# Elimination of rail noise as a step towards sustainable transport

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**Abstract**

Current problems while carrying out the modernization of the railway infrastructure in the Czech Republic are very strict limits of the noise level along the railroad tracks, which leads to a massive construction of countermeasures, especially the noise barriers. The paper describes the situation from the point of view of both emission limits and noise abatement measures. At the beginning of this paper the noise sources from the rail transport are remarked. Next part of this paper presents Directives on the interoperability, especially in view of the role of rail noise in these directives. Last but not least the possible measures to reduce noise from the rail transport are mentioned.

**Keywords:** noise, railway transport, sustainable transport, noise barriers, interoperability

## 1. INTRODUCTION

Rail transport is rightly considered to be environmentally friendly transport, yet it also negatively affects the environment. One of the major negative impacts of rail transport is noise. In the European Union was a breakthrough year in 1996, when the core document "Green Paper on future noise policy of the EU" was drafted. The main objective of this paper was to improve the noise situation in the environment. Since then, the European Commission is working towards a form of transport that is sustainable, energy-efficient and respectful of the environment.

Ministry of the Environment of the Czech Republic define the sustainable transport as transport "that will enable conditions for carrying people and cargo in a manner that is functional, safe and economical, while it at the same avoids depletion of non-renewable energy sources, and reduces the environmental load caused by emissions and noise to the levels no longer hazardous to human health, natural ecosystems and the Earth's climate [4]."

Among the important documents dealing with traffic noise belong the directives on the interoperability. These directives aim at accelerating the integration of the European Union rail network through increased technical harmonization, guaranteeing a high level of safety. This harmonization also brings a significant noise reduction.

The issue of noise and its possible elimination is the same as the Interoperability Directives discussed in this contribution.

## 2. NOISE FROM RAIL TRANSPORT

The most significant negative impacts from rail transport are just noise and vibration. The size of these effects depends on many factors, especially the way routing, type of traction, construction and technical condition of the

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superstructure, the technical condition of vehicles and the amount of traffic. Furthermore the noise propagation depends on climatic conditions, the configuration of the surrounding terrain and the type of surface of the surrounding terrain.

Noise is one of the key issues of transport, including rail transport. Rail noise originates mainly from three main sources, and also depends on train speed. Sources of the rail noise and their typical dependence on train speed are represented in the figure 1[1].

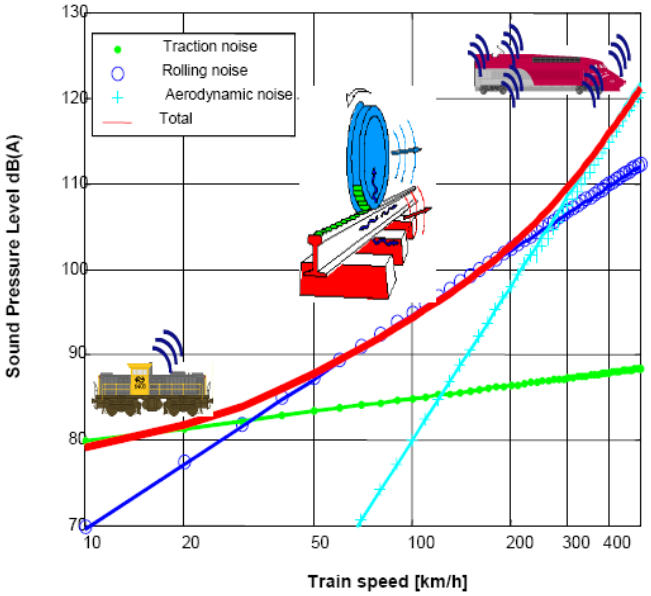


Fig.1. Rail exterior sound sources and typical dependence on train speed [1]

The first one is rolling noise, causing by wheel-rail interaction. The noise of rolling wheels is involved as well as the track itself. This kind of the noise source becomes dominant up to speeds around 200 km/h.

The next one is power equipment noise caused by locomotive engine, exhaust outlets, traction motors, gears and fans. This kind of noise source, which is more significant for diesel traction, compared to electric traction, generally has little or no independency on train speed. Power equipment noise source occur when full power is required, for example at low speed when rolling noise will be low.

Last noise source from rail transport is aerodynamic effects. This kind of noise arises from the flow of air over the train surface. At the low speeds power equipment and traction noise is predominant, and aerodynamic noise prevails typically around 250 km/h and more. There are also “the other noise sources” for example curve squeal, broadband braking noise, or radio equipment for the information of employees and the public.

There are three issues according to Position Paper on the European Strategies and Priorities for Railway Noise Abatement [7] that can be pointed out. The first one is freight transport. Freight rail traffic is primarily caused by the rolling noise, because of freight wagons braking technology. This problem is even greater because freight trains usually operate at night. High speed trains, producing mainly aerodynamic noise, represent the second group of issues. The last one is urban railway transport. This kind of transport operates in densely populated areas, and requires the necessary noise reduction measures.

Since the Czech Republic does not yet have high-speed rail network, is faced with only two of the three aforementioned issues - noise from rail freight and commuter traffic noise. There are a variety of noise control measures, which are discussed further in the fourth section of this contribution.

## 3. LEGISLATION IN FIELD OF RAILWAY NOISE

One of the many activities designed to reduce noise levels of the population is defining its limits. Emission limits for transport infrastructure in the Czech Republic are given in Table 1.

Table 1. Occupational exposure limits in equivalent sound pressure level LAeq,T [Government Decree No. 272/2011] for protected outdoor area and other outdoor spaces, including corrections

| Noise from traffic | LAeq,16h day (dB) | LAeq,8h night (dB) |
|---|---|---|
| Basic hygienic limits - road transport | 50 | 40 |
| Basic hygienic limits – rail transport | 50 | 45 |
| Road transport - road, with the exception of special-purpose communications | 55 | 45 |
| Road transport - the main road | 60 | 50 |
| Rail transport | 55 | 50 |
| Protective zone of railway | 60 | 55 |
| Old noise pollution - road transport | 70 | 60 |
| Old noise pollution - rail transport | 70 | 65 |

In former Czechoslovakia limits were part of the Ministry of Health Decree No. 13/1977 Coll., "On health protection against adverse effects of noise and vibration" from 1977.

The basic law of acoustics - Act No. 258/2000 Coll., "The protection of public health and amending certain related laws" was adopted in 2000. In connection with this Act, was adopted also Government Decree No. 502/2000 Coll., which has been amended several times, first in 2004 (No. 88/2004) and then in 2011 with the adoption of Regulation No. 272/2011 Coll., "On health protection against adverse effects of noise and vibration".

This Regulation shall set maximum allowable sanitary noise limits in the protected interior of buildings, protected structures outdoors and protected outdoor space.

An important term is the old noise pollution. Old noise pollution is understood such a state of noise from transport, which occurred before the year 2000, ie before the adoption of Act No. 258/2000 Coll.

## 4. DIRECTIVES ON INTEROPERABILITY

The term interoperability is defined like the ability of the rail system to allow safe and uninterrupted movement of trains and it is clear that it means integration of the railway system. In the rail sector interoperability is a European Commission initiative to promote a single market. There have been several directives adopted by the European Council since 1996.

Very important documents in the fight against noise is the EU Directive 2000/14/EC relating to the Harmonized noise emission of machines, products and equipment and Directive 2002/49/EC on the assessment and management of environmental noise, known abbreviation END (Environmental Noise Directive). The aim of this Directive, which the EU Member States adopted in the solution of acoustic conditions from long-term strategic perspective, is to provide a uniform procedure for long-term reduction of noise in the environment.

Other EU documents that are directly related to noise from rail transport were two key Directives - Directive 96/48/EC on the interoperability of the trans-European high-speed railways and Directive 2001/16/EC on the interoperability of the trans-European conventional rail tracks. The previous text shows that the first the high speed railways was dealt. The reason is that high speed lines are relatively new and still evolving.

These Directives were replaced by the Council Directive 2008/57/EC on the interoperability of the rail system and in 2011 were amending by the Commission Directive 2011/18/EU.

## 5. NOISE ABATEMENT MEASURES

Railway noise can be controlled at three different locations: at the source, between source and inhabitant and near the inhabitant. The first group of noise abatement measures is represented by the modifications to the vehicle, especially its retrofitting. Noise barriers represent a further possibility to reduce the impact of noise by preventing its propagation. This group of noise abatement belongs among the most common method using between the railway

lines and inhabitants. Finally, railway noise can be reduced near the inhabitant. The most common noise abatement from this group of measurements is the application of insulated windows or façade insulation.

There are two basic types of the noise abatement measures: the active and passive. Active noise abatement measures prevent the occurrence of noise itself, for instance the decreasing of speed limit or relocation of vehicles. These active measures can be broadly divided into four groups: measures urban, architectural, transport - organizational and technical.

Great emphasis is placed primarily on the technical measures that can be implemented directly on the rolling stock or railway track. Particularly rolling noise from freight transport is a major source of rail noise. This kind of noise source is created by rough running surfaces of wheels and tracks. The commonly used iron brake blocks during braking influence the wheel and track surface and cast its roughness. The solution is the use of composite brake blocks of materials that will reduce rolling noise by up to 50 %. Despite the obvious merits the replacement of brake blocks brings considerable investment costs.

Currently are using two types of brake blocks, type "K" and type "LL". The key role plays also the effort to keeping the surface of wheels and rails in good state. It is necessary to apply measures to achieve smooth running surfaces on the wheels and on the tracks. We are talking about the principle of “smooth wheels on smooth rails”.

Among the technical noise abatement measures implemented directly on the vehicle belongs abovementioned retrofitting with K-blocks and LL brake blocks and also the wheel absorbers. Noise reduction potential of retrofitting is about 8–10 dB. Effectiveness of the wheel absorbers depends on local conditions, and reaches only 1–3 dB. There may be difficulties with maintenance of the wheel absorbers too.

Track absorbers and acoustic rail grinding belongs to the group of noise abatement measures applied on railway track. The effectiveness of both of these measures varies between 1–3 dB. While the measures implemented directly on the vehicle, reduce noise on an entire network, infrastructure measures have only local effect.

Passive measures are already limiting the resulting noise. A typical representative of this type of measure is the implementation of noise barriers, or noise insulated windows. Both of these measures have only local effect. Noise barriers also influence on railway maintenance procedures. Noise insulated windows reach efficiencies of up to 30 dB, but only when windows are closed. Summary of noise abatement measures is given in Table 2.

Table 2. Summary of noise abatement measures [author]

| Group of noise abatement measure | Location | Kind of noise abatement measure | | Effect |
|---|---|---|---|---|
| Active | At the source | Rolling stock | Retrofitting | Network wide |
| | | | Wheel absorbers | |
| | | Railway track | Track absorbers | Local |
| | | | Acoustic rail grinding | Local |
| Passive | Between source and inhabitant | Noise barriers | | Local |
| Passive | Near the inhabitant | Insulated windows | | Local |
| | | Façade insulation | | |

The effectiveness of the noise barriers varies between 5–15 dB and depends on the local geography and compliance with the design conditions which include:

- height of the wall,
- surface weight of 10 kg/m$^2$,
- enclosed area without any holes, gaps etc.,
- for long walls must be designed and implemented emergency exits,
- respecting of the engineering network,
- respecting of the architectural design of the wall, there should be the negative effect on landscape.

Noise barriers are undoubtedly a place especially in densely populated areas. In combination with other noise abatement measures, especially those at the sources of noise can achieve their smaller heights and lengths. This combination can save considerable funds.

In terms of economic efficiency should be preferred measures at the source, namely vehicles and tracks. The fact that noise barriers are not efficient according to cost - benefit analysis, was also the result of the project STAIRRS (Strategies and Tools that Assess and Implement Noise Reduction Measures for Railway Systems) [3]. This project was one of the major projects ongoing in the attic of the European Union.

The aim of the project was to evaluate the effectiveness of different measures that reduce railway noise. The main conclusion of this project was that retrofitting freight rolling stock has the highest cost effectiveness and the noise barriers have a low cost effectiveness.

Yet in Europe, including the Czech Republic, spend considerable sums on the construction of noise walls. Among the reasons why noise barriers are being favoured belong for example the separation of infrastructure and operations. This separation gives no motivation to look at the whole system. The next reason is political, because locally elected politicians favour local solutions. Last but not least, we should mention the philosophical obstacles. Noise barriers are more visible measure than retrofitting. There is also misgiving that the money planed for retrofitting will be used for anything else.

In the Czech Republic along the railway lines began to build noise barriers in the first half of the '90s, in the context of the modernization of railways. Another milestone came in 2006 when Regulation No. 148/2006 Coll. "On health protection against adverse effects of noise and vibration" was adopted. Until 2010 about 115 km of noise barriers has been built in the Czech Republic. Examples of noise barriers which are realized along railway lines in the Czech Republic are given in Figures 2 and 3. There is a new Act on Railways 134/2011 Coll. amending Act No. 266/1994 Coll. in the Czech Republic. This law, that implements European Union legislation, came into effect from January 2012.

Figure 2,3: Examples of noise barrier in the Czech Republic [author]

## 6. DISCUSSION

Noise of rail transport, particularly freight transport, significantly affects the lives of people around the transport infrastructure and it is therefore necessary to implement measures for its decreasing. Measures to reduce noise from railway transport can be either technical or legislative basis.

The first group of measures related to railway noise management involved [8]:

- Track type and quality – including wheel-rail rolling contact
- Quieter rolling stock and operation
- Railway structures and noise barriers
- Spatial planning and urban design
- Building insulation

The second group of measures is characterized by leading role of the European Union. One of the many activities designed to reduce noise levels of the population is to define its limits. The European Union can play a major role in reducing noise through legislation via interoperability directives and also via creation of technical standards for interoperability (TSI), which include noise standards for equipment and railway infrastructures.

When operating the trans-European conventional rail system must respect existing regulations on noise in accordance with Annex III to Directive 2008/57/EC. For the subsystem "rolling stock" is specified by Decision No 2011/229/EU four chapters - stationary noise, starting noise, pass-by noise and driver's cab interior noise.

## 7. CONCLUSION

Eliminate noise from rail traffic is necessary. Technical measures to reduce noise can be divided into two groups. Measures applied to the vehicle to reduce wheel roughness and other vehicle noise shall have effect throughout the whole network. These global actions impact on the all locations where trains are operated.

The second group of noise abatement measures consists of those measures that are implemented directly on the rail infrastructure or in its immediate vicinity, for example noise barriers. These local actions impact only on the location where the noise reduction measure is taken. For the most effective noise decreasing is necessary to focus on the global noise abatement measures.

If somebody compares different types of noise abatement measures, he has to compare the noise level reduction, costs and investors (who pay the noise level reduction costs). There are two main subjects – organizations in the railway sector: carriers and infrastructure managers. And each of them can do different types of the noise abatement measures. That is why all stakeholders on a railway transport field must cooperate. Very important is a public opinion and medicine research – noise impact to person health.

There are several cases – inhabitants in a railway line neighborhood protested against noise barriers – in the Czech Republic. The next interesting noise abatement measures point of view is railway transport safety. An experiment executes in the Czech Republic recently: If somewhere happened railway accident where noise barriers are along the railway line, rescuers does not able to cut an opening in the concrete noise barrier.

In conclusion is necessary to note that traffic noise from rail transport is the current issue that must be resolved. To design the optimal noise abatement measures is necessary to know the conditions of its emergence and propagation.

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