SLOVENSKI STANDARD
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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 - 4. del: Specifične karakteristike - Terenske vrednosti difrakcije 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 4: Intrinsic characteristics - In situ values of sound diffraction under direct sound field conditions

Bahnanwendungen - Oberbau - Lärmschutzwände und verwandte Vorrichtungen zur Beeinflussung der Luftschallausbreitung - Prüfverfahren zur Bestimmung der akustischen Eigenschaften - Teil 4: Produktspezifische Merkmale - In-situ-Werte von Schallbeugung in direkten Schallfeldern

Applications ferroviaires - Voie - Dispositifs de réduction du bruit - Méthode d'essai pour la détermination des performances acoustiques - Partie 4: Caractéristiques intrinsèques - Valeurs in situ de la diffraction 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
93.100	Gradnja železnic	Construction of railways

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Contents

Foreword

This document (prEN 16272-4:2014) has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This European Standard has been prepared, under the direction of Technical Committee CEN/TC 256 "Railway applications", by Working Group 40 "Noise barriers".

This European Standard 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 16272-3-2, *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*

EN 16272-6, *Railway applications – Track – Noise barriers and related devices acting on airborne sound propagation – Test method for determining the acoustic performance – Part 6: Intrinsic characteristics – In situ values of airborne sound insulation under direct sound field conditions*

Introduction

Part of the market of railway noise barriers and related devices acting on airborne sound propagation is constituted of products to be added on the top of noise barriers and intended to contribute to sound attenuation acting primarily on the diffracted sound field. These products will be called added devices. This standard has been developed to specify a test method for determining the acoustic performance of added devices.

The test method can be applied *in situ*, i.e. where the railway noise barriers and the added devices are installed. The method can be applied without damaging the railway noise barriers or the added devices.

The method can be used to qualify products before the installation along railways as well as to verify the compliance of installed added devices to design specifications. Repeated application of the method can be used to verify the long term performance of added devices.

NOTE This method could be used to qualify added devices for other applications, e.g. to be installed along roads or nearby industrial sites. In this case special care has to be taken into account in considering the location of the noise sources and the single-number ratings should be calculated using an appropriate spectrum.

No other national or international standard exists about the subject of this standard.

1 Scope

This European Standard describes a test method for determining the intrinsic characteristics of sound diffraction of added devices installed on the top of railway noise barriers. The test method prescribes measurements of the sound pressure level at several reference points near the top edge of a noise barrier with and without the added device installed on its top. The effectiveness of the added device is calculated as the difference between the measured values with and without the added devices, correcting for any change in height (the method described gives the acoustic benefit over a simple barrier of the same height; however, in practice the added device can raise the height and this would provide additional screening depending on the source and receiver positions).

The test method is intended for the following applications:

— preliminary qualification, outdoors or indoors, of added devices to be installed on noise barriers;

— determination of sound diffraction index difference of added 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 added devices (with a repeated application of the method);

— interactive design process of new products, including the formulation of installation manuals.

The test method can be applied both *in situ* and on samples purposely built to be tested using the method described here.

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 the restricted frequency range and the reasons of the restriction(s) shall be clearly reported. A single-number rating is calculated from frequency data.

For indoors measurements see Annex A.

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 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*

EN 16272-6, *Railway applications – Track – Noise barriers and related devices acting on airborne sound propagation – Test method for determining the acoustic performance – Part 6: Intrinsic characteristics – In situ values of airborne sound insulation under direct sound field conditions*

EN ISO 354, *Acoustics – Measurement of sound absorption in a reverberation room*

IEC 60942, *Electroacoustics – Sound calibrators*

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

IEC 61672-1, *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 purposes of this document, the following terms and definitions apply.

3.1
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 (3.3 and 3.4).

3.2
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 (3.3 and 3.4).

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

Note 1 to entry In some noise barriers the acoustic function and the structural function cannot be clearly separated and attributed to different components

3.6
rail side exposure
the use of the product as a noise reducing device installed alongside railways

3.7
sound diffraction index
the result of a sound diffraction test whose components are described by the formula in 5.6. $DI_{x,refl}$ refers to measurements on a reflective reference wall. $DI_{x,abs}$ refers to measurements on an absorptive reference wall. $DI_{x,situ}$ refers to in situ measurements; where x is “0” when the added device is not on the top of the test construction and “ad” when the added device is on the top of the test construction (see 3.2)

3.8
sound diffraction index difference
difference between the results of sound diffraction tests on the same reference wall with and without an added device on the top, described by the formulae in 5.10

3.9
test construction
construction on which the added device is placed. For in situ measurements it is an installed noise reducing device; for qualification tests it is a reference wall (see 5.2)

3.10
reference plane of the test construction
the vertical plane passing through the midpoint of the top edge of the construction (reference wall or installed noise reducing device) on which the added device has to be placed (see Figures 1, 2, 4, 5, 8)

3.11
reference height of the test construction without the added device, $h_{ref,0}$
height of the highest point of the test construction in relation to the surrounding ground surface. This highest point is not necessarily lying in the plane of longitudinal symmetry of the reference test construction, if this symmetry exists (Figure 1)

3.12
reference height of the test construction with the added device on the top, $h_{ref,add}$
height of the highest point of the added device installed on the test construction in relation to the surrounding ground surface. This highest point is not necessarily lying in the plane of longitudinal symmetry of the reference test construction, if this symmetry exists (Figure 4)

3.13
free-field measurement for sound diffraction index measurements
Measurement carried out placing the loudspeaker and the microphone as specified in 5.3, 5.4 and 5.5 without any obstacle, including the test construction with or without added device, between them (see for example Figure 7)

3.14
Adrienne temporal window
the composite temporal window described in 5.8.5

3.15
background noise
noise coming from sources other than the source emitting the test signal

3.16
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)

3.17
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 idealization of a signal infinitely short in time that carries a unit amount of energy

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
α	Sound absorption coefficient measured according to EN ISO 354	-
DI_j	Sound diffraction index in the *j*-th one-third octave frequency band	dB
$DI_{0,refl}$	Sound diffraction index for the reflective reference wall without the added device	dB
$DI_{ad,refl}$	Sound diffraction index for the reflective reference wall with the added device	dB
$DI_{0,abs}$	Sound diffraction index for the absorptive reference wall without the added device	dB
$DI_{ad,abs}$	Sound diffraction index for the absorptive reference wall with the added device	dB
$DI_{0,situ}$	Sound diffraction index for the *in situ* test construction without the added device	dB
$DI_{ad,situ}$	Sound diffraction index for the *in situ* test construction with the added device	dB
ΔDI_{refl}	Sound diffraction index difference for the test sample on the reflective reference wall	dB

Symbol or abbreviation	Designation	Unit
ΔDI_{abs}	Sound diffraction index difference for the test sample on the absorbing reference wall	dB
ΔDI_{situ}	Sound diffraction index difference for the test sample on an situ test construction	dB
$DL_{\Delta DI,refl}$	Single-number rating of sound diffraction index difference for the test sample on the reflective reference wall	dB
$DL_{\Delta DI,abs}$	Single-number rating of sound diffraction index difference for the test sample on the absorbing reference wall	dB
$DL_{\Delta DI,situ}$	Single-number rating of sound diffraction index difference for the test sample on the *in situ* test construction	dB
δ_i	Any input quantity to allow for uncertainty estimates	-
Δf_j	Width of the *j*-th one-third octave frequency band	Hz
f	Frequency	Hz
F	Symbol of the Fourier transform	-
f_{min}	Low frequency limit of sound diffraction 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_{ref}	Reference height of the test construction	m
$h_{ref,0}$	Reference height of the test construction without the added device	m
$h_{ref,ad}$	Reference height of the test construction with the added device	m
$h_i(t)$	Incident reference component of the free-field impulse response	dB
$h_{d,k}(t)$	Diffracted component of the impulse response at the *k*-th measurement point	dB
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	-
L_b	Minimum length of the reference wall	m
L_d	Minimum length of the added device under test	m
n	Number of measurement points	-
SI	Sound Insulation Index measured according to EN 16272–6	dB
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	-
$w_{ik}(t)$	Time window (Adrienne temporal window) for the component of the free-field impulse response received at the *k*-th measurement point	-
$w_{t,k}(t)$	Time window (Adrienne temporal window) for the component of the impulse response diffracted by the top edge of the test construction and received at the k-th measurement point	-

5 Sound diffraction index difference measurements

5.1 General principle

The sound source emits a transient sound wave that travels toward the noise reducing device under test and is partly reflected, partly transmitted and partly diffracted by it. The microphone placed on the other side of the noise reducing device receives both the transmitted sound pressure wave travelling from the sound source through the noise reducing device and the sound pressure wave diffracted by the top edge of the noise reducing device under test (for the test to be meaningful the diffraction from the vertical edges of the test construction shall be sufficiently delayed in order to be outside the Adrienne temporal window). If the measurement is repeated without the added device and the test construction between the loudspeaker and the microphone, the direct free-field wave can be acquired. The power spectra of the direct and the top-edge diffracted components, corrected to take into account the path length difference of the two components, give the basis for calculating the diffraction index.

The final sound diffraction index shall be a weighted average of the diffraction indices measured at different points (see Figures 1 to 6).

When the test method is applied *in situ*, the measurement procedure and sound diffraction index calculation shall be carried out two times, with and without the added device placed on the test construction.

When the test method is applied on samples purposely built to be tested according to the present standard, the added device shall be subsequently placed on the top of two reference walls (reflective and absorptive), or of the same reference wall in two different configurations, (see 5.2) and the measurement procedure and sound diffraction index calculation shall be carried out for both walls, with and without the added device on the top.

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 Dimensions and specifications

5.2.1 Added devices

The added device shall have a minimum length L_d of 10 m. The reference wall shall have a minimum length L_b of 10 m and a minimum height of 4 m. The reference wall shall be vertical, flat and fixed firmly and without any air gaps on a supporting construction (foundation, floor, etc.). The top surface of the supporting construction shall be level with the surrounding ground surface.

The maximum size of the added device measured perpendicularly from the reference plane either in the direction of the source or in the direction of the microphones shall not exceed a value of 1,0 m (see Figure 8).

5.2.2 Reference walls

Two versions of the reference wall shall be used in the tests:

A A reflective reference wall, constructed of homogeneous panels with a smooth surface finish. The wall shall be free of air leaks and shall have a thickness not greater than 0,20 m. The wall shall have the minimum values of Sound Insulation Index measured according to EN 16272–6 specified in Table 2, in order that the sound transmission through the reference wall is negligible.

Table 2 —Minimum values of the Sound Insulation Index of the reference wall, measured according to EN 16272–6 (tolerance: ± 0,5 dB)

Octave centre frequency (Hz)	125	250	500	1000	2000	4000
SI (dB)	21,0	22,0	24,0	26,0	29,0	32,0

B An absorptive reference wall, constructed as mentioned under A, lined on the source side with an absorptive flat layer of a single porous material having the minimum values of sound absorption coefficient measured according to EN ISO 354 specified in Table 3.

Table 3 —Minimum values of the sound absorption coefficient for the absorptive treatment of the reference wall, measured according to EN ISO 354 (tolerance: ± 0,05)

Octave centre frequency (Hz)	125	250	500	1000	2000	4000
α	0,20	0,50	0,85	0,95	0,95	0,95

5.2.3 *In situ* tests

When applying the test method *in situ* on existing noise barriers, with the intention of obtaining results valid over the entire frequency range specified in 5.6, the test construction shall satisfy the requirements in 5.2.2.

If these requirements cannot be fulfilled by the existing noise barrier, the obtained results shall only be valid over a restricted frequency range (see 5.8.7) and for the type of noise reducing device being tested.

5.3 Positions of the sound source

Two angles of incidence, 90° and 45°, shall be used (see Figures 2 and 5).

For execution of the diffraction test at a right angle to the test construction the sound source shall be placed as follows (see Figures 1, 2, 4 and 5):

— in the vertical plane containing the perpendicular bisector plane to the reference plane;

— horizontally: at 2 m distance from the reference plane of the test construction;

— vertically: in relation to the reference height h_{ref} of the test construction,

  — for the obligatory source position S1: centre of the source 0,50 m lower than h_{ref};

  — for the obligatory source position S2: centre of the source 0,15 m lower than h_{ref};

— oriented towards the microphone position M1 (see 5.4, and Figures 1 and 3).

For execution of the diffraction test at an angle of 45° with the reference plane of the test construction the sound source shall be placed as follows (see Figures 2 and 5):

— in a vertical plane that makes an angle of 45° with the reference plane of the test construction, passing through its mid-point;

— horizontally: at 2 m distance from the reference plane of the test construction;

— vertically in relation to the reference height h_{ref} of the test construction,

  — for the obligatory source position S3: centre of the source 0,50 m lower than h_{ref};

  — for the obligatory source position S4: centre of the source 0,15 m lower than h_{ref};

— oriented towards the microphone position M6 (see 5.4, and Figures 2 and 3).