Assessment of track related noise mitigation measures

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Introduction

Noise is the big environmental problem of the European railways. As long as rolling noise is the main source such as for rail freight traffic during night time the noise problem is closely linked to wheel/rail interaction. Within the last two decades research on assessing and reducing rolling noise made big steps forward. Mitigation measures on both vehicles and tracks began to develop.

Among others, EU funded research projects such as Metarail and Stairrs [1] were able to improve the understanding of rolling noise generation and the factors influencing it. This knowledge flew into standards like the ISO 3095 [2] or the TSI Noise for Conventional Rail Systems [3] and represents the state-of-the-art of the acoustic assessment of rolling stock under type testing conditions. However, a standard for the type test of infrastructure components as rail dampers or rail pads is still missing and under development.

psiA-Consult has been working for several years for Austrian Federal Railways (ÖBB) Infrastructure to develop and assess new solutions and products to reduce rolling noise originating from the infrastructure and track. Within the framework of these activities an automatic monitoring system for railway noise and vibration generation has been developed. Some main features and results from a recent project investigating the rolling noise reduction from different rail dampers fixed to a track in a narrow curve will be presented here.

Standard measurement procedures

For the assessment of noise emitted by railbound vehicles, there are a number of (international) standards ([2], [3], [4]); however there is no corresponding counterpart for the assessment of infrastructure and track noise.

The absence of clear rules, particularly regarding the required sample size (recorded trains) and accuracy that can bee achieved leads to data that are incorrect or not comparable. Thus noise control measures at the infrastructure (e.g. rail absorbers, steel bridge improvements) are not assessed in the right way.

The CEN/TC256/WG3/SubGroup D has decided to cover the issue of measuring and evaluating railway infrastructure noise. However, it will take some time still before such a standard will in force. Until then we need intermediate procedures. The way road traffic noise community handles the problem can be used as a guiding line here.

Today two different procedures are used in the assessment of road traffic noise with regards to the road surface:

- Controlled passing level (CPB): A defined standard vehicle is used to measure the noise on different road surfaces. This method is proposed for example in the German guideline for assessing the noise emitted by road bridge junctions [5]. Applied on railway noise means that a reference vehicle or train must be available and run over different tracks while emission level are measured according EN ISO 3095.

  To determine the effect of the measure on the track for smooth and rough wheels, the reference train has to include vehicles with cast iron and K-bloc or disc brakes as well. Finally, it is essential that nothing changes the condition of the wheel between the different measurements. A single wheel flat in a reference train may spoil the results.

- Statistical passing level (SPB): If a reference vehicle or train is not available noise generation at different sites can be determined from pass-bys of ordinary trains of daily operation. This methodology is the standard for assessing the noise from different road surfaces [6]. The statistical pass-by method takes into account that different vehicle will emit different noise levels depending on maintenance status, tires, driving behaviour etc. Therefore, it is necessary to collect a “sufficient” sample to obtain statistical significance. What „sufficient“ really means has been defined for road traffic but isn’t for the railways.

Some examples

Sample size for SPB

The number of trains that can be caught in a one day measurement of 10 to 24 hours depends on the traffic density and the mix of train categories. Figure 1 shows the results of a measurement campaign over 3 respectively 7 days. Data has been acquired by an automatic measuring system. If we summarize levels by day we get reasonable differences.

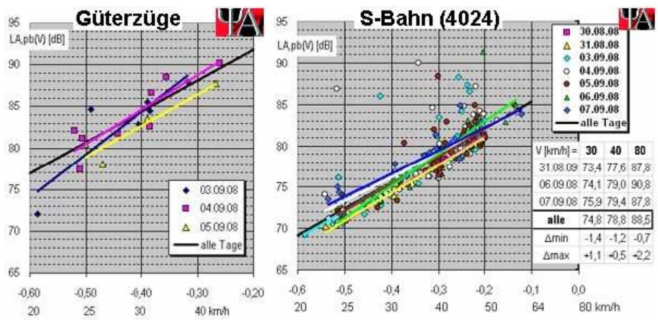

Figure 1 : daily and total average speed dependent pass-by level of freight (left) and S-Bahn trains (right)

A-weighted speed dependent pass-by level $L_{A,pb}(V)$ differs up to 3 dB if per chance we have been out for the measurement on day A or B!

If we assume that this random deviation will also occur after the noise reduction measure has been installed, we often have higher deviations than actual effects. Therefore, randomly we would conclude between has some negative effect up to has a big positive effect. In the first case the customer would be disappointed in the second he would be very happy for the while. However, these moods would not last for long since at a different application results could be different as well.

Assessment of statistical significance

The confidence interval is a statistical tool, which helps to assess the quality of measurement data. The 95% confidence is the area in which the actual average of all trains will lie with a probability of 95%. It is not possible to improve insufficient data by the confidence interval but the confidence interval gives a warning if data available is not adequate to draw the right conclusions.

Figure 2 shows the average level difference measured (yellow diamonds) for 3 train categories on 2 different tracks as well as the 95% confidence interval (red lines). The first train category (Kat.21) has an average improvement in A-weighted pass-by level $\Delta L_{A,pb}$ of 1,3 dB. The 95 % confidence interval ranges from 0,7 to 1,8 dB. This means that with a probability of 95% the actual improvement will be at least 0,7 dB and maximum 1,8 dB.

The average measured improvement for the second train category (Kat.12) is only 0,1 dB. The 95 % confidence interval underpins the conclusion that nothing changes dramatically since the "actual" improvement will lie between -0,2 and +0,3 dB with 95 % probability.

The average measured change was -0,2 dB for the third category (Kat.1), so the conclusion would be nothing changes really. If we look at the 95 % confidence interval we see, that the actual result will range from a reduction of +1,6 dB down to a 2 dB increase of pass-by level. The conclusion is clear from these results: with the data available we are not able to draw final conclusions.

Conclusions

The assessment of the acoustic impact of measures applied to the track or the rail is an important task at the moment. Industry is putting more and more products on the market that are supposed to reduce track contribution to total pass-by noise. Despite this demand for a clear regulation, how to measure and assess the noise emission from infrastructure components, there is no standard or guideline available for the time being.

The analysis of a number of measurements made by psiA-Consult leads to the following conclusions:

- A specific test train („golden vehicle“) whose acoustic and operational conditions are known and is the optimum for comparative measurements.
- If such a test train is not available, we have to use trains in the daily operation. Noise generation from vehicles in the daily operation will vary a lot. This means statistical significance only can be achieved if a sufficiently large sample of trains is available. In many cases a one day measurement with just few trains will not be satisfactory.
- The right number of samples collected is essential since level spread between trains of daily operation can range between ± 5 dB, while the effect of the measures often is in the range between 2 and 3 dB only.
- In former times, the collection of a sufficient number of pass-bys was too expensive due to the personnel costs. Today mobile multi-channel measurement systems such like ***acramos***® are available and can collect pass-by data for several weeks automatically at a low price. These systems collect noise and vibration data as well as Meta information such as train category, speed, meteorology etc. This exercise helps to get assessment right.

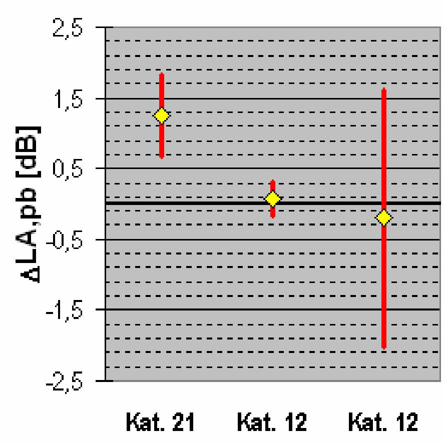

Figure 2: 95% Confidence interval of measured level difference of 3 train categories on 2 different tracks

References

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[5] Hamann-Consult (ed.): F&E-Projekt 15.402/2004/ARB „Aufstellung von Vorgaben zum Maß der Lärmminderung von Fahrbahnübergängen“: Kontrolliertes Vorbeifahrtverfahren; Dresden 2007.

[6] EN ISO 11819-1: „Messung des Einflusses von Straßenoberflächen auf Verkehrsgeräusche - Teil 1: Statistisches Vorbeifahrtverfahren“. Ausgabe 2001