Track decay rate of different railway noise test sites

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For noise type testing of rolling stock the vehicle shall contribute mainly to total pass-by noise. As a consequence a test track is needed, which radiate only little noise. There is an intensive discussion in the scientific community how to specify a low radiating test track. In prEN ISO 3095 as well as High Speed TSI the components that lead to a low radiating track are tightly specified. This approach is not entirely satisfying since it excludes a number of other track types, which are also low radiating but do not fulfil the design specification. Therefore a different approach using functional requirements is preferred.

1 Introduction

The decay rate of the rail vibrations is one possible indicator for the noise radiation of a track. There are two basic methodologies to determine track decay rate, the AEIF method and the TNO/PBA method.

In Dürnkrut/Austria, the Austrian Federal Railways (ÖBB) operate a noise test site that fulfils the prEN ISO 3095:2001 [1] and High Speed TSI [2] requirements. A number of measurements have proven that this test track is a low noise radiating one. With regards to the international discussion on the definition of a track specification the Dürnkrut test site was chosen to determine the vibration decay rate from frequency response measurements (AEIF method [3]) as well as from rail vibration measurements using TNO's PBA pass-by analysis tool [4]. Both results have been compared and set into relation with results from other tracks.

2 Measurement methodologies

2.1 AEIF methodology

AEIF has developed a methodology to measure the vertical and lateral decay rate by banging the rail (without static pre-load) with an impact hammer and measuring the vibration response in different distance from the impact point. This methodology is now under discussion to be included in the type-testing requirements for EN ISO 3095 ([3]).

Measurement of the hammer impacts on the rail means access to the track and can be completed within about 1 hour if the track is closed. However, we performed this measurement also between train pass-bys but this procedure increases time needed depending on train density.

The processing of the vibration data gained is very time consuming since it has to be done manually so far. For each of the nineteen 3rd octave bands in the frequency range of 80 to 5000 Hz an average of ten horizontal and lateral impacts at no less than twenty impact positions have to be analysed to end up with a valid indicator for decay rate.

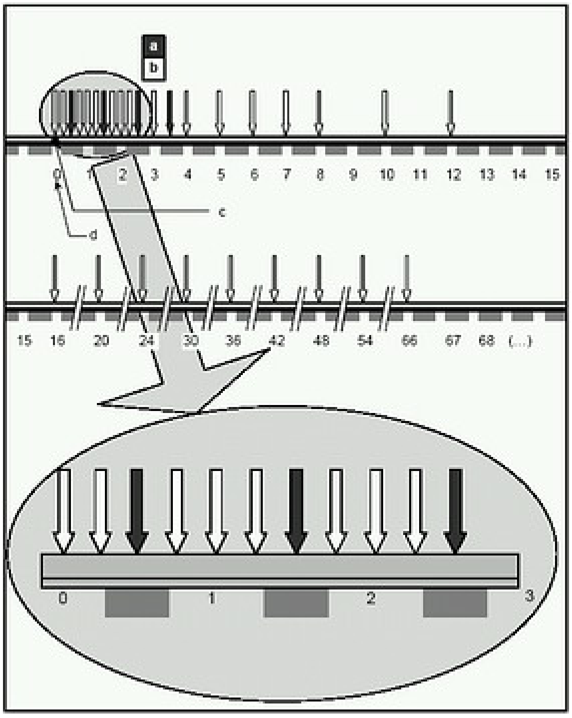

Figure 1: track decay rates – set of locations of excitation in reference to the fixed response point: **a.** hammer impulse over the sleeper, **b.** hammer impulse in between the sleepers, **c.** accelerometer position, **d.** inter-sleeper index [3]

2.2 TNO/PBA methodology

The TNO method is included in the PBA software tool and calculates the decay rate of the track from the vibration signal of trains passing by (pre-loaded track). At least two accelerometers mounted on the rail to detect the vertical rail foot and the lateral railhead vibrations. For this method about ten to fifteen train pass-bys are needed. There is only short access to the track needed to mount and dismount the accelerometers. The recordings of the vertical and lateral track vibration are done from outside the track.

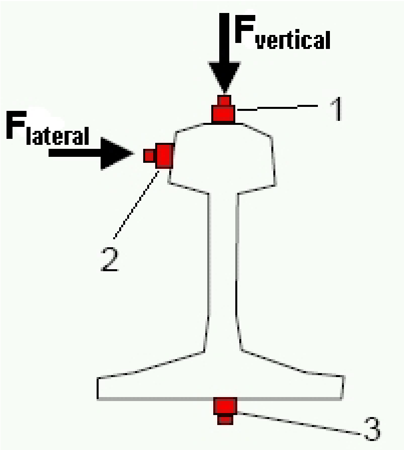

Figure 2: accelerometer positions on the rail cross-section; AEIF method: 1 or 3, 2; PBA method: 2, 3

The data processing is performed by the software tool and thus is less time consuming and less expensive than for AEIF method. Analysis of the ten to fifteen vibration recordings can be completed within few hours while AEIF method needs few days (without specific analysis software).

3 Results

3.1 Comparing the methodologies

psiA-Consult GmbH has applied both methodologies at the ÖBB noise test site in Dürnkrut. The test track there is a ballasted track with mono-bloc concrete sleepers without sleeper pad, stiff rail pads and VA 71b rail. This rail has been developed by Voest-Alpine Rail Company as a low noise radiating one. The overall shape of the VA 71b rail, namely the height, rail foot width and railhead dimensions are the same as UIC 60 type only the rail web is wider to be less noise radiating. This track type fulfils the requirements for noise test tracks according High Speed TSI [2].

The result of the comparative decay rate measurement is displayed in figure 3. The two dark blue lines represent the vertical vibration decay rates for the test track. White squares mark the decay rate according to PBA method while blue squares mark the decay rate measured by the AEIF method. We can see that the PBA decay rate tends to be about 5 dB/m higher than the AEIF decay rate.

3.2 Results from different track types

Figure 3 shows the results of PBA vertical decay rate from 2 more track types used by the ÖBB. The red line displays the decay rate of the standard ballast track with mono-bloc concrete sleepers, Vossloh fastener and UIC 60 rails. The magenta line represents a test track with bi-bloc concrete sleepers, Nabla fasteners and UIC 60 rail as well. The mono-bloc track has a very similar, however little lower decay rate than the VA71b track. That is not surprising since the overall construction of both tracks is more or less identical. The only difference refers to the rail profile.

The decay rate of the bi-bloc track is significant lower than the rest mainly in noise sensitive frequency range of 800 to 1600 Hz. Nevertheless, results from pass-by noise measurements showed almost the same noise levels for both disc and cast iron block braked vehicles.

4 Conclusions

The last draft of the CEN/ISO 3095 makes the AEIF methodology mandatory for the measurement of track decay rate. However, comparative measurements demonstrate that there are also other, sometimes more practical and convenient ways of determining the decay rate of a track from vibration analysis of a train passing by.

AEIF methodology is a very time consuming procedure and has to be done manually so far. Whereas the PBA software developed by TNO during the STAIRRS project calculates the decay rate of the track from the vibration signal of accelerometers mounted on the rail when a train passes by. For this method about 10-15 train pass-bys are needed. The data processing is done by software and thus is less time consuming and less expensive than for AEIF method.

The essential technical difference between the 2 methodologies is the pre-load of the track. AEIF method measures the decay rate of track without any preload while PBA method analysis data of a track with static (train weight) and dynamic (pass-by) pre-load of track. Since dynamic track properties often are highly non-linear any method including static pre-load will come up with more authentic results.

References

[1] prEN ISO 3095:2001: Railway applications – Acoustics – Measurement of noise emitted by rail bound vehicles. Draft standard 2001-02

[2] High Speed TSI: Commission decision of 30 May 2002 concerning the technical specification for interoperability relating to the rolling stock sub-system of the trans-European high-speed rail system referred to in Article 6(1) of Directive 96/48/EC (2002/735/EC).

[3] CEN/TC256 WI201: Railway applications – Noise emissions – Characterisation of the dynamic properties of track sections for pass-by noise measurements. Working paper 2005-06

[4] Dittrich, M.G.; de Beer, W.J: Acoustical characterisation of rail vehicles and tracks

[5] Dittrich M.G.: The Applicability of prEN ISO 3095 for European Legislation on Railway Noise, TNO/TPD report , Delft 2001

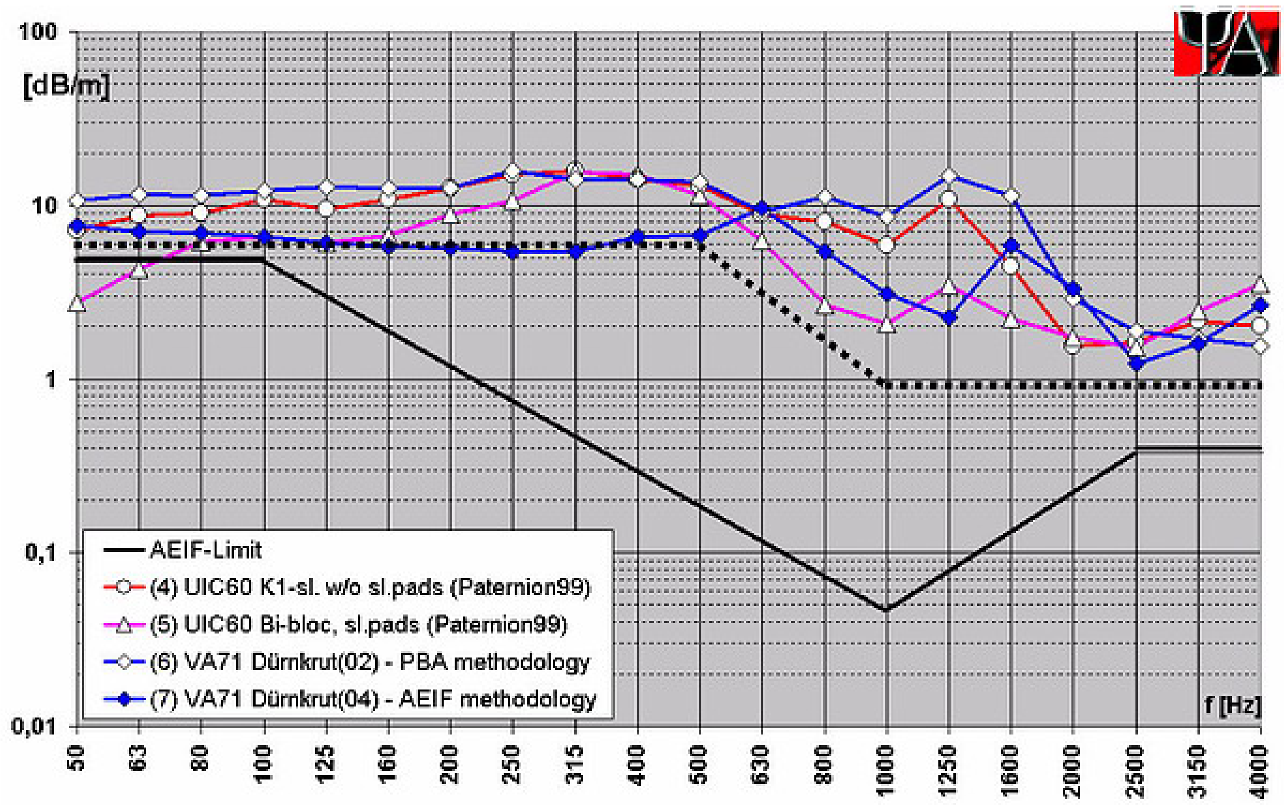

Figure 3: vertical decay rate processes according to AEIF method (7) and TNO/PBA method (6)