 1 000 Hz	± 1,5 dB
1 250 Hz – 2 000 Hz	± 1,0 dB

If an investigation of the level difference ΔL_{c} is required for frequencies above 2 kHz the distance of the microphone to the covering plate shall be reduced to an appropriate value.

In the case of ΔL_{c} exceeding the limits specified in Table A.1, it is recommended to change the test setup in order to decrease the resulting deviations.

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