[1.]Ervin LUMNITZER, [2.]Beata HRICOVÁ

ANALYSIS OF RAILWAY NOISE EMISSIONS AND ITS VISUALIZATION

[1-2.]Technical University, Faculty of Mechanical Engineering,
Department of Process and Environmental Engineering, Košice, SLOVAKIA

Abstract: Environmental noise is inherently linked to various forms of transport, as well as other work-related or free-time activities. With the increasing intensity of traffic and the increasing rate of urbanization the impact of traffic noise is becoming even more pronounced, as it influences the quality of life and health of the population. One of the non-negligible partial sources of environmental noise is a rail transport. The paper presents the results of measurements of noise of passing trains, their visualization and evaluation. The paper also identified dominant sources of noise that contribute to the resulting noise emissions from rail transport.

Keywords: emissions, environmental noise, rail transport, visualization

INTRODUCTION

Nowadays, railway traffic noise is acknowledged to negatively impact the wellbeing of the whole community, particularly in urban environments. Unfortunately, the traditional approach to support decision making in noise reduction intervention seems to start only from the compliance to the regulations in place, rather than from the identification of an optimal trade-off between the cost of the annoyance of the community and the cost of the intervention.

The expansion of the existing route system for increasing freight transport and long-distance traffic as well as reactivating routes for communal or privately operated local public transport is moving into the spotlight of transport policy. Noise pollution frequently leads to considerable reservations among the population in this infrastructure plan particularly when freight transport is planned at night. To counter these reservations, ambitious goals were formulated for noise reduction of rail traffic. Innovative sound control measures and quiet vehicles are supposed to help the achievement of these goals. Especially in recent years, many technologies have been developed and tested which can be taken into account due to the introduction of the new calculation methods (Schall 03, CNOSSOS EU).

Rail traffic noise is made of 3 dominant components:

- aerodynamic noise,
- rolling noise,
- traction noise.

Aerodynamic noise dominates at speeds above 200 km.h^{-1}. Therefore, this kind of noise is nearly absent in the Slovak Republic. Significant noise sources at high speeds include a pantograph, uncoupled chassis and turbulence due to inappropriate aerodynamic shape of a vehicle. Traction engine noise dominates at speeds of up to 60 km.h-1 and its level does not change with the change of the speed. Significant noise emissions are produced by independent traction, where the drive vehicles are driven mostly by a diesel engine. In this case, noise emissions depend on the actual engine speed more than it is the case with electric traction. At certain speeds as well as at the start-up, noise emissions of traction vehicles using independent traction are significantly higher than when using electric traction.

In the range of about 60 to 200 km.h^{-1}, that is the medium speed (and in the vast majority of cases considered), **the rolling noise** generated by the interaction of the surface of the wheel and tracks. In extreme cases, the difference between the noise emitted by the rough track and the smooth track may be up to 20 dB. Another key contributor to the rolling noise is the roughness of circular surfaces of wheels. The main cause of wheel roughness is a brake with a classic cast iron brake pad. Carriages with the disc brake have smoother wheels and thus emit lower amounts of noise emissions. The permissible noise emissions of train sets are defined in Directive 2001/16/EC, the Conventional Rail Systems. The Directive covers the noise emitted by trucks, power-driven vehicles, complete units and passenger cars. The Directive is valid for the trans-European rail network. It also describes subsystems and outlines requirements for noise emissions. The basic subsystems are divided according to the emitted noise – road freight vehicles, units and trailers. The TSI noise subsystem contains requirements for acoustic parameters of vehicles while taking into account different types of noise.

ANALYSIS OF NOISE SOURCES OF PASSING TRAINS

The noise emitted by the train set can be divided into:

- stationary noise (when the vehicle is still),
- noise at the start-up,
- noise emitted by the vehicle at a steady speed,
- noise in the driver's cabin

Stationary noise is mostly caused by vehicle components such as compressors, cooling systems and air conditioning. Start-up noise is a combination of traction noise and rolling noise with the above components in use.

Noise emitted when the vehicle is passing along a fixed point is mostly rolling noise. The noise indicator is the sound level A - noise measured when the train passes, at the distance of 7.5 m from the track centreline, 1.2 m above the track.

In the following table we outline the limits for external noise emitted by a vehicle while passing along a fixed point:

Table 1. Limits for the fixed point

Type of vehicle	Allowed limits L_{pAeq} [dB]
Electric locomotives	85
Diesel - electric locomotives	85
Electric units	81
Diesel-electric locomotives	82
Personal carriage	80

According to the Directive, the operational and technical specifications of the railway noise are broken down according to the different types of noise.

MEASUREMENT OF VARIOUS PASSING TRAINS AND EVALUATION OF RESULTS

The measurement conditions were defined by the methodology developed on the basis of the Directive EN ISO 3095 in line with allowed deviations. An asserted descriptor is the sound level A.

— Placement of measurement points

The sound meters were placed in accordance with the TSI methodology for measuring train passes. The acoustic camera was located 16.5 m from the centre of the track and it was positioned so that the horizontal axis of the acoustic camera was parallel to the track and its centre was approximately 0.5 m above its level.

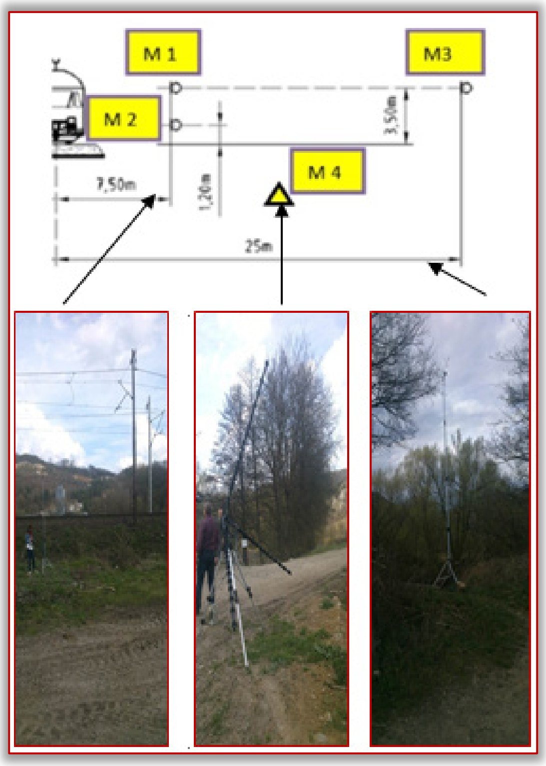

Figure 1. Location of measurement points

The measurement interval was selected according to the TSI parameters - the measurement starts at a moment the weighted sound pressure level A is 10 dB lower than the level found at the moment when the front part of the train is in front of the microphone; the measurement ends at a time the sound pressure level A is 10 dB lower than the level found at the moment the end of the train is in front of the microphone. The following figure shows an example of how a time interval, T, was selected for the entire train or a complete unit.

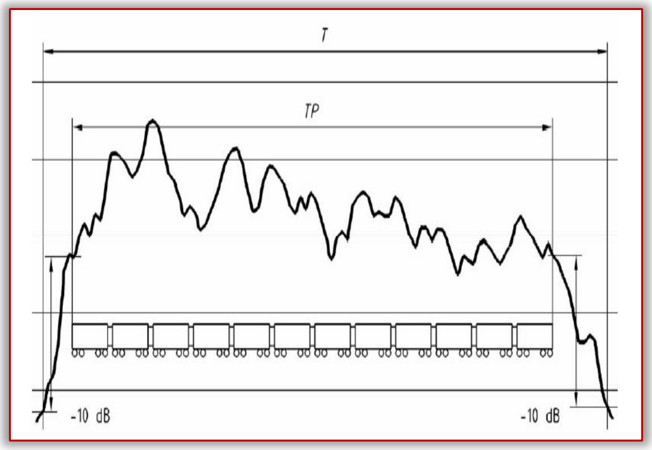

Figure 2. Selecting a time interval

When measuring trailers, the time interval T starts at the moment the centre of the first tested vehicle passes in front of the microphone and ends when the centre of the last tested vehicle passes in front of the microphone. Figure 3 shows the desired measuring time interval T after measuring individual trailer (at least two vehicles of the same type are necessary). In addition, the Figure also shows the time course of the equivalent sound level A when a train is passing.

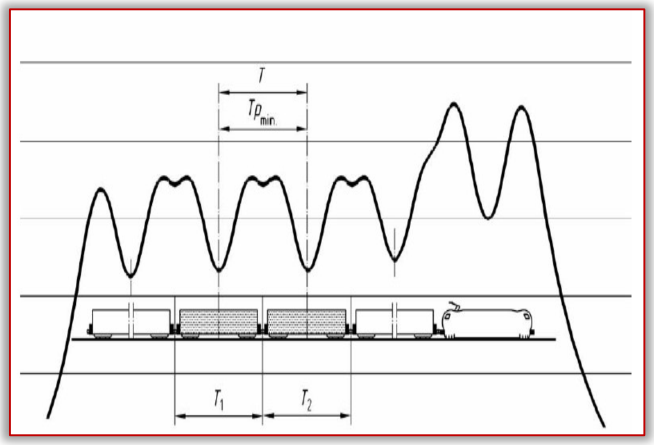

Figure 3. Time course of the equivalent sound level A

The time interval for specific measurements was determined according to the length of the set (number of carriages).

RESULTS OF THE PASSING TRAIN MEASUREMENTS

A number of measurements has been performed. The paper outlines only the results of one measurement - RegioJet train set. This train is pulled by the locomotive Škoda 163 and behind it are 10 new RegioJet - ASTRA carriages (Relax, Business, Standard and a carriage for parents with children). The track speed is 70 km.h^{-1}.

Figure 4 shows the results of the measurement of the RegioJet train. Figure 5 shows the course of sound pressure at the measuring point M1.

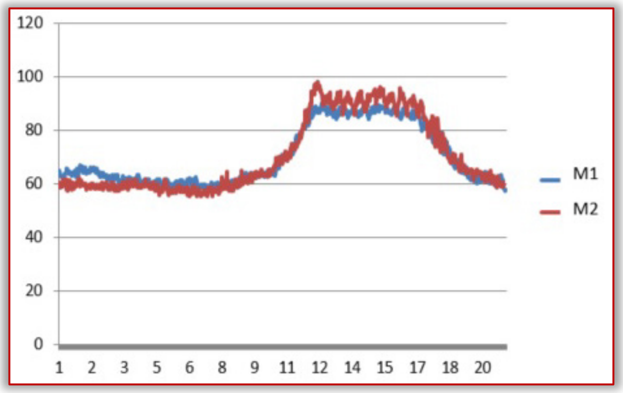

Figure 4. RegioJet passing

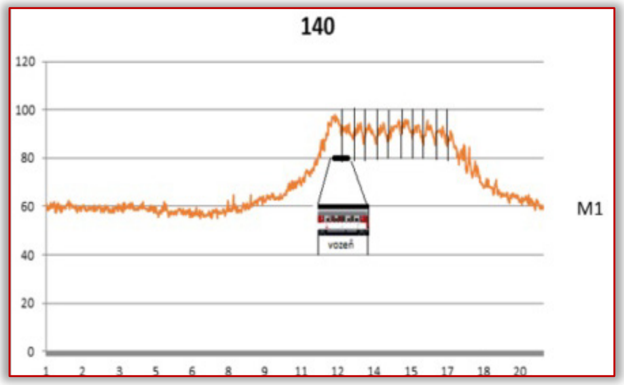

Figure 5. Acoustic pressure at M1

RESULTS OF SOUND VISUALIZATION

Sound visualization was performed using an acoustic camera. Figure 6 shows the frequency range of the train set.

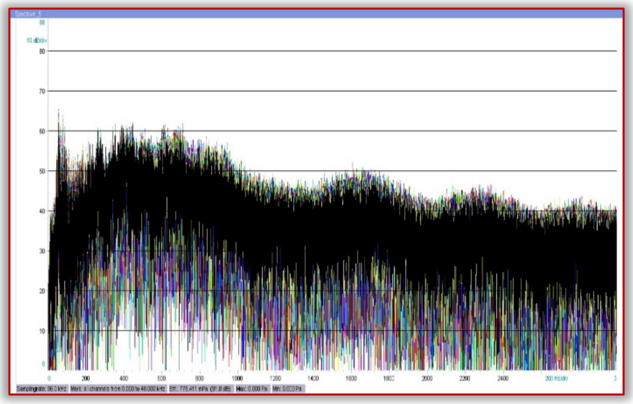

Figure 6. Frequency spectrum of the train set

The spectrum features values up to 65 dB in the frequency range of 40 to 80 Hz, and the subsequent increase in audible levels up to 60 dB in the frequency range from 300 to 600 Hz. These findings are also apparent from the spectrogram in Figure 7.

The highest emission values were recorded for the frequency ranging between 300 to 600Hz. The spectrogram clearly shows the passage of carriages and the locomotive. Interestingly enough, carriage emit different noise levels than the locomotive.

Samples of selected acoustic images are shown in Figure 8 - Figure 10.

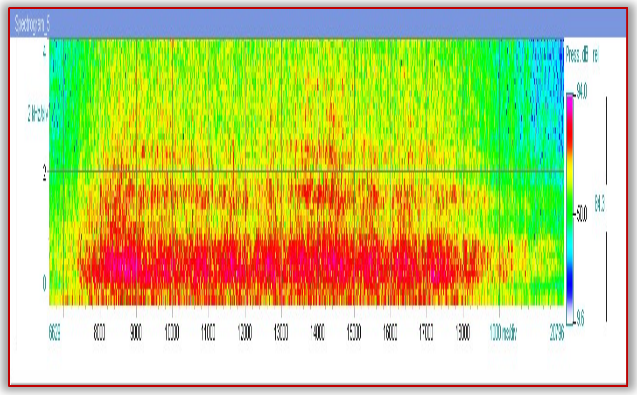

Figure 7. Spectogram of train passing

Figure 8. Acoustic image - rolling noise, 80 Hz

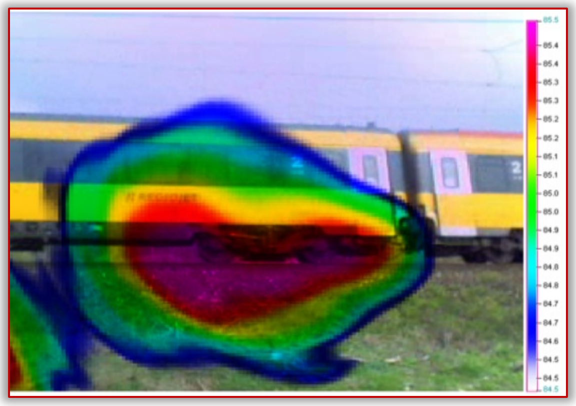

Figure 9. Acoustic image – chassis noise

Figure 10. Acoustic image – 380 – 400 Hz

CONCLUSION

The measurements showed discrepancies between real values and limit values set by Directives. This discrepancy was noted for passing locomotives as well as carriages. The measurements noted mainly rolling noise.

On the basis of these findings, it is necessary to focus mainly on the railway superstructure when designing measures regarding noise.

Acknowledgement

This research was supported by the research was carried out as part of the project KEGA 032TUKE-4/2018.

Bibliography

[1] Ervin Lumnitzer, Beata Hricová, Psychoakustické parametre železničného hluku, 2016. In: Fyzikálne faktory prostredia. Roč. 6, mimoriadne č. 1 (2016), s. 46-49.

[2] Ervin Lumnitzer, Beata Hricová, Miriama Piňosová, Acoustical parameters of the sound absorbents, 2015. In: International journal of interdisciplinarity in theory and practice. - 2015 Vol. 2015, no. 3 (2015), p. 16-20. http://www.itpb.eu/

[3] Úradný vestník Európskej únie, SMERNICA 2001/16/ES EURÓPSKEHO PARLAMENTU A RADY Dostupné na internete]: http://eur-lex.europa.eu/legal-content/

[4] Jarosław Zwolski, Noise and Vibration, http://www.zits.pwr.wroc.pl/zwolski/source/CE14_Noise&Vibration.pdf

[5] Petr Karván, Metodika pre meranie akustických parametrov vozidiel podľa TSI, Technická zpráva, Dostupné ma internete, http://www.mdcr.cz/

[6] Strategický plán rozvoja dopravnej infraštruktúry SR do roku 2020, [cit. 2015-3-20], http://www.zeleznicne.info/view

ISSN: 2067-3809
copyright © University POLITEHNICA Timisoara,
Faculty of Engineering Hunedoara,
5, Revolutiei, 331128, Hunedoara, ROMANIA
http://acta.fih.upt.ro