SLOVENSKI STANDARD
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Protihrupne ovire za cestni promet - Preskusna metoda za ugotavljanje akustičnih lastnosti - 5. del: Bistvene lastnosti - Terenske vrednosti odboja zvoka z uporabo usmerjenega zvočnega polja

Road Traffic Noise reducing devices - Test method for determining the acoustic performance - Part 5: Intrinsic characteristics - In situ values of sound reflection under direct sound field conditions

Lärmschutzvorrichtungen an Straßen - Prüfverfahren zur Bestimmung der akustischen Eigenschaften - Teil 5: Produktspezifische Merkmale - In-situ-Werte der Schallreflexion in gerichteten Schallfeldern

Dispositifs de réduction du bruit du trafic routier - Méthode d'essai pour la détermination de la performance acoustique - Partie 5: Caractéristiques intrinsèques - Valeurs in situ de réflexion acoustique dans des conditions de champ acoustique direct

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ICS:

17.140.30	Emisija hrupa transportnih sredstev	Noise emitted by means of transport
93.080.30	Cestna oprema in pomožne naprave	Road equipment and installations

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English Version

Road Traffic Noise reducing devices - Test method for determining the acoustic performance - Part 5: Intrinsic characteristics - In situ values of sound reflection under direct sound field conditions

Lärmschutzvorrichtungen an Straßen - Prüfverfahren zur Bestimmung der akustischen Eigenschaften - Teil 5: Produktspezifische Merkmale - In-situ-Werte der Schallreflexion in gerichteten Schallfeldern

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

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Contents

Foreword

This document (prEN 1793-5:2014) has been prepared by Technical Committee CEN/TC 226 “Road equipment”, the secretariat of which is held by AFNOR.

This European Standard has been prepared, under the direction of Technical Committee CEN/TC 226 “Road equipment”, by Working Group 6 “Anti noise devices”.

This document is currently submitted to Enquiry.

It should be read in conjunction with:

EN 1793-1, *Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 1: Intrinsic characteristics of sound absorption*

EN 1793-2, *Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 2: Intrinsic characteristics of airborne sound insulation under diffuse sound field conditions*

EN 1793-3, *Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 3: Normalized traffic noise spectrum*

EN 1793-4, *Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 4: Intrinsic characteristics – In situ values of sound diffraction*

CEN/TS 1793-6, *Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 6: Intrinsic characteristics – In situ values of airborne sound insulation under direct sound field conditions*

Introduction

This document describes a test method for determining the intrinsic characteristics of sound reflection of noise reducing devices designed for roads in non-reverberant conditions (a measure of intrinsic performance). It can be applied *in situ*, i.e. where the noise reducing devices are installed. The method can be applied without damaging the surface.

The method can be used to qualify products to be installed along roads as well as to verify the compliance of installed noise reducing devices to design specifications. Regular application of the method can be used to verify the long term performance of noise reducing devices.

The method requires the average of results of measurements taken in different points in front of the device under test and/or for specific angles of incidences. The method is able to investigate flat and non-flat products.

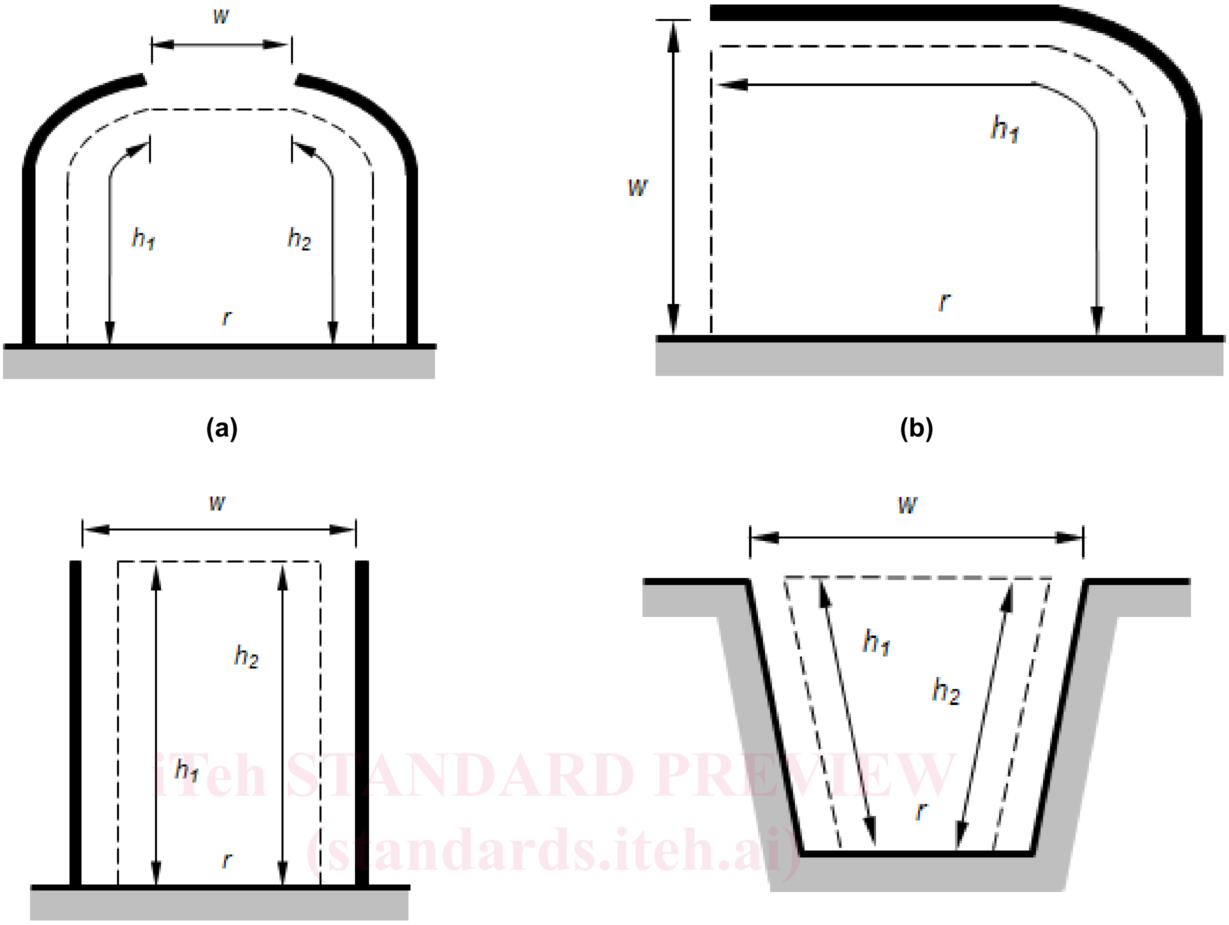
The measurements results of this method for sound reflection are not directly comparable with the results of the laboratory method (e.g. EN 1793-1), mainly because the present method uses a directional sound field, while the laboratory method assumes a diffuse sound field. The test method described in the present document should not be used to determine the intrinsic characteristics of sound reflection of noise reducing devices to be installed in reverberant conditions, e.g. claddings inside tunnels or deep trenches.

For the purpose of this document reverberant conditions are defined based on the envelope, e, across the road formed by the device under test, trench sides or buildings (the envelope does not include the road surface) as shown by the dashed lines in Figure 1. Conditions are defined as being reverberant when the percentage of open space in the envelope is less than or equal to 25 %, i.e.

Reverberant conditions occur when $w/e \leq 0,25$, where $e = (w+h_1+h_2)$

This method introduces a specific quantity, called reflection index, to define the sound reflection in front of a noise reducing device, while the laboratory method gives a sound absorption coefficient. Laboratory values of the sound absorption coefficient can be converted to conventional values of a reflection coefficient taking the complement to one. In this case, research studies suggest that a quite good correlation exists between laboratory data, measured according to EN 1793-1 and field data, measured according to the method described in the present document.

NOTE This method may be used to qualify noise reducing devices for other applications, e.g. to be installed nearby industrial sites. In this case the single-number ratings should be calculated using an appropriate spectrum.



(a)

(b)

(c)

(d)

Figure 1 — (not to scale) Sketch of the reverberant condition check in four cases. (a) Partial cover on both sides of the road; envelope, $e = w+h_1+h_2$. (b) Partial cover on one side of the road; $e = w+h_1$. (c) Deep trench envelope, $e = w+h_1+h_2$. (d) Tall barriers or buildings; envelope, $e = w+h_1+h_2$. In all cases r: road surface; w: width of open space

1 Scope

The present document describes a test method for measuring a quantity representative of the intrinsic characteristics of sound reflection from road noise reducing devices: the reflection index.

The test method is intended for the following applications:

- determination of the intrinsic characteristics of sound reflection of noise reducing devices to be installed along roads, to be measured either on typical installations alongside roads or on a relevant sample section;
- determination of the *in situ* intrinsic characteristics of sound reflection of noise reducing devices in actual use;
- comparison of design specifications with actual performance data after the completion of the construction work;
- verification of the long-term performance of noise reducing devices (with a repeated application of the method).

The test method is not intended for the following applications:

- determination of the intrinsic characteristics of sound reflection of noise reducing devices to be installed in reverberant conditions, e.g. inside tunnels or deep trenches.

Results are expressed as a function of frequency, in one-third octave bands between 100 Hz and 5 kHz. If it is not possible to get valid measurements results over the whole frequency range indicated, the results shall be given in a restricted frequency range and the reasons of the restriction(s) shall be clearly reported.

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.

EN 1793-1, *Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 1: Intrinsic characteristics of sound absorption*

EN 1793-2, *Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 2: Intrinsic characteristics of airborne sound insulation under diffuse sound field conditions*

EN 1793-3, *Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 3: Normalized traffic noise spectrum*

EN 1793-4, *Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 4: Intrinsic characteristics – In situ values of sound diffraction*

EN 1793-6, *Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 6: Intrinsic characteristics - In situ values of airborne sound insulation under direct sound field conditions*

IEC 60942:2003, *Electroacoustics – Sound calibrators*

IEC 61260:1995, *Electroacoustics – Octave-band and fractional-octave-band filters*

IEC 61672-1:2002, *Electroacoustics – Sound level meters – Part 1: Specifications*

ISO/IEC Guide 98, *Guide to the expression of uncertainty in measurement*

3 Terms and definitions

For the purpose of this European Standard the following definitions apply:

3.1

noise reducing device (NRD)

a noise reducing device is a device that is designed to reduce the propagation of traffic noise away from the road environment. This may be a noise barrier, cladding, a road cover or an added device. These devices may include both acoustic and structural elements

3.2

noise barrier

noise reducing device, which obstructs the direct transmission of airborne sound emanating from road traffic

3.3

acoustic element

element whose primary function is to provide the acoustic performance of the device

3.4

structural element

element whose primary function is to support or hold in place acoustic elements

3.5

cladding

noise-reducing device, which is attached to a wall or other structure and reduces the amount of sound reflected

3.6

cover

noise-reducing device, which either spans or overhangs the highway

3.7

added device

added component that influences the acoustic performance of the original noise-reducing device (acting primarily on the diffracted energy)

3.8

roadside exposure

the use of the product as a noise reducing device installed alongside roads

3.9

sound reflection index

the quantity, resulting from a sound reflection test, described by formula (1)

3.10

measurement grid for sound reflection index measurements

a vertical measurement grid constituted of nine equally spaced microphones in a 3x3 squared configuration

Note 1 to entry The orthogonal spacing between two subsequent microphones, either vertically or horizontally, is s = 0,40 m.

Note 2 to entry See Figure 3 and point 5.6.

Note 3 to entry Microphones are numbered like in Figure 3.b.

3.11
reference height

a height h_S equal to half the height, h_B, of the noise barrier under test: $h_S = h_B/2$

Note 1 to entry When the height of the device under test is greater than 4 m and, for practical reasons, it is not advisable to have a height of the source $h_S = h_B/2$, it is possible to have h_S = 2 m, accepting the corresponding low frequency limitation (see 5.5.7).

Note 2 to entry: See Figures 2 and 3.

3.12
(source and microphone) reference plane for sound reflection index measurements

a plane facing the sound source side of the noise reducing device and touching the most protruding parts of the device under test within the tested area

Note 1 to entry See Figures 2 and 4.

3.13
source reference position

a position facing the side to be exposed to noise when the device is in place, located at the reference height h_S and placed so that the horizontal distance of the source front panel to the reference plane is d_S = 1,50 m

Note 1 to entry See Figures 2 and 4.

3.14
measurement grid reference position

a position of the measurement grid compliant with all the following conditions: i) the measurement grid is vertical; ii) the measurement grid is on the noise reducing device side to be exposed to noise when the device is in place; iii) the central microphone (microphone n. 5) is located at the reference height h_S ; iv) the horizontal distance of the central microphone to the reference plane is d_M = 0,25 m; v) the line passing through the centre plate of the loudspeaker and the central microphone is normal to the reference plane

Note 1 to entry See Figures 2, 3 and 4.

3.15
reference loudspeaker-measurement grid distance

the distance between the front panel of the loudspeaker and the central microphone (microphone n. 5) of the measurement grid (kept in vertical position)

Note 1 to entry the reference loudspeaker-measurement grid distance is equal to d_{SM} = 1,25 m (see Figures 2 and 4)

3.16
free-field measurement for sound reflection index measurements

measurement taken with the loudspeaker and the measurement grid in an acoustic free field in order to avoid reflections from any nearby object, including the ground, keeping the same geometry as when measuring in front of the noise reducing device under test

Note 1 to entry See Figure 5.

3.17
maximum sampled area

the surface area, projected on a front view of the noise reducing device under test for reflection index measurements, which must remain free of reflecting objects causing parasitic reflections

3.18
Adrienne temporal window

the composite temporal window described in 5.5.5

3.19
background noise

noise coming from sources other than the sound source emitting the test signal

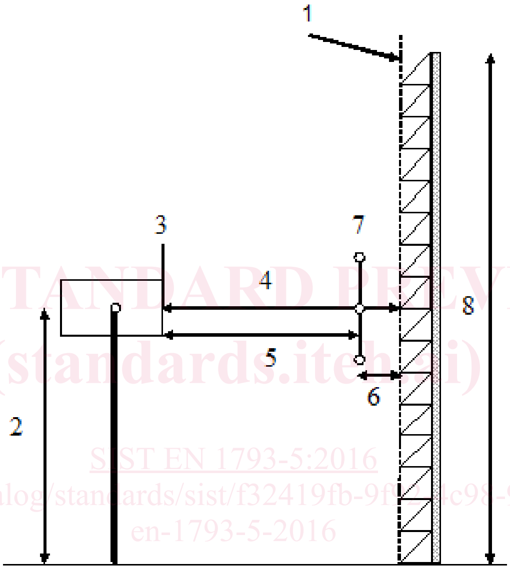
3.20
signal-to-noise ratio, S/N

the difference in decibels between the level of the test signal and the level of the background noise at the moment of detection of the useful event (within the Adrienne temporal window)

3.21
impulse response

the time signal at the output of a system when a Dirac function is applied to the input. The Dirac function, also called δ function, is the mathematical idealisation of a signal infinitely short in time that carries a unit amount of energy

Note 1 to entry It is impossible in practice to create and radiate true Dirac delta functions. Short transient sounds can offer close enough approximations but are not very repeatable. An alternative measurement technique, generally more accurate, is to use a period of deterministic, flat-spectrum signal, like maximum-length sequence (MLS) or exponential sine sweep (ESS), and transform the measured response back to an impulse response.



Key:

1 Source and microphone reference plane

2 Reference height h_S [m]

3 Loudspeaker front panel

4 Distance between the loudspeaker front panel and the reference plane d_S [m]

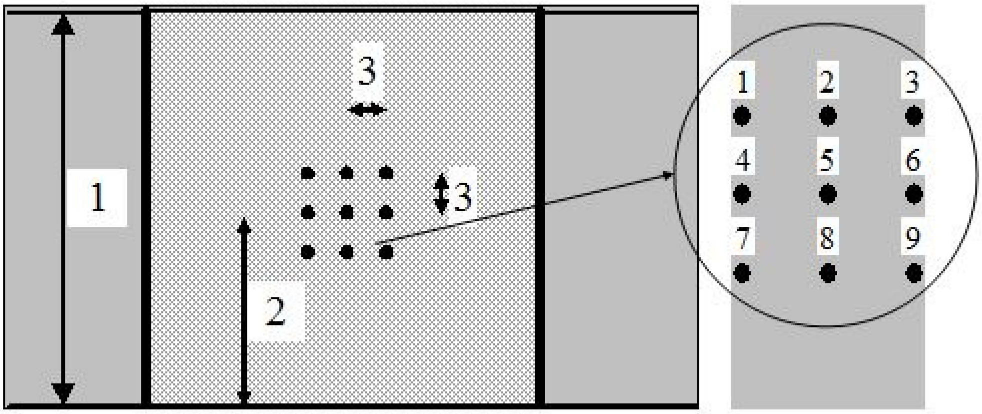
5 Distance between the loudspeaker front panel and the measurement grid d_{SM} [m]

6 Distance between the measurement grid and the reference plane d_M [m]

7 Measurement grid

8 Noise reducing device height h_B [m]

Figure 2 — (not to scale) Sketch of the sound source and the measurement grid in front of the noise reducing device under test for sound reflection index measurements

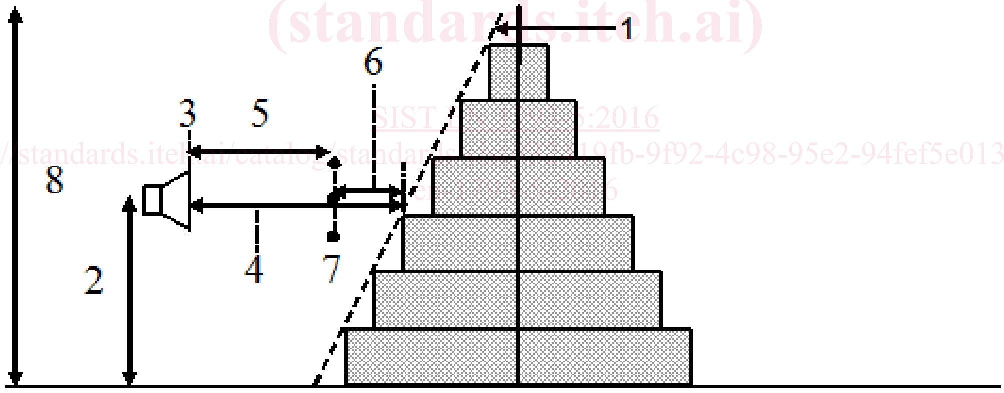


(a) (b)

Key:

1	noise reducing device height h_B [m]	**2**	Reference height h_S [m]
3	Orthogonal spacing between two subsequent microphones s [m]		

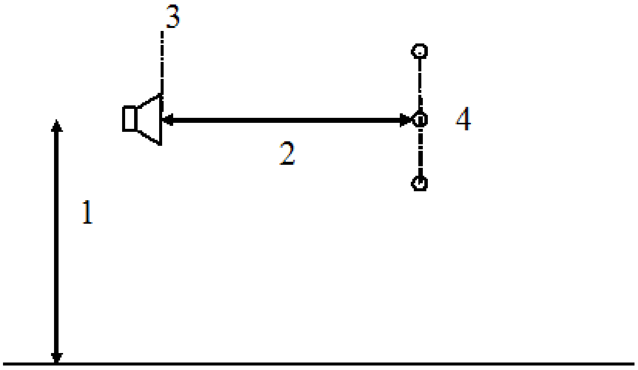
Figure 3 — (not to scale) (a): Measurement grid for sound reflection index measurements (source side) - (b): Numbering of the measurement points as seen from the sound source



Key:

1	Source and microphone reference plane	2	Reference height h_S [m]
3	Loudspeaker front panel	4	Distance between the loudspeaker front panel and the reference plane d_S [m]
5	Distance between the loudspeaker front panel and the measurement grid d_{SM} [m]	6	Distance between the measurement grid and the reference plane d_M [m]
7	Measurement grid	8	Noise reducing device height h_B [m]

Figure 4 — (not to scale) Placement of the sound source and measurement grid for sound reflection index measurement for an inclined noise reducing device (side view)



Key:

1	Reference height h_S [m]	2	Distance between the loudspeaker front panel and the measurement grid d_{SM} [m]
3	Loudspeaker front panel	4	Measurement grid

Figure 5 — (not to scale) Sketch of the set-up for the reference "free-field" sound measurement for the determination of the sound reflection index

4 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

Table 1 – Symbols and abbreviations

Symbol or abbreviation	Designation	Unit
a	major axis of the ellipsoid of revolution used to define the maximum sampled area at oblique incidence	m
a_0, a_1, a_2, a_3	Coefficient for the expression of the four-term full Blackman-Harris window	-
b_s	Depth of the surface structure of the sample under test	m
b_m	Width of a portion of material of the sample under test	m
c	Speed of sound in air	m/s
$C_{geo,k}$	Correction factor for the geometrical divergence	-
$C_{dir,k}$	Correction factor for the sound source directivity	-
$C_{gain,k}$	Correction factor for changes in the sound source gain	-
d_M	Horizontal distance from the source and microphone reference plane to the measurement grid; it is equal to d_M = 0,25 m	m
d_S	Horizontal distance from the front panel of the loudspeaker to the source and microphone reference plane; it is equal to: d_S = 1,50 m	m
d_{SM}	Horizontal distance from the front panel of the loudspeaker to the measurement grid; it is equal to: d_{SM} = 1,25 m	m
DL_{RI}	Single number rating of sound reflection	dB
δ_i	Any input quantity to allow for uncertainty estimates	-
Δf_g	Frequency range encompassing the one-third octave frequency bands between 500 Hz and 2 kHz	Hz
Δf_j	Width of the j-the one-third octave frequency band	Hz

Δt	temporal step between the discrete points of the acquired data (linked to the given sample rate by $\Delta t = 1/f_s$)	ms
$\Delta\tau$	moving step of the free field impulse response in the adjustment procedure included in the generalized signal subtraction technique (see 5.5.4)	ms
Δt_{k5}	Time delay gap between the arrival of direct sound at microphone *k* ($k \neq 5$) and microphone 5	ms
Δt_k	Time delay gap between the arrival of direct and reflected sound at microphone *k*	ms
Δd_{k5}	Path length difference between the arrival of direct sound at microphone *k* ($k \neq 5$) and microphone 5	m
Δd_k	Path length difference between the arrival of direct and reflected sound at microphone *k*	m
ε_k	Tolerance on the path length difference at microphone *k*	m
F	Symbol of the Fourier transform	-
f	Frequency	Hz
f_{min}	Low frequency limit of sound insulation index measurements	Hz
f_s	Sample rate	Hz
f_{co}	cut-off frequency of the anti-aliasing filter	Hz
h_B	Noise barrier height	m
h_S	Reference height	m
$h_{ik}\ (t)$	Incident reference component of the free-field impulse response at the *k*-th measurement point	-
$h_{rk}(t)$	Reflected component of the impulse response at the *k*-th measurement point	-
j	Index of the *j*-th one-third octave frequency band (between 100 Hz and 5 kHz)	-
k_p	Coverage factor	-
k_f	Constant used for the anti-aliasing filter	-
L_p	Sample period length of a non-homogeneous noise reducing device	m
n_j	Number of measurement points on which to average	-
r	Radius of the maximum sampled area at normal incidence	m
R_{sub}	Reduction factor	dB
RI_j	Sound reflection index in the *j*-th one-third octave frequency band	
s	Orthogonal spacing between two subsequent microphones	m
s_r	Standard deviation of repeatability	-
s_R	Standard deviation of reproducibility	-
t	Time	s or ms
$T_{W,BH}$	Length of the Blackman-Harris trailing edge of the Adrienne temporal window	ms
$T_{W,ADR}$	Total length of the Adrienne temporal window	ms
u	Standard uncertainty	-
U	Expanded uncertainty	-
$w_{ik}(t)$	Reference free-field component time window (Adrienne temporal window) at the *k*-th measurement point	-
$w_{rk}(t)$	Time window (Adrienne temporal window) for the reflected component at the *k*-th measurement point	-

5 Sound reflection index measurements

5.1 General principle

The sound source emits a transient sound wave that travels past the measurement grid (microphone) position to the device under test and is then reflected on it (Figures 2 and 4). Each microphone, being placed between the sound source and the device under test, receives both the direct sound pressure wave travelling from the sound source to the device under test and the sound pressure wave reflected (including scattering) by the device under test. The direct sound pressure wave can be better acquired with a separate free field measurement (see Figure 5). The power spectra of the direct and the reflected components, gives the basis for calculating the sound reflection index.

The measurement must take place in an essentially free field in the direct surroundings of the device, i.e. a field free from reflections coming from surfaces other than the surface of the device under test. For this reason, the acquisition of an impulse response having peaks as sharp as possible is recommended: in this way, the reflections coming from other surfaces than the tested device can be identified from their delay time and rejected.

5.2 Measured quantity

The expression used to compute the reflection index *RI* as a function of frequency, in one-third octave bands, is:

$$RI_j = \frac{1}{n_j}\sum_{k=1}^{n_j}\left[\frac{\int_{\Delta f_j}\left|F\left[h_{r,k}(t)\cdot w_{r,k}(t)\right]\right|^2 df}{\int_{\Delta f_j}\left|F\left[h_{i,k}(t)\cdot w_{i,k}(t)\right]\right|^2 df}\cdot C_{geo,k}\cdot C_{dir,k}\left(\Delta f_j\right)\cdot C_{gain,k}\left(\Delta f_g\right)\right] \qquad (1)$$

where

$h_{i,k}(t)$	is the incident reference component of the free-field impulse response at the *k*-th measurement point;
$h_{r,k}(t)$	is the reflected component of the impulse response taken in front of the sample under test at the *k*-th measurement point;
$w_{i,k}(t)$	is the time window (Adrienne temporal window) for the incident reference component of the free-field impulse response at the *k*-th measurement point;
$w_{r,k}(t)$	is the time window (Adrienne temporal window) for the reflected component at the *k*-th measurement point;
F	is the symbol of the Fourier transform;
j	is the index of the one-third octave frequency bands (between 100 Hz and 5 kHz);
Δf_j	is the width of the j-th one-third octave frequency band;
k	is the microphone number according to Figure 3.b (k = 1, ..., 9);
n_j	is the number of microphone positions on which to average ($n_j \geq 6$; see 5.6.2);
$C_{geo,k}$	is the correction factor for geometrical divergence at the *k*-th measurement point;
$C_{dir,k}(\Delta f_j)$	is the correction factor for sound source directivity at the *k*-th measurement point.
$C_{gain,k}(\Delta f_g)$	is the correction factor to account for a change in the amplification settings of the loudspeaker and in the sensitivity settings of the individual microphones when changing the measurement configuration from free field to in front of the sample under test or vice versa, if any (see 5.5.1 and Formula (4));
Δf_g	is the frequency range encompassing the one-third octave frequency bands between 500 Hz and 2 kHz.