SLOVENSKI STANDARD
SIST-TS CEN/TS 16272-5:2014

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Železniške naprave - Zgornji ustroj proge - Protihrupne ovire in pripadajoče naprave, ki vplivajo na širjenje zvoka v zraku - Preskusna metoda za ugotavljanje akustičnih lastnosti - 5. del: Posebne karakteristike - Terenske vrednosti odboja zvoka pri usmerjenem zvočnem polju

Railway applications - Track - Noise barriers and related devices acting on airborne sound propagation - Test method for determining the acoustic performance - Part 5: Intrinsic characteristics - In situ values of sound reflection under direct sound field conditions

Bahnanwendungen - Oberbau - Lärmschutzwände und verwandte Vorrichtungen zur Beeinflussung der Luftschallausbreitung - Prüfverfahren zur Bestimmung der akustischen Eigenschaften - Teil 5: Produktspezifische Merkmale - In-situ-Werte zur Schallreflexion in gerichteten Schallfeldern

Applications ferroviaires - Voie - Dispositifs de réduction du bruit - Méthode d'essai pour la détermination des performances acoustiques - Partie 5: Valeurs in situ de la réflexion acoustique dans des conditions de champ acoustique direct

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17.140.30	Emisija hrupa transportnih sredstev	Noise emitted by means of transport
45.020	Železniška tehnika na splošno	Railway engineering in general

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English Version

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Contents

Foreword

This document (CEN/TS 16272-5:2014) has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

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

This Technical Specification is one of the series EN 16272 "*Railway applications – Track – Noise barriers and related devices acting on airborne sound propagation – Test method for determining the acoustic performance*" as listed below:

— *Part 1: Intrinsic characteristics – Sound absorption in the laboratory under diffuse sound field conditions*

— *Part 2: Intrinsic characteristics – Airborne sound insulation in the laboratory under diffuse sound field conditions*

— *Part 3-1: Normalized railway noise spectrum and single number ratings for diffuse field applications*

— *Part 3-2: Normalized railway noise spectrum and single number ratings for direct field applications*

— *Part 4: Intrinsic characteristics – In situ values of sound diffraction under direct sound field conditions*

— *Part 5: Intrinsic characteristics – In situ values of sound reflection under direct sound field conditions*

— *Part 6: Intrinsic characteristics – In situ values of airborne sound insulation under direct sound field conditions*

— *Part 7: Extrinsic characteristics – In situ values of insertion loss*

It should be read in conjunction with:

EN 16272-1, *Railway applications – Track – Noise barriers and related devices acting on airborne sound propagation – Test method for determining the acoustic performance – Part 1: Intrinsic characteristics – Sound absorption in the laboratory under diffuse sound* field conditions

EN 16272-3-1, *Railway applications – Track – Noise barriers and related devices acting on airborne sound propagation – Test method for determining the acoustic performance – Part 3-1: Normalized railway noise spectrum and single number ratings for diffuse field* applications

EN 16272-3-2, *Railway applications – Track – Noise barriers and related devices acting on airborne sound propagation – Test method for determining the acoustic performance – Part 3-2: Normalized railway noise spectrum and single number ratings for direct field applications*

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

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

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

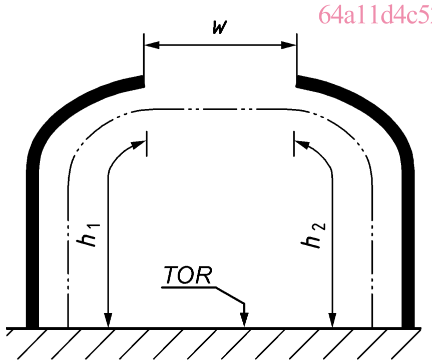
The method requires the average of results of measurements taken in different points in front of the device under test and/or for specific angles of incidences. The method is able to investigate flat and non-flat products.

The measurements results of this method for sound reflection are not directly comparable with the results of the laboratory method (EN 16272-1), 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.

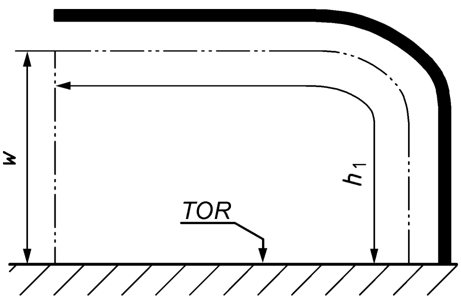
For the purpose of this Technical Specification reverberant conditions are defined based on the envelope, *e*, across the rail formed by the barriers, trench sides or buildings (the envelope does not include the railway surface) as shown by the dashed lines in Figure 1. Conditions are defined as being 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 $e = (w + h_1 + h_2)$

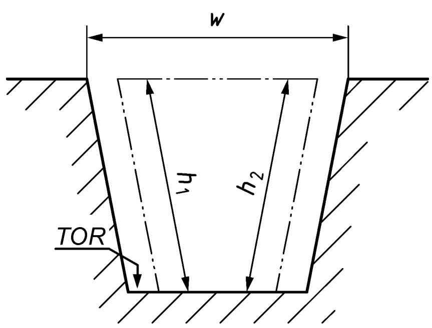
This criterion is applied also to the open space between the train body and the barrier surface.



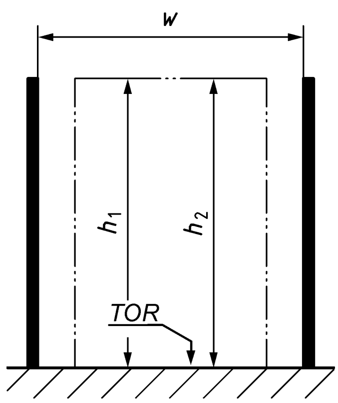
(a) Partial cover on both sides of the railway; envelope, $e = w + h_1 + h_2$



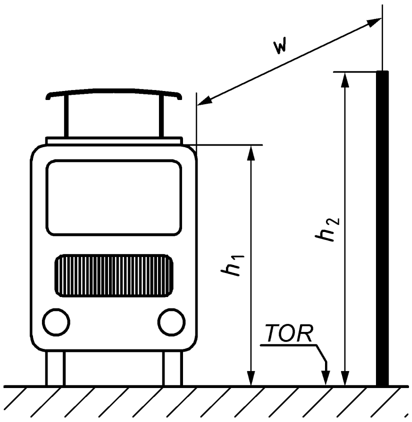
(b) Partial cover on one side of the railway; $e = w + h_1$



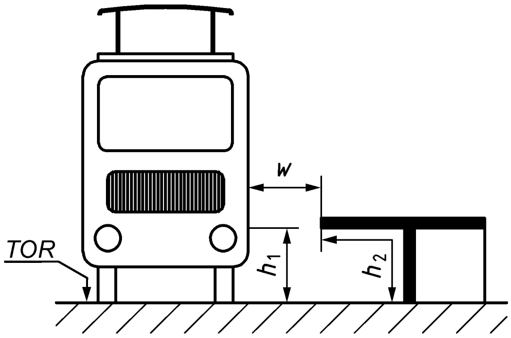
(c) Deep trench envelope, $e = w + h_1 + h_2$



(d) Tall barriers or buildings; envelope, $e = w + h_1 + h_2$



(e) Train passing close to a noise barrier envelope, $e = w + h_1 + h_2$



(f) Train passing close to a platform at the station, $e = w + h_1 + h_2$

Key

TOR top of rail

w width of open space

Figure 1 — (not to scale) Sketch of the reverberant condition check in six cases.

This method introduces a specific quantity, called reflection index, to define the sound reflection in front of a noise barrier or cladding, 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 16272-1 and field data, measured according to the method described in the present document.

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

1 Scope

This Technical Specification describes a test method for measuring a quantity representative of the intrinsic characteristics of sound reflection from railway noise barriers: the reflection index.

The test method is intended for the following applications:

— determination of the intrinsic characteristics of sound reflection of noise barriers to be installed along railways, to be measured either on typical installations alongside railways or on a relevant sample section;

— determination of the *in situ* intrinsic characteristics of sound reflection of noise barriers and claddings 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 barriers and claddings (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 should be given in a restricted frequency range and the reasons of the restriction(s) should be clearly reported.

All noise reducing devices different from noise barriers and related devices acting on airborne sound propagation, e.g. devices for attenuation of ground borne vibration and on board devices are out of the scope of this Technical Specification.

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.

prEN 16272-3-2:2012, *Railway applications – Track – Noise barriers and related devices acting on airborne sound propagation – Test method for determining the acoustic performance – Part 3-2: Normalized railway noise spectrum and single number ratings for direct field applications*

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

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purpose of this document the following definitions apply.

3.1
acoustic element
element whose primary function is to provide the acoustic performance of the device

3.2
Adrienne temporal window
the composite temporal window described in 5.5.5

3.3
background noise
noise coming from sources other than the source emitting the test signal

3.4
cladding
noise reducing device, which is attached to a wall or other structure and reduces the amount of sound reflected

Note 1 to entry: Claddings are generally made of acoustic and structural elements (see 3.3 and 3.4).

3.5
impulse response
the time signal at the output of a system when a Dirac function is applied to the input

Note 1 to entry: 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.

3.6
maximum sampled area
the surface area, projected on a front view of the noise reducing device under test for reflection index measurements, which shall remain free of reflecting objects causing parasitic reflections

3.7
noise barrier
noise reducing device, which obstructs the direct transmission of airborne sound emanating from railways; it may either span or overhang the railway

Note 1 to entry: Noise barriers are generally made of acoustic and structural elements (see 3.3 and 3.4).

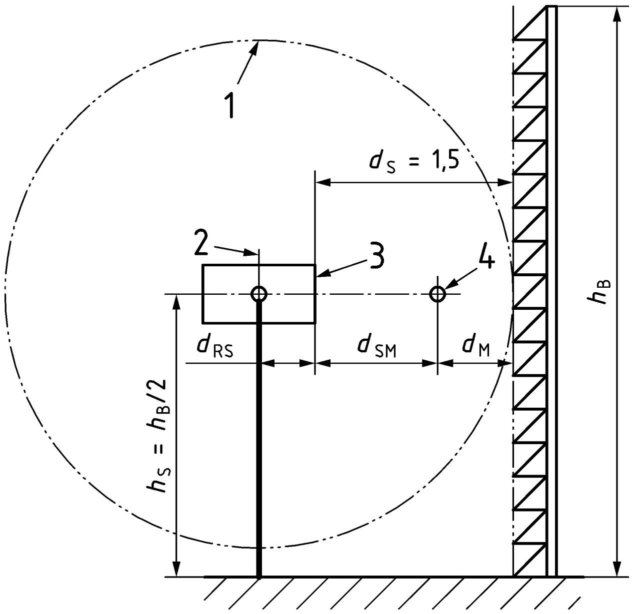
3.8
reference height
a height h_S equal to half the height h_B of the noise barrier or cladding under test: $h_S = h_B/2$ (see Figures 2 and 3)

3.9
rotation of the loudspeaker-microphone assembly
a set of nine measurement positions, including the reference position, reached rotating the loudspeaker-microphone assembly, around the axis of rotation R (see Figure 2), on the same plane in steps of 10° (Figures 5, 6 and 7)

3.10
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)

3.11
sound reflection index
the result of a sound reflection test described by formula (1) (see 5.2)

3.12
structural element
element whose primary function is to support or hold in place acoustic elements



Key

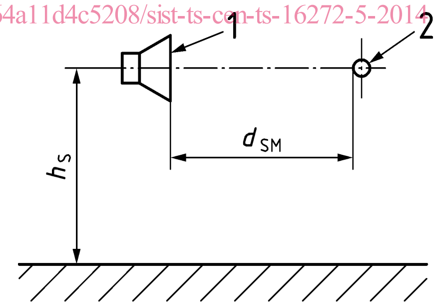
1 reference circle

2 axis of rotation

3 loudspeaker front panel

4 microphone

Figure 2 — (not to scale) Sketch of the loudspeaker-microphone assembly in front of the noise reducing device under test for reflection index measurements



Key

1 loudspeaker front panel

2 microphone

Figure 3 — (not to scale) Sketch of the set-up for the reference “free-field” sound measurement for the determination of the reflection index measurement

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 Blackman-Harris window	-
c	Speed of sound in air	m/s
d_M	Horizontal distance from the microphone to the reference circle; it is equal to d_S = 0,25 m	m
d_p	Horizontal distance from the loudspeaker front panel to the microphone projected on a vertical plane, placed between the microphone and the noise reducing device under test, tangential to the reference circle when the loudspeaker-microphone assembly is horizontal	m
d_{RS}	Horizontal distance from the reference axis of rotation to the loudspeaker front panel; it is equal to: d_{RS} = 0,15 m	m
d_S	Horizontal distance from the front panel of the loudspeaker to the reference circle; it is equal to: d_S = 1,50 m	m
d_{SM}	Horizontal distance from the front panel of the loudspeaker to the microphone; 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_j	Width of the *j*-the one-third octave frequency band	Hz
f	Frequency	Hz
F	Symbol of the Fourier transform	-
f_{min}	Low frequency limit of sound reflection 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
$h_i(t)$	Incident reference component of the free-field impulse response	-
$h_{rk}(t)$	Reflected component of the impulse response at the *k*-th angle	-
j	Index of the *j*-th one-third octave frequency band (between 100 Hz and 5 kHz)	-
k	Coverage factor	-
k_f	Constant used for the anti-aliasing filter	-
n_j	Number of angles on which to average	-
r	Radius of the maximum sampled area at normal incidence	m
RI_j	Sound reflection index in the *j*-th one-third octave frequency band	dB
t	Time	s or ms
$T_{W,BH}$	Length of the Blackman-Harris trailing edge of the Adrienne temporal window	ms

Symbol or abbreviation	Designation	Unit
$T_{W,ADR}$	Total length of the Adrienne temporal window	ms
u	Standard uncertainty	-
U	Expanded uncertainty	-
$w_i(t)$	Reference free-field component time window (Adrienne temporal window)	-
$w_r(t)$	Time window (Adrienne temporal window) for the reflected component	-

5 Sound reflection index measurements

5.1 General principle

The sound source emits a transient sound wave that travels past the microphone position to the device under test and is then reflected on it (Figures 2, 3, 5 and 6). The microphone 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 power spectra of the direct and the reflected components, corrected to take into account the path length difference of the two components, gives the basis for calculating the reflection index.

The measurement shall 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 sound reflection index *RI* as a function of frequency, in one-third octave bands, is:

$$RI_j = \frac{1}{n_j} \sum_{k=1}^{n_j} \frac{\int_{\Delta f_j} \left| F\left[t \times h_{rk}(t) \times w_r(t)\right] \right|^2 df}{\int_{\Delta f_j} \left| F\left[t \times h_i(t) \times w_i(t)\right] \right|^2 df} \quad (1)$$

where:

$h_i(t)$	is the incident reference component of the free-field impulse response;
$h_{rk}(t)$	is the reflected component of the impulse response at the *k*-th angle;
$w_i(t)$	is the incident reference free-field component time window (Adrienne temporal window);
$w_r(t)$	is the reflected component time window (Adrienne temporal window);
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;
n_j	is the number of angles on which to average ($n \leq 9$ per rotation; see 5.5.2 and Table 1);
t	is a time whose origin is at the beginning of the impulse response acquired by the measurement chain.

NOTE The reflections from different portions of the surface under test arrive at the microphone position at different times, depending on the travel path from the loudspeaker to the position of each test surface portion and back. The longer the travel path from the loudspeaker to a specific test surface portion and back, the greater the time delay. Thus, the amplitude of the reflected sound waves from different test surface portions, as detected at the microphone position, is attenuated in a manner