

# Noise from High Speed Trains: Harmonization of National and European Legislation

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## Abstract

Noise legislation in Europe is constantly changing due to an always broader spectrum of knowledge and under the revision process of existing directives and standards. The paper aims at describing the up-to-date situation of European legislation. The issue of testing and homologating a new train in a member state is then addressed, describing briefly the train layout, the regional legislation and the measures to avoid any barrier to the introduction of interoperable trains in one or more EU member states.

**Keywords:** railway, noise, homologation, testing, directives, national legislation.

## 1 Introduction

An intense and rigorous activity held in the last decade led to the publication of the Technical Specifications for Interoperability (TSI) that include both conventional rail (CR) [1] and high speed (HS) [2] in Europe.

One of the fundamental components of rolling stock interoperability is noise. Under a mandate of the European Commission, the AEIF (Association Européenne pour l'Interopérabilité Ferroviaire) conducted several external noise measuring campaigns during high speed trains pass-by [3]. At the same time, EN standards were prepared to support the Directives on Interoperability, namely for rail roughness [4] and dynamic behaviour of the track [5] related to noise generation and radiation.

Before all the aforementioned activities, a law was published in Italy in 1998 [6] concerning exterior noise limits from an environmental point of view and is still in force. Even stricter limits will come in force from 2012, fourteen years after publication.

In 2010 Trenitalia emitted a tender to purchase a fleet of new high speed train. Ansaldo Breda and Bombardier won the tender and immediately started the design of the new train also from the acoustic point of view. New improved acoustic designs will be introduced in comparison with the last 300 km/h trains entered into service in Italy in 1992.

As the scope of the TSIs and the Italian law is slightly different, an approach that could reconcile the different requirements of national law and European Directives will be necessary to remove the inevitably arising clashes.

This paper describes the approach followed by the manufacturer with the scientific support of a second party (University of Florence), to ensure the application of the principles of the Directives (i.e. the free circulation of people and goods throughout Europe) by using the maximum transparency in the reciprocal relationships between all the actors involved in the Technical Admission into service of new rolling stock.

## **2 The new Trenitalia ETR 1000 train**

The ETR1000, which has been ordered in September 2010 by the Italian operator Trenitalia, is a very high-speed train jointly developed and built by AnsaldoBreda and Bombardier Transportation (Figure 1). This non-articulated eight-car, single-deck train set, with distributed traction, is designed to have a service speed from 300 km/h to 360 km/h. The carbody will be made of aluminium and the power will reach 8.8 MW.

With a length of 202 m, this new rolling stock will be able to carry up to 600 passengers while offering also bistro services. It will be possible to couple two train sets in order to double its capacity. Foreseen for cross-border services within Europe, it will satisfy interoperability requirements and be equipped with four different voltage systems, both AC and DC. The contract with Trenitalia includes 50 train sets, with an entry into service by 2013.



Figure 1. Artist's impression of the new ETR1000 for Trenitalia (source: AnsaldoBreda).

The reason for introducing here the new train is that it is going to be the first interoperable high speed train in Italy to which the Italian and European legislations will apply, arising a potential clash as it will be explained in the rest of this paper, together with the efforts made to guarantee the correct application of all existing rules.

### **3 European Legislation status and development**

Progress in railway noise abatement has a high priority on the European level. This is based on the fact that European citizens are very positive to railways in general except that the noise should be minimized. To enable further expansion of railways in Europe continuous progress must be made to reduce the noise annoyance from rolling stock and railway infrastructure. Development of a harmonized European legislation related to noise is an important part to assure the required progress.

As pointed out in [7] it is of great importance that the legislation is relevant so that it will in practice under normal operation conditions give a real effect of reducing railway noise exposure in Europe.

#### **3.1 European Noise Legislation 2002- 2009**

The first step towards a Technical Specification for Interoperability (TSI) was taken more than a decade ago. The first TSI published in 2002 was the TSI for High-Speed (TSI RST HS) [8]. This was a rolling stock TSI including many parameters where one part is a chapter on noise. The limit values were set with no or little input from the experts in the sector and the existing rolling stock at that time.

When this TSI HS was revised in 2008 [2] a different process was chosen involving all major stakeholders and experts. This TSI includes exterior noise at standstill, acceleration and pass-by at the speeds 200, 250, 300 and 320 km/h as well as interior noise in the drivers cab at maximum service speed of the train and for warning horn operation. Learning by the mistake of the first version the process of drafting the noise part of the TSI-HS 2008 was associated with a very comprehensive measurement campaign of noise from high speed trains, financed directly by the Commission the so called NOEMIE campaign [3]. This is an unusual action from the Commission but was considered necessary since it was evident that nobody at that time actually knew what were the noise levels emitted by HS rolling stock on specific track with known track parameters. A discussion and some data were available as reflected in [9] but there was no systematic knowledge of actual pass-by noise levels at high speed. Result from the NOEMIE campaign was very useful for developing an appropriate legislation in this field.

Next step in the development of TSIs was to have a small number of TSI for specific sub areas where fast progress was deemed of great importance. One of the areas was

noise for Conventional Rail (CR) with speeds up to 190 km/h. In 2006 a special TSI dedicated to noise for conventional rail the TSI NOI CR was published [10]. The scope of this TSI is freight wagons, diesel and electric locomotives, EMU, DMU and coaches. It includes exterior noise at standstill, acceleration and pass-by at 80 km/h and at top speed up to 190 km/h as well as interior noise in the driver's cab at speed and with the horn blowing.

### 3.2 Limited revision TSI Noise for conventional rail in 2011

The TSI NOI CR was updated during 2011 with a limited revision [1]. Before some of the changes of this limited revision are detailed it is important to understand the background and basic principles for the development and revision of the TSIs. The intention is that the noise limits for the authorization of any new *rolling stock* will be defined exclusively by Noise TSI. In case these limits are fulfilled, no member state may require further noise reductions of the *rolling stock*, and where noise emission limits are exceeded locally other means (e.g. improvements to track superstructure, use of noise barriers, specific grinding campaigns) shall be used. Figure 2 illustrates the authorisation principle.

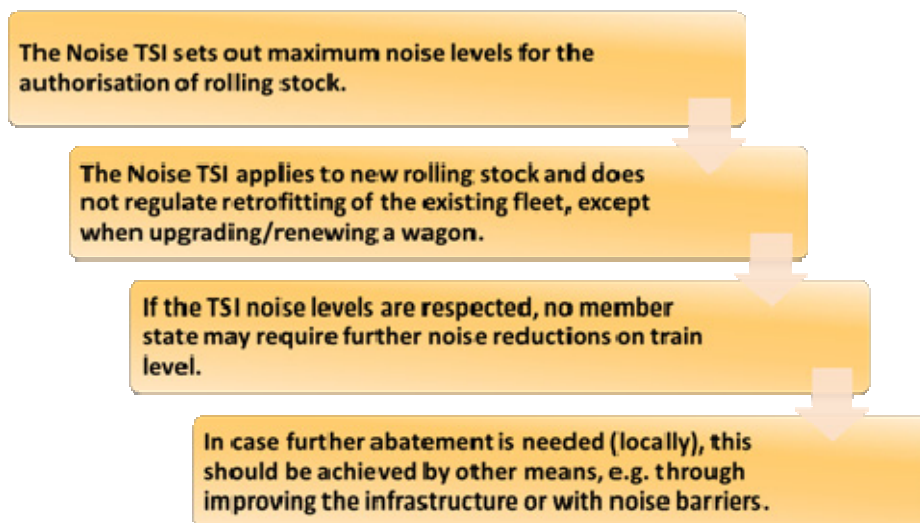


Figure 2. Noise TSI principles - authorisation

During 2009 the European Railway Agency (ERA) received a mandate from the Commission to do a limited revision of the TSI NOI CR from 2006. This limited revision was published and came into force in April 2011 [1]. The mandate was related to adapt to technical progress and market trends particularly regarding testing on non-reference track but the noise limits and the scope were left unchanged. These will be within the scope for a full revision scheduled to 2013. Figure 3 summarizes the main parts that are changed in the limited revision [1].

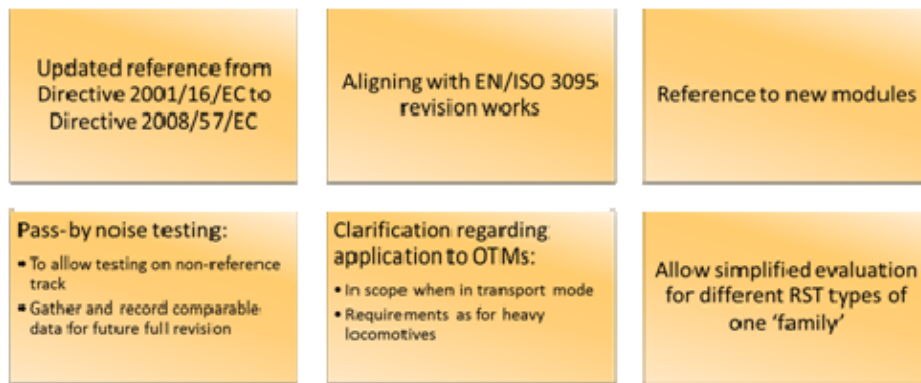


Figure 3. Main changes introduced in limited revision of CR TSI NOI in 2011

A fundamental point about the applicability of [1] is the question of the geographical scope as “the geographical scope of this TSI is the trans-European conventional rail system as described in Annex I to Directive 2008/57/EC.” Any rolling stock running on the CR TEN lines will be in the geographical scope, and this also applies for high speed rolling stock. Nevertheless, if a high speed train is compliant with the provisions in the HS RST TSI:2008 [9], it is deemed to comply with requirements of [1] without further testing or verification.

Additionally, in [1] there is no definition of speed limits. Where a rolling stock has a maximum speed higher than or equal to 190 km/h and is intended to operate on the CR TEN lines, it is in the scope of [1] or, stated differently, provisions listed in [1] apply also to high speed rolling stock when running on CR TEN lines.

The two important points as shown in Figure 3 related to allowing testing on non-reference track applying a small deviation method and the simplified evaluation method will be further explained in the next sections.

### 3.3 Testing on non reference track - small deviation method

In the limited revision [1] the following is stated:

*”It is permitted to carry out the test on track that does not comply with annex A and if the noise levels do not exceed the values shown in table 5, there is a presumption of conformity to this requirement.*

*The following conditions of the track on which the pass-by noise measurement is performed shall be measured and recorded:*

- *the vertical and lateral track decay rate in accordance with EN 15461*
- *the track acoustic roughness in accordance with EN 15610.*

*If the track on which the measurements were performed did meet the reference conditions as set out in annex A, or if the acceptance criteria of annex B are met, the measured values shall be marked ‘comparable’. Otherwise the measured values shall be marked ‘non-comparable’.*

The rationale of the above described testing principle is more clearly illustrated in the flow chart shown in Figure 4.

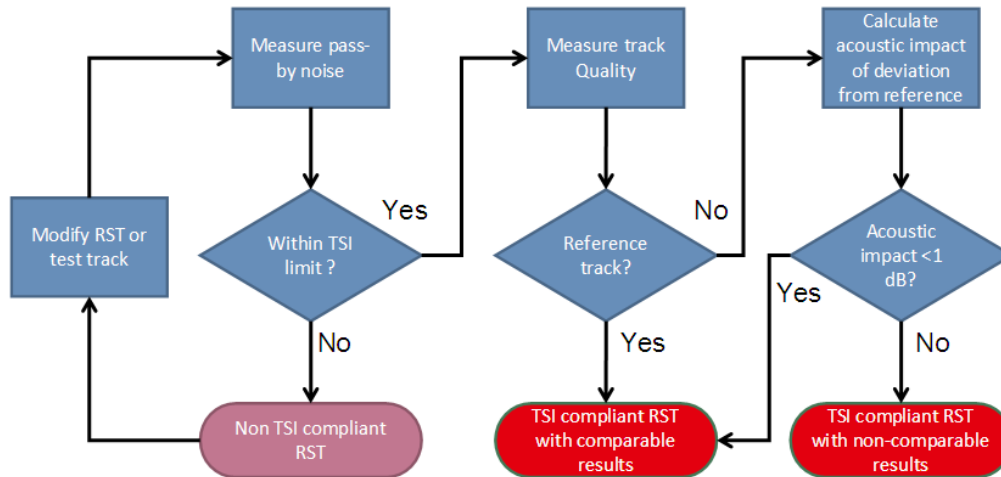


Figure 4. Pass-by testing principle

While the *reference track* conditions must be evaluated according to EN 15461 [5] for the vertical and lateral track decay rate and according to EN 15610 [4] for the track acoustic roughness, one of the new topics introduced by CR TSI NOI [1] is the concept of the small deviation calculation method, i.e. a method to assess acceptable small deviations from rail roughness requirements.

The ‘small deviations’ method aims at introducing some flexibility in the conformity assessment of a test track section towards a limit curve of acoustic rail roughness within the frame of constant speed tests. Both the limit curve and the measured acoustic rail roughness spectra are assumed to be one-third octave band wavelength spectra.

The method relies on a calculation of a correction to the measured level based on the effect of exceeding a specified spectrum of acoustic rail roughness. The difference between the corrected pass-by noise level and the measured one is then compared to an acceptance criterion. If the criterion is fulfilled, the acoustic impact of the rail roughness deviations is deemed ‘small’ and the measured pass-by noise level is considered to be comparable.

Extrapolating and calculating the pass-by noise at a new known site based on measured results from another site is possible and methods are discussed in [11]. Included in the present limited revision of TSI [1] is however no allowance to adjust the noise levels, only to calculate if the effect on noise is more or less than 1 dB in order to classify the data as comparable or not.

A practical example for application of the small deviation procedure is detailed in [12] including also a small deviation method for track decays. Leaving the reader to [1] and [12] for further details, it is emphasized here that the method is train speed dependent (compliance must be examined for one pass-by at each speed). As previously mentioned, the data shall be considered to be comparable if the estimated noise impact  $\Delta L_{pAeq, Tp}$  calculated is  $\leq 1$  dB.

From the point of track decay rates (TDR) it is interesting to note that the small deviations principle is not applicable to TDR. Nevertheless, comparing the current version of CR TSI NOI [1] with the previous one [10], it is worth noting that the specifications are changed, restricting the field of application by excluding the one-third octave bands centred at frequencies below 250 Hz (Figure 5). Also, intermediate data values were added to the graph for better usability.

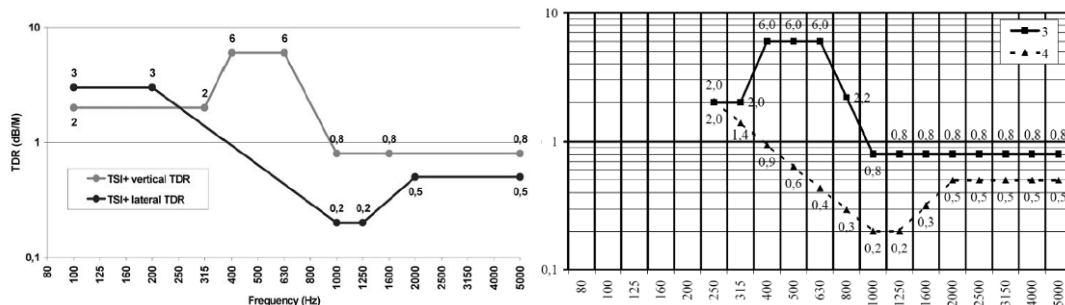


Figure 5. Comparison of previous (2006, left) and current (2011, right) specifications for track decay rate lower limits of TSI CR Noise

### 3.4 Simplified evaluation method

Although by default all new types of conventional vehicles need to be assessed in compliance with the requirements of CR TSI NOI [1], it is now permitted to substitute some or all of the tests by a *simplified evaluation method*, which consists of acoustically comparing the type under assessment to an existing type with documented noise characteristics compliant with the noise TSI (referred to as the *reference type*).

*“The simplified evaluation on a unit shall consist of providing evidence to show that the acoustically relevant systems and characteristics are either identical to those of the reference type, or such that they will not result in higher noise emission of the unit under assessment. The simplified evaluation can either be a calculation, or simplified measurement (e.g. sound power of noise sources), or a combination of both. Noise relevant systems which differ from the reference type shall be identified in the technical file.”*

Units eligible for a simplified evaluation are: Different formations of multiple units, renewed or upgraded units and new units which are largely based on an existing design (same vehicle family).

A simplified evaluation may be applied for a number of cases. Some interesting cases are outlined in [13] such as having a new formation, exchange of a single component, modification of the wheel type and modification of the aerodynamics of a unit. It will be the judgement of the involved Notified Bodies to decide what the appropriate evaluation method in each case is.

### 3.5 Full revision of Noise TSIs (2013/2014)

For reasons that will be apparent later, it is fundamental to observe that also in [1], as in all the TSIs, the so-called *two step approach* is maintained. In fact, the excerpt from [1] says that “It is recommended that in the case of new rolling stock to be ordered after 23 June 2016, or authorised to be placed into service after 23 June 2018, points 4.2.1.1 and 4.2.2.4 of this TSI are applied with a reduction of 5 dB except for DMUs and EMUs. For both latter cases the reduction is 2 dB. *This recommendation will serve only as a basis for revising points 4.2.1.1 and 4.2.2.4 in the context of the TSI revision process mentioned in point 7.2.*”

The process for a full revision has started with a kick off meeting called by the European Railway Agency (ERA) in early May 2011. A so called Working Party including representative from the different stakeholders, representing the Member State as well as industry and operators. One important part is the extension of scope for the full revision to include the entire railway network in Europe, hence also the off-TEN network. The background to this scope extension is to assure that no parallel national legislation is needed concerning the same topics as the European legislation, in this case rolling stock noise. Other important point for the full revision is the possible merging of the noise part in the TSI RST HS [2] with the TSI NOI CR [1] in to one TSI Noise for all speeds.

In addition to study lower pass-by noise limits, the full revision is also aimed at considering squeal and brake noise limits and to further reduce verification burden by permitting more flexibility in assessment. The last point is illustrated in Figure 6.

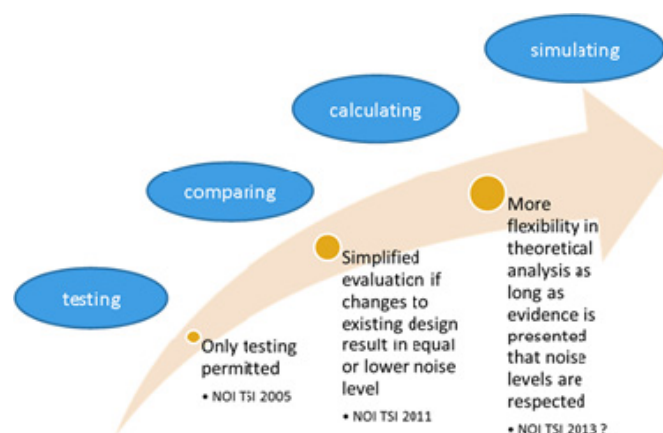


Figure 6. Possible evolution of assessment methods.



However, to reduce the actual noise exposure in Europe the track radiation and the track roughness must also be reduced under normal operation conditions. Reducing the total levels during test by reducing the track radiation or the roughness on the reference track will not achieve this.

A system approach including rolling stock, rolling stock maintenance and infrastructure and finding a proper balance between these is crucial to achieve further progress for pass-by noise. At the moment, the contribution from the track is considerable or even dominating for some cases on normal operation track as well as on reference track [7]. Further noise reduction measures applied to the vehicles will in these cases be ineffective for reducing the total levels. It is in general also important to minimize parameters included in legislation and prioritize legislation to target cases where the highest ratio of reduced noise exposure per Euro spent is achieved.

## **4 Comparison of European and Italian legislation on railway noise**

### **4.1 The DPR 459/1998**

In 1995 Italy published the Law 447/1995 [14] (known as the “Framework Law on Noise Pollution”) in order to regulate the noise disturbance to which Italian citizens are subjected to.

One of the explicit provisions of the law was that within one year after its publication several rules for the enforcement of the law (for noise produced by road, airport, railways etc. sources) had to be published, indicating that “these rules shall be harmonized with the European Union directives that will be acknowledged by the Italian State”. The Framework Law indicated the rules had to be emitted “by the President of the Italian Republic, after a resolution by the Council of Ministry, on the proposal of the Ministry of Environment together with, on the basis of the respective competences, the Ministries of Health, of Industry, of Commerce, of Transport, of Public Works and of Defense”.

The rule for railway noise was eventually published three years later (Decreto del Presidente della Repubblica, DPR 459/1998, [6]), “on the proposal of the Ministry of the Environment, in concert with the Ministry of Health and the Ministry of Transport and Navigation”. It is clearly a law about environmental protection of citizens.

The rule DPR459 [6] has a set of common articles with the other similar rules (especially with regard to the definition of the zones in the territory and the respective limits) and at article 6 (which refers further to Annexes A and B) defines the “maximum limits of emission for new rolling stock” that have to be declared in the tenders.

It is important to note that DPR459 does not contain provisions for trains running faster than 250 km/h and consider only concentrated power train sets (as the ETR500, ICE and TGV trains of that time) while self-propelled multiple units, intended clearly as DMU by looking at the declared limit, had to be tested at 80 km/h.

The infrastructure is not defined in any way, and from the reading of the whole DPR459 it is clear that it was written when the Italian railways (FS) were a “monolithic” structure: no responsibility is assigned to infrastructure owner or the train operating company as at that time they were still coincident (the so-called “divisionalization” process started in 2000).

Of even greater importance for this work, DPR459 uses  $L_{pA,max}$  (i.e. the maximum peak recorded during pass-by recorded with the FAST time constant).

In the meantime, the General Direction for Transport and Energy (DG-TREN) of the European Union, with the contribution of the specifically established AEIF (Association Européenne pour l’Interopérabilité Ferroviaire), conducted several external noise measuring campaigns during high speed trains pass-by in order to understand which were the actual limits of the technology and which were the really achievable results in terms of minimum pass-by noise emission. As already described, the NOEMIE project, ended in 2005 [3], provided results that were fundamental to write [2] while EN standards on rail roughness and dynamic behavior of the track related to noise generation were prepared to support the Directives on Interoperability.

As a general consideration, it can therefore be observed that after the publication of DPR459 an intense and deep activity was performed at European level, and that this activity led to an update of the maximum limits of noise during pass-by and, what’s more, to a clear specification of the conditions of the site where this characteristic of trains must be measured and fulfilled.

In the far 1998, the legislator imposed limits that were going to enter in force in 2012. It was not anticipated, that the outcome of measurements taken around Europe was going to show that those desires were not reachable by railway technology, As a comparison on the adopted method, the *two-step approach* used in the Directives is more flexible and descends directly from the feedback from experience, while DPR459 drafters used a sort of “crystal ball” to set the limits in a so far future. No revision of the DPR 459 was done after the first release re-checking the limits and taking into account new expertise for noise emission of railway rolling stock.

## 4.2 Comparison of DPR 459/1998 and TSI HS RS

DPR459 [6] states that the maximum level  $L_{pA,max}$  recorded during a pass-by at 250 km/h (microphone located at 25 m from the track centerline, at a height of 3.5 m above top-of-rail level) of a *material trainante* (i.e. a locomotive) which enters in service after 1.1.2012 shall be  $L_{pA,max} \leq 85$  dB(A). TSI HS RS [2] defines a different

indicator and a different level:  $L_{pAeq, Tp} \leq 87$  dB(A) with a tolerance of 1 dB(A), bringing the actual limit to  $L_{pAeq, Tp} \leq 88$  dB(A) (Table 1).

	Train speed	Measurement location	Quantity	Requirement
HS RST TSI	250 km/h	y = 25 m z = 3.5 m	$L_{pAeq, Tp}$	$\leq 88$ dB(A)
DPR 459 (from 1.1.2012)	250 km/h	y = 25 m z = 3.5 m	$L_{pAmax (fast)}$	$\leq 85$ dB(A)

Table 1. Comparison of external limits from DPR459 and TSI HS RS

As a general consideration, it should first of all be noted that indicators including maximum values are naturally highly unstable and therefore not fully suitable for legislation

As it is clear, unless the noise during train pass-by is *absolutely constant*, the inequality  $L_{pA, eqTp} < L_{pA, max}$  always holds. The exact difference between the two indicators depends on the acoustics (and aeroacoustics) properties of each train and the track and wheel quality, but could be set precautionary at around 2 dB(A). It results therefore that requiring  $L_{pA, max} \leq 85$  dB(A) is approximately equivalent to require  $L_{pAeq, Tp} \leq 83$  dB(A), i.e. DPR459 is 5 dB(A) more restrictive than TSI HS RS!

### 4.3 Actions in progress

Modifying a law is certainly not an easy process anywhere, but the inconsistency of DPR459 vs. TSI HS RS appears clearly.

The Authority which manages the technical admission in service of rolling stock is the Agenzia Nazionale per la Sicurezza Ferroviaria (ANSF) that was contacted in order to open a technical table to discuss the subject.

Several actions could be taken, the first being the request to update the DPR to European Legislation as specifically requested by the Framework Law 447/1995. A quite simple way to amend the DPR could be the sentence “maximum noise emission levels during pass-by tests of new rolling stock shall be determined according to TSI HS and TSI CR and the related European standards”.

It is worth to underline, anyway, that the purpose is to assure limited noise from rolling stock and at the same time avoid that trains homologated around Europe are

stopped at the Italian border because they do not fulfill the requirements of an old and never updated national law.

The instance that TSI and EN do not cover exactly the field covered by DPR, being the former dealing with homologation and the latter dealing with maximum exposure limits, should be managed carefully such that the principle that European legislation has to be applied in all European Union countries and supersedes national laws can be applied also to this case.

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