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

Lärmschutzvorrichtungen an Straßen - Prüfverfahren zur Bestimmung der akustischen Eigenschaften - Teil 4: Produktspezifische Merkmale - In-situ-Werte der Schallbeugung

Dispositifs de réduction du bruit du trafic routier - Méthode d'essai pour la détermination des performances acoustiques - Partie 4: Caractéristiques intrinsèques - Valeurs in-situ de la diffraction acoustique

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Supersedes CEN/TS 1793-4:2003

English Version

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

Dispositifs de réduction du bruit du trafic routier - Méthode d'essai pour la détermination des performances acoustiques - Partie 4: Caractéristiques intrinsèques - Valeurs in-situ de la diffraction acoustique

Lärmschutzvorrichtungen an Straßen - Prüfverfahren zur Bestimmung der akustischen Eigenschaften - Teil 4: Produktspezifische Merkmale - In-situ-Werte der Schallbeugung

This European Standard was approved by CEN on 13 December 2014.

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

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Foreword

This document (EN 1793-4:2015) has been prepared by Technical Committee CEN/TC 226 "Road equipment", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2015 and conflicting national standards shall be withdrawn at the latest by September 2015.

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 document supersedes CEN/TS 1793-4:2003.

The major changes compared to the previous published version are:

- the airborne sound insulation characteristics of the reference wall are specified in terms of the minimum values of the Sound Insulation Index, measured according to EN 1793-6, it needs to have;
- the sound absorbing characteristics of the reference wall are specified in terms of the minimum values of the sound absorption coefficient, measured according to EN ISO 354, it needs to have when lined on the source side with an absorptive flat layer of a single porous material;
- the sound source positions have been reduced from six to four and are now all obligatory;
- the microphone positions have been reduced from 12 to 10 and are now all obligatory;
- a "free-field" impulse response to be measured for each microphone position and therefore a geometrical spreading correction factor is no more needed in Formula (1);
- consideration of the measurement uncertainty has been added (see Clause 5 and Annex B);
- the summary of the test procedure (Clause 6) has been updated to reflect the changes compared to the previous published version.

This document 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 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*

CEN/TS 1793-5, *Road traffic noise reducing devices — Test method for determining the acoustic performance — Part 5: Intrinsic characteristics — In situ values of sound reflection and airborne sound insulation.*

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*

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: 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

Part of the market of road traffic noise reducing devices is constituted of products to be added on the top of noise reducing devices and intended to contribute to sound attenuation acting primarily on the diffracted sound field. These products will be called added devices. This European 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 traffic noise reducing devices and the added devices are installed. The method can be applied without damaging the traffic noise reducing devices or the added devices.

The method can be used to qualify products before the installation along roads 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.

This method could be used to qualify added devices for other applications, e.g. to be installed along railways or nearby industrial sites. In this case, special care needs 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 European 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 traffic noise reducing devices. The test method prescribes measurements of the sound pressure level at several reference points near the top edge of a noise reducing device 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 could 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 reducing devices;
- 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 1793-3, *Road traffic noise reducing devices — Test method for determining the acoustic performance — Part 3: Normalized traffic noise spectrum*

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*

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

EN ISO 354, *Acoustics — Measurement of sound absorption in a reverberation room (ISO 354)*

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

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
structural elements
those elements whose primary function is to support or hold in place acoustic elements

3.1.2
acoustical elements
those elements whose primary function is to provide the acoustic performance of the device

3.1.3
noise barrier
noise reducing device which obstructs the direct transmission of airborne sound emanating from road traffic

3.1.4
added device
acoustic element added on the top of a noise reducing device and intended to contribute to sound attenuation acting primarily on the diffracted sound field

3.1.5
roadside exposure
use of the product as a noise reducing device installed alongside roads

3.1.6
sound diffraction index
result of a sound diffraction test whose components are described by the formula in 4.6

Note 1 to entry: The symbol for the sound diffraction index includes information on the setup used during the test: $DI_{x,refl}$ 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).

3.1.7
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 4.10

3.1.8
test construction
construction on which the added device is placed

Note 1 to entry: For *in situ* measurements the test construction is an installed noise reducing device; for qualification tests it is a reference wall (see 4.2).

3.1.9
reference plane of the test construction
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 Figure 1, Figure 2, Figure 4, Figure 5 and Figure 8)

3.1.10
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

Note 1 to entry: This highest point is not necessarily lying in the plane of longitudinal symmetry of the reference test construction, if this symmetry exists (Figure 1).

3.1.11
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

Note 1 to entry: This highest point is not necessarily lying in the plane of longitudinal symmetry of the reference test construction, if this symmetry exists (Figure 4).

3.1.12
free-field measurement for sound diffraction index measurements
measurement carried out placing the loudspeaker and the microphone as specified in 4.3, 4.4 and 4.5 without any obstacle, including the test construction with or without added device, between them (see for example Figure 7)

3.1.13
Adrienne temporal window
composite temporal window described in 4.8.5

3.1.14
background noise
noise coming from sources other than the source emitting the test signal

3.1.15
signal-to-noise ratio, S/N
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)

3.1.16
impulse response
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

3.2 Symbols

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
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 1793–6	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	-

4 Sound diffraction index difference measurements

4.1 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 sound diffraction index.

The final sound diffraction index shall be a weighted average of the diffraction indices measured at different points (see Figure 1, Figure 2, Figure 3, Figure 4, Figure 5 and Figure 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 4.2) 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 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.

4.2 Dimensions and specifications

4.2.1 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).

4.2.2 Reference walls

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