The European standards for roads and railways noise barriers: state of the art 2015

Jean-Pierre Clairbois
A-Tech Acoustic Technologies, Brussels, Belgium.

Massimo Garai
Department of Industrial Engineering, University of Bologna, Bologna, Italy.

Summary
This paper highlights the 2015 state of the two parallel packages of European standards on noise barriers and related devices acting on airborne sound propagation: one for roads, the other for railways. The first package has been developed by CEN/TC226/WG6. As in the road sector noise barriers are under the CPR 305/2011, the package includes a harmonized standard (EN 14388) and a set of supporting standards for testing or calculating the relevant characteristics: sound absorption, sound insulation, effectiveness of added devices on the top edge, mechanical and safety characteristics etc. Recently, a new specific standard about fire reaction has been added; moreover, a brand new standard on the sustainability of noise reducing devices is being drafted. The second package is being developed by CEN/TC256/SC1/WG40. In the railway sector, noise barriers are considered outside CPR 305/2011 but conforming to the Technical Specifications for Interoperability (TSI). While the main characteristics of noise reducing devices remain the same, WG40 adapted to railways and improved the existing standards for roads. Moreover, some specific standards have been drafted and are on the way to publication: one presenting a calculation method for the mechanical performance under dynamic loadings caused by passing trains and the other on the resistance to fatigue due to the same loadings. Some standards on the evaluation of long-term performance of noise reducing devices are also under consideration.

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1. Introduction

Noise barriers and related devices acting on airborne sound propagation (road/rail covers, claddings and added devices) are collectively called Noise Reducing Devices (NRDs). They are an essential part of the road and rail infrastructures when noise protection of people and the environment is required. The related European standards are written by CEN/TC226/WG6, started in 1989, for the road sector and by CEN/TC256/SC1/WG40, started in 2008, for the railway sector. As the technical knowledge is continuously evolving, these standards are continuously updated through corrigenda, revisions or addition of new standards: as done almost every 2 à 3 years [1], this paper presents the state of the art of both road and railway packages of standards as of February 2015.

2. Structure of the packages of standards

Both packages can be subdivided in three main sub-packages (see Figure 1): acoustical characteristics, mechanical and safety characteristics, long-term performance and sustainability. These sub-packages can be differently articulated in order to take into account the needs of the specific sector (road/rail). Moreover, in the road sector noise barriers are under the CPR 305/2011 [1], and thus there is a main standard, the harmonized standard EN 14388, specifying the conditions to give the CE marking to a specific product, while the others standards are considered *supporting standards* for testing or calculating the relevant characteristics of NRDs for CE marking. In the railway sector, noise barriers are considered outside the CPR 305/2011; instead, according to the Directive 2008/57/EC [3], they must conform to the Technical Specifications

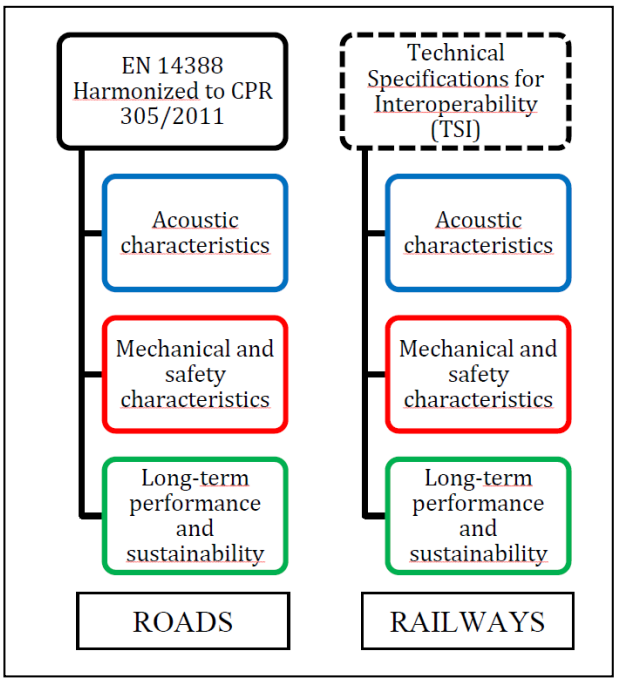

Figure 1. Main structure of the packages of standards for the road (on the left) and rail (on the right) sector.

for Interoperability (TSI). Therefore, there is a big difference in the way similar standards are used: road NRDs are qualified for CE marking following a mandatory procedure for the *assessment and verification of constancy of performance* (AVCP) that involves accredited laboratories and notified bodies under System 3 according to CPR 305/2011 [1]; rail NRDs are qualified following an approval procedure, different from one country to another, decided by national rail authorities. This is a problem originated outside CEN and that should be solved at political level.

3. The acoustic characteristics

The acoustic characteristics must be measured under a sound field similar to the one existing for the intended use of the noise reducing device: a diffuse sound field for applications inside tunnels or deep trenches or under wide covers, a direct sound field for all other conditions, which correspond to the vast majority of cases. Therefore, the two working groups prepared two parallel sets of standards, specific to the corresponding sound field (Figure 2). The diffuse field tests rely on the similar test codes from building acoustics, while the direct field standards have been developed with a long research (see for example [4], [5]) spanning over two European projects: ADRIENNE [6] and QUIESST [7]. The last one succeeded also in obtaining the repeatability and reproducibility of direct field measurements [9].

It is worth noting that, under direct sound field conditions, it is also possible to qualify the "added devices" placed on the top of noise barriers to improve the acoustic performance while acting primarily on the diffracted sound energy (EN 1793-4 and prEN 16272-4).

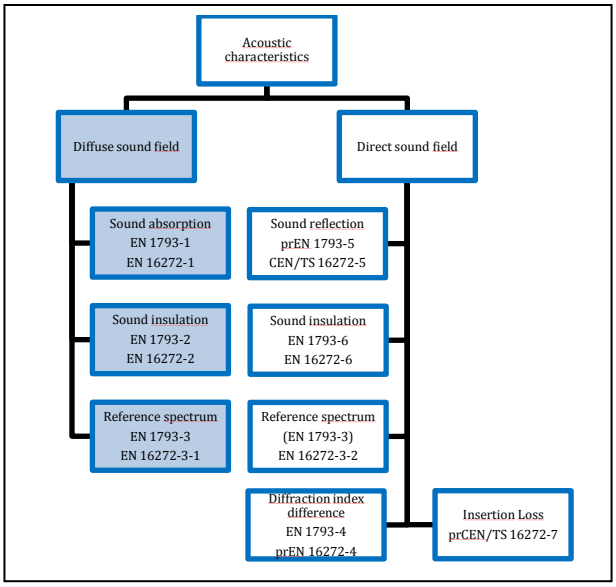

Figure 2. Relationships among the standards on the acoustic characteristics of NRDs.

As already stated in 2013, EN 1793-1 is under revision, adapting its foreword, introduction, scope, test arrangements and test reports with a definitive reference to diffuse sound field conditions: as the existing EN 1793-1 was the only existing standard to qualify NRD before EN 1793-5 has been submitted, limiting 1793-1 to diffuse field is not straightforward for many stakeholders. However, work is still going on in order to definitively differentiate tests under diffuse or under direct sound field conditions. Considerations about the possible wrong use of classes for the single-number ratings, problems enhanced during QUIESST [7] and presented in [9] are also taken into account, in order to avoid any consideration of classes in the future standards. Those last considerations about classes are also taken into account in the revision of EN 1793-2, as well as any future revision of supporting standards using classes if they are not fully consistent with the uncertainties concerns.

About EN 1793-3 a new program work item (PWI) had been started in order to study the possibility of different reference spectra, corresponding to either the diffuse sound field conditions or the direct ones: since then, studies

carried out have finally shown that there was no need for different spectra, whatever the sound field conditions: as of today, the revision of EN 1793-3 has been abandoned. Similarly, WG40 (rails) decided to adopt just one spectrum for both cases until more data would be available, the reason why both EN 16272-3-1 and 16272-3-2 present the same rail noise spectrum).
EN 1793-4, describing the test method for characterizing the diffraction effects of added devices, and EN 1793-5, describing the test method for characterizing the sound reflection under direct sound field conditions have now positively passed the CEN Enquiry and are now at the stage of the formal vote, what means that they will become soon the reference methods for characterizing diffraction / resp. sound reflection of most of the NRD (those used under direct sound field conditions). Just to remember that EN 1793-6 is already the reference for characterizing sound insulation under the same sound field conditions.
As soon as EN 1793-4 and -5 will be approved, the use of the old fashion ISO (laboratory) methods (initially developed for building applications) will be strictly limited to diffuse sound field applications: this will be a major step in characterizing NRD with 5 different and specific test methods, finally now fully relevant with the intended use !
Sound absorption and airborne sound insulation are *intrinsic* characteristics, i.e. independent from the environment where the NRD is installed, but the most relevant characteristic, the insertion loss, is *extrinsic*, i.e. strongly influenced by the specific environment, but also by the way (and the quality under which) the NRD has been installed...
WG6 did not consider developing standards about insertion loss, but WG40 did it since its start in 2008 and prepared CEN/TS 16272-7, currently under CEN enquiry. This TS is intended to improve the old ISO 10847 [10] that has been previously rejected by CEN experts due to its poor repeatability and reproducibility.

4. The mechanical and safety characteristics

Non-acoustic characteristics are also very important for acoustic devices, because their underestimation can degrade the acoustic performance of the NRD, or degrade its safety concerns.
The non-acoustic characteristics for the road sector have been traditionally grouped in two standards since 1998:

- EN 1794-1 on the mechanical performance and stability requirements under static loadings (wind load and static load, self-weight, impact of stones, safety in collisions, dynamic load from snow clearance), and
- EN 1794-2 on the general safety and environmental requirements (resistance to brushwood fire, shatter properties, environmental protection, means of escape in emergency, light reflection, transparency).

In general, the brushfire test in EN 1794-2 gives the basic information for most applications for noise reducing devices. In case that more stringent requirements are necessary, further testing for reaction to fire shall be done according to the new prEN 1794-3 on the *reaction to fire* of NRDs, which is in accordance with EN 13501-1. This new draft standard also contains indications for smoke density and toxic fumes, because this could create dangerous situations for the traffic and nearby living people. prEN 1794-3 is currently submitted to the CEN enquiry.
In the rail sector, prEN 16727-1 deals with the mechanical performance under *static loading*s including calculation and test methods. It builds on the experience gained with EN 1794-1 and provides criteria to verify railway noise barriers and related devices according to basic mechanical performance under standard conditions of exposure, irrespective of the materials used. A range of conditions and optional requirements is provided to allow for the wide diversity of intended uses within Europe.
Most of the attention of WG40 has been focused on the mechanical performance of noise barriers under *dynamic loadings* caused by passing trains (similar considerations could also be thought for road traffic NRD that are placed very close to the traffic, as in tunnels or trenches). Noise barriers must withstand this impact without any part of them being detached or displaced in a way that creates a safety hazard for passing trains or people. As a result, two innovative drafts are now undergoing the CEN enquiry: prEN 16727-2-1 and prEN 16727-2-2. prEN 16727-2-1 describes the basic requirements for the verification of ultimate and serviceability limit states and the resistance to fatigue, either of the noise barrier or its components, by means of analytical methods and/or tests.
The following types of test procedures may be used in alternative or in combination:

- Test on small samples for defining specific categories, which may not be covered by Eurocodes (verification procedure A).
- Test on a global element for defining the limit state against fatigue (verification procedure B). In order to verify the assumptions of the design model, a static load test of the components shall be performed according to prEN 16727-1.
- Fatigue resistance of the noise barrier components determined for defined loading conditions by mean of full scale tests under a given representative loading and a given number of cycles (verification procedure C).

prEN 16727-2-2 presents a calculation method, developed in Germany, and aiming to assess at the design stage the capacity of noise barriers having a post-panel structure with piled foundations to resist the pressure variation caused by passing trains, including an allowance for dynamic response of the structure. The air pressure wave generated by a passing train is described in terms of two block loads in EN 1991-2 Eurocode 1, sub-clause 6.6.2. For calculating more realistic static and dynamic actions on noise barriers, amendment to the EN1991-2 values are necessary by considering the shape of the air pressure wave and the dynamic effects. The calculation method can be applied to claddings attached to rigid structures as well.

5. Long-term performance and sustainability

Noise barriers and related devices acting on sound propagation should not only fulfil their acoustic function and structural design requirements, but also maintain their performance during the required working life. The acoustic elements have to resist the actions of multiple agents within the road or rail side environment that could significantly degrade their performance. The structural elements need to retain acceptable minimum safety factors at the end of their working life. All the elements in the construction of NRDs should be resistant to electrolytic or/and chemical corrosion and embrittlement, be dimensionally stable and have generally a high ageing resistance under many different environmental exposures.
In both road and rail sectors, there are two similar standards (undergoing the CEN enquiry in the rail WG): one for the acoustic characteristics, and another for the non-acoustic ones. They specify requirements for assessing the working life and provide the relevant exposure conditions, with reference to EN 60721-3-4 [11][11].

The sustainability of NRD projects has been systematically considered in the frame of the QUIESST project [7]. This approach takes into account the whole life cycle of a NRD project, including 4 life cycle stages:

- Stage 1. design, consultancy and planning;
- Stage 2: construction, manufacturing and contracting;
- Stage 3: usage, maintenance and repair;
- Stage 4: removal and demolition.

For each life cycle stage all the four sustainability factors (environmental, technical, social, economic) are taken into account.
This brand new topic has been introduced to the standardization level in order to provide the stakeholders with Key Performance Indicators relevant of the sustainability of the NRD projects. The target delay for getting corresponding EN standards is about 2016.

6. Conclusions

Road Noise Reducing Devices (NRD) and railway noise barriers are covered by significant EU standards: Tables I and II list all published or drafted standards as of February 2015. All those standards do consider the major characteristics and performance that every project should include in order to have optimized noise reduction for many years. This is the result of more than 25 years of work, implying all the relevant EU stakeholders.
Any acoustician that has to design new projects should carefully consider those standards as relevant tools to optimize their design.

Acknowledgements

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[10] ISO 10847(1997): Acoustics -- In-situ determination of insertion loss of outdoor noise barriers of all types

[11] EN 60721-3-4: Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 4: Stationary use at non-weather protected locations (IEC 60721-3-4:1995).

Table I. European standards on noise reducing for roads. Standards with an asterisk (*) are under revision.

Standard	*Status*	*Short description*
EN 1793-1*	Published 2012	Sound absorption under diffuse sound field conditions
EN 1793-2*	Published 2012	Sound insulation under diffuse sound field conditions
EN1793-3	Published 1997	Road traffic A-weighted reference spectrum
EN 1793-4	Formal vote 2015	Diffraction index difference - Added devices
EN 1793-5	Formal vote 2015	Sound reflection under direct sound field conditions
EN 1793-6	Published 2012	Sound insulation under direct sound field conditions
EN 1794-1*	Published 2011	Mechanical performance and stability requirements
EN 1794-2*	Published 2011	General safety and environmental requirements
EN 1794-3	CEN enquiry 2015	Burning behaviour of noise reducing devices &
EN 14389-1*	Published 2007	Long-term performance - Acoustical characteristics
EN 14389-2*	Published 2004	Long-term performance – Non acoustical characteristics
EN zzzzz	Drafting 2015-16	Sustainability assessment
hEN 14388*	Published 2005	Road traffic noise reducing devices - Specifications

Table II. European standards on noise barriers and related devices acting on airborne sound propagation for railways.

Standard	*Status*	*Short description*
EN 16272-1	Published 2012	Sound absorption under diffuse sound field conditions
EN 16272-2	Published 2012	Sound insulation under diffuse sound field conditions
EN16272-3-1	Published 2012	Rail traffic A-weighted reference spectrum - diffuse field
EN16272-3-2	Published 2014	Rail traffic A-weighted reference spectrum - direct field
EN 16272-4	Formal vote 2015	Diffraction index difference - Added devices
CEN/TS 16272-5	Published 2014	Sound reflection under direct sound field conditions
EN 16272-6	Published 2014	Sound insulation under direct sound field conditions
EN 16272-7	CEN enquiry 2015	Insertion loss
EN 16727-1	CEN enquiry 2015	Mechanical performance and stability requirements
EN 16727-2-1	CEN enquiry 2015	Dynamic loadings - Fatigue
EN 16727-2-2	Formal vote 2015	Dynamic loadings – Calculation method
EN 16727-3	CEN enquiry 2015	General safety and environmental requirements
EN yyyyy	To write	Burning behaviour of noise reducing devices
EN zzzzz-1	Ready for enquiry	Long-term performance - Acoustical characteristics
EN zzzzz-2	Ready for enquiry	Long-term performance – Non acoustical characteristics
EN zzzzz-3	Drafting 2016	Sustainability assessment