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The European Qualification System For Road Traffic Noise Reducing Devices

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The European qualification system for traffic noise reducing devices (NRD's) is based on an advanced framework of ten standards. This framework is based on a "product standard" (EN 14388) which specifies the performance requirements in terms of measurable characteristics and associated test methods. Each characteristic is rated according to as system of "classes"; for this purpose, a normalised road traffic noise spectrum has been defined (EN 1793-3). Sound absorption and airborne sound insulation must be tested in laboratory using methods which can be regarded as tuned versions of the ISO 354 and ISO 140-3 ones (EN 1793-1 and -2). The same properties can also be measured in situ on installed NRD's, following a new technical specification (EN/TS 1793-5), based on an impulsive technique with the use of a MLS test signal. A similar technique can also be applied to characterise sound diffraction of "added devices" placed on the top of NRD's (EN/TS 1793-4). Two standards are devoted to non-acoustic performances, such as mechanical stability, fire resistance, etc. (EN 1794-1 and -2). Finally, specific standards deal with long term durability of acoustic and non acoustic characteristics (EN 14389-1 and -2).

1. INTRODUCTION

The European qualification system for road traffic noise reducing devices (NRD's) is based on an advanced framework build on a "product standard" EN 14388 [1], which specifies the performance requirements for NRD's in terms of measurable characteristics and nine "supporting standards", describing the associated test methods. They cover acoustic, non-acoustic and long term performance.

NRD's have not only to be acoustically performant, but also to be safe and able to keep their performances along time. The CEN working group works thus not only on standards for qualifying acoustic characteristics, either in laboratory [2,3] or in situ [5,6], but also on standards for qualifying non-acoustic characteristics, which can affect the safety, and/or indirectly the acoustic performances of NRD's [7,8]. Finally, the European standards also consider the long-term durability of all those acoustic and non-acoustic characteristics [9,10].

The compliance of a NRD with the specified requirements and with the stated values must be demonstrated by an initial type testing and a factory production control extended in time. Following EN 14388 it is possible to prepare a "declaration of conformity" of NRD's according to the European rules (*EC declaration of conformity*), which authorises the affixing of the CE marking on products. Thus, the whole EN package helps in qualifying the NRD's on the European market, in selecting the most suitable NRD's for each application, and in keeping them performing correctly for many years.

2. ACOUSTIC CHARACTERISTICS – LABORATORY MEASUREMENTS

Laboratory measurements of sound absorption and airborne sound insulation, following the principles of the ISO test methods, were the first to be used for characterizing NRD's. EN standards use "tuned" versions of these, and single number ratings following a normalized road traffic noise spectrum [2,3,4].

3. ACOUSTIC CHARACTERISTICS – IN SITU MEASUREMENTS

The European research project *Adrienne* [11,12] produced innovative methods for testing the sound reflection/absorption and the airborne sound insulation characteristics of noise reducing devices in situ. These methods are now included in the technical specification EN/TS 1793-5 [5]. The *Adrienne* method is based on the recovering of an acoustic impulse response close to the barrier under test [13]. Its principles are used for both sound reflection index and sound insulation index measurements.

3.1 Sound reflection

A loudspeaker is placed facing the traffic side of the noise reducing device and a microphone is placed between the sound source and the NRD (Figure 1).

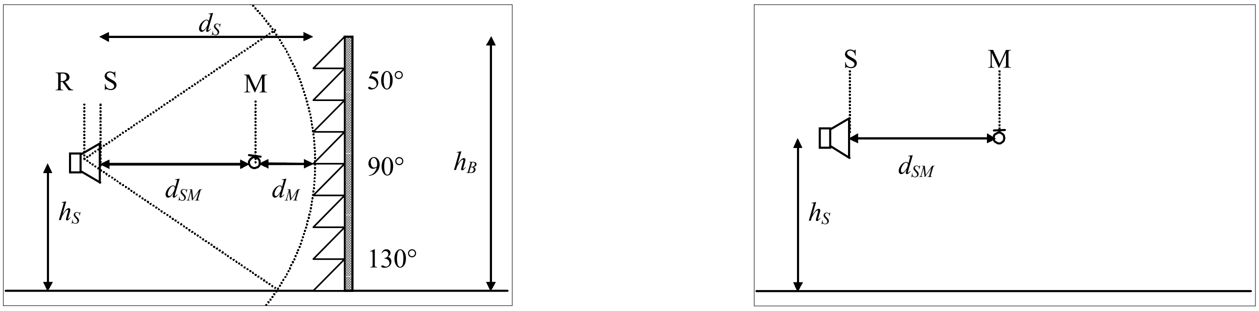

Figure 1. *Reflection index measurement set-up in front of a non flat noise reducing device: reflected components measurements (left) and "free-field" (incident) component measurement (right).*

With the loudspeaker emitting a transient sound , the microphone receives both the direct sound pressure wave traveling 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 a quantity called *sound reflection index* [5]. The *sound reflection index* is calculated using the signal subtraction technique [14] that requires an exact reproduction of the time signals for both the direct and (direct + reflected) components. Measurements must be repeated at nine incidence angles for a flat sample; for non-flat or non homogeneous samples, the number of measurements to average is increased [5].
The low frequency limit is inversely proportional to the width of the analysis window and depends also on its shape; for an *Adrienne* window 7,4 ms wide this limit is about 160 Hz [15]. The angle averaging influences this limit: it is the reason why, in EN/TS 1793-5, it is limited to 90° ± 0° below 200 Hz, ± 10° at 250 Hz, ± 30° at 315 and 400Hz, and ± 40° over 400 Hz.

3.2 Airborne sound insulation

A loudspeaker is placed facing the traffic side of the noise reducing device, a microphone is placed on the opposite side. The loudspeaker emits a transient sound wave that is partly reflected, partly transmitted and partly diffracted by the NRD (Figure 2).
The microphone receives: the transmitted sound pressure wave, traveling from the sound source through the NRD to the microphone and the sound pressure waves diffracted by the edges of the

NRD. The power spectra of the direct and the transmitted components, corrected to take into account the path length difference of the two components, gives the basis for calculating the outdoor sound transmission loss, which has been called *sound insulation index* [5]. The measurement in front of the NRD is repeated at nine points placed on an ideal grid (scanning points). The final *sound insulation index* is the logarithmic average of these nine results. A set of nine measurements must be repeated in front of the acoustic elements and in front of a post.
Comparisons between field and laboratory results show a quite acceptable correlation for sound reflection ($r = 0{,}89$) and a very good correlation for sound insulation ($r = 0{,}97$ for acoustic elements; $r = 0{,}93$ for posts): existing differences can be explained with the different sound fields, averaging techniques and mounting conditions between the outdoor and laboratory tests [15,16].

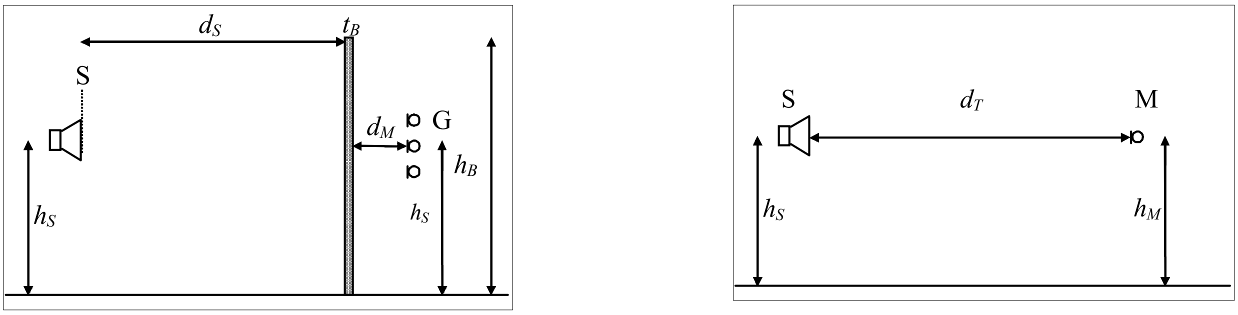

Figure 2. *Sound insulation index measurement set-up in front of a non flat noise reducing device: transmitted components measurements (left) and "free-field" (incident) component measurement (right).*

3.3 Sound diffraction

Part of the market of traffic noise reducing devices is constituted of products designed 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 are called "added devices". A new EN standard has been drafted in order to qualify them [6]. The *Adrienne* method have been again considered to characterize a *diffraction index* for a NRD, with and without the added device.
A loudspeaker 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 (Figure 3).
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. If the measurement is repeated without anything 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 measurement procedure and diffraction index calculation shall be carried out twice: one with, and one without the added device placed on the test construction. The *diffraction index difference* is then calculated: this is regarded as a relevant characteristic of the added device under test.

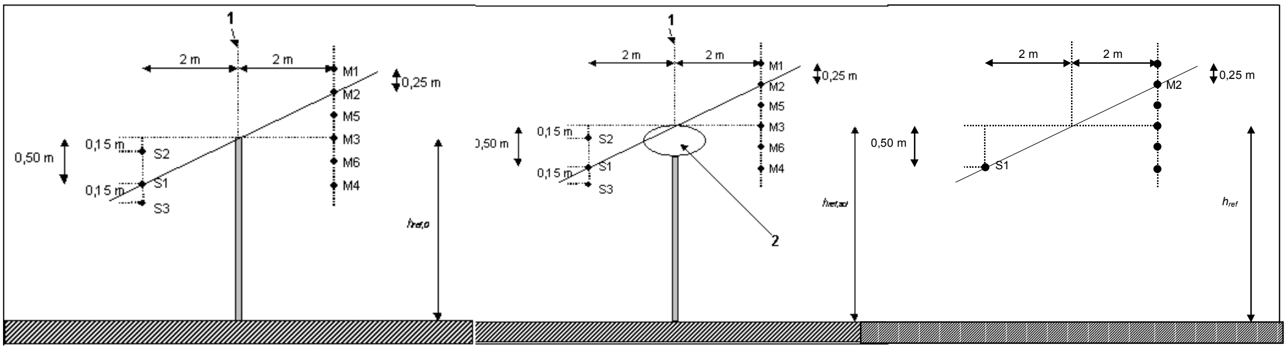

Figure 3. *Sound diffraction index measurement: loudspeaker (S) and microphone (M) locations: without added device (left), with added device (centre) and "free-field" (incident) component measurement (right).*

4. NON-ACOUSTIC CHARACTERISTICS

Non-acoustic characteristics are also very important for qualifying NRD's.

4.1 Mechanical performance and stability requirements

Apart safety concerns, NRD's are exposed to a range of forces due to wind, dynamic air pressure caused by passing traffic, and self weight. They may also be subjected to shocks caused by stones or other debris thrown up by passing vehicle and, in some countries, the dynamic force of snow clearance devices. The deflections caused by such loads during the working life should not reduce the acoustic performance of NRD's. In order to correctly select new NRD's to be installed along roads, EN 1794-1 [7] provides criteria to categorise NRD's 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 practice within Europe.

4.2 General safety and environmental requirements

NRD's should not assist the spread of fire from adjacent brushwood, should not reflect light in such a way as to prejudice road safety, should be made from materials which do not emit noxious fumes or release breakdown products which might in time have adverse effects on the environment (either as the result of natural or industrial processes, or as the result of fire). Finally NRD's should allow a means of escape by road users and access by operatives in the event of an emergency. EN 1794-2 provides criteria and test methods to categorise NRD's according to the above mentioned characteristics.

5. LONG TERM DURABILITY

Durability means that NRD's alongside roads should not only fulfil their acoustic function and structural design requirements, but also maintain their performance during the required working life. This is a very sensitive topic, as NRD's can be made from different combinations of different materials, each one possibly reacting in different manners to ageing. Specific drafts are progressing, regarding acoustic [9], and non-acoustic characteristics [10]. The acoustic part is still in progress: the increasing use of EN/TS 1793-5 [5] could be of great help in order to understand how ageing influences the actual in-situ acoustic performances.

6. CONCLUSIONS

The *Adrienne* method led to the final draft of EN/TS 1793-5, characterizing in situ values of sound reflection and airborne sound insulation; until now, its numerous results are consistent with the laboratory ones. EN/TS 1793-4 is now submitted for sound diffraction of "added devices". By characterizing the acoustic (either in laboratory or in situ) and non acoustic characteristics of NRD's, the whole EN package helps in qualifying the NRD's on the European market, in selecting the most suitable NRD's for each application, and in keeping them performing correctly for many years.

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