

Reduction of Freight Train Noise: Wheel Absorbers are Entering the Real Operation Phase

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ABSTRACT

Freight train noise is still the main annoying kind of railway noise. The launch of composite brake blocks has shifted the need for further measures by about ten years into the present days.

However, freight train operation is determined by very different constraints compared with passenger traffic. The main feature is that no freight would pay a higher price for travelling with a silent train. Therefore, the implementation of any measure must be triggered and supported by an external support, usually a public authority.

At first, the general absorbing principles together with technology constraints are shown, followed by an assessment of the operational usability.

The operational conditions are leading to highly increased requirements on the mechanical strength of the wheels. Also, the resistance to chemical impacts became important when the related loads are carried.

A very special condition is a high temperature load up to 500 °C at the wheel tire.

Schrey & Veit has started the setup of freight wheel absorbers in about 2000, keeping the principle of the wheel specific tuned mass-spring systems. GHH-Radsatz has set up a related wheel design. During a research & development project, funded by the Swiss Federal Office for Environment, an important step towards the real operation phase was taken. This includes design improvements as well as field measurements for the standardized benefit quantification. A benefit of 4 dB was proved.

The paper gives an overview on the current end user's view together with political/co-funding options, on the technical/acoustical requirements, on the development methodology and presents an example of a ready-to-market product. Additionally, today barriers for a widespread usage are summarized, leading to ideas on next steps.

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1. INTRODUCTION

In 2016, the Swiss Federal Office for Environment (Bundesamt für Umwelt [BAFU]) published the call for tenders “Bahnlärmforschung 2016” (‘Railway Noise Investigation 2016’) [1] on R&D activities aiming on the reduction of railway freight wagon noise. Improved vehicles have to reduce the rating noise level L_r (according Swiss LSV regulation) by at least 1 dB compared to the original vehicle. A consortium, founded by Schrey & Veit (wheel damper production), Wascosa (wagon owner), GHH-Radsatz (wheelsets production) und Akustikberatung Wiemers (accredited test body), was awarded to set up and qualify these ‘silent freight wagons’.

The project aims on the development of a ready-to-market ‘silent’ wheelset type to refurbish existing block braked bogies. This allows many vehicles to meet the TSI Noise [2] limits without extensive refurbishment and cost afford, therefore reduced overall timelines are also able. Investment costs are mainly cut down due to the remaining usage of all brake components. This means, already changed brake blocks from cast iron to composite materials are not required to be changed again. Of course, the noise reduction from the brake block changing has to remain at the vehicle, both from financial reason (already made investments and vehicle classification at noise related track access charges) and also from public expectations.

Further noise mitigation measures are also possible, for example shielding (close to the bogie) or improvements at the wagon structure or bogie frame. More details and examples of measures are presented by Thompson [3].

2. STARTING POINT

In subproject B2 of the public funded project ‘Low Noise Train on Real Track’ („Leiser Zug auf realem Gleis“ [„LZarG“]) [4], wheel manufacturer GHH-Radsatz did extensive R&D investigations aiming on a noise emitting reduced freight train wheelset with wheel absorber. Different tasks had been worked on by GHH-Radsatz, Technische Universität Dresden and also Schrey & Veit (development of temperature resisting absorber). The new invented wheel design was named “BA 308”.

Inside the LZarG project, a set of 12 BA 308 wheelsets (including wheel absorbers) had been produced and were tested in Y25 bogies. Subsequent acoustic qualification measurements were executed two times: Initial measurements with the origin absorber design and a second run with an optimized absorber design. A reduction of the $L_{Aeq,Tp}$ according ISO 3095 [5] resp. TSI Noise of 3.5 dB was found. A third measurement run with innovative freight bogies DRRS 25L (instead of Y25 bogies) results in an increased noise reduction of 4.5 up to 5 dB.

After these measurements, a trial operation of more than three years at DB Cargo was started. Wagon type was a bulk freight vehicle of type Tanoos 896, shifting potash salt from Hamburg port to Zielitz. At running distances of 170 tkm for some wagons, no defects etc. are visible at the wheels. Thus, the general ability for operation was proved.

In this time the call for tenders “Bahnlärmforschung 2016” (‘Railway Noise Investigation 2016’) of the BAFU was published. This offered the chance to realize further improvements on the whole system. Main focus was laid on the corrosion protection at both wheels and absorbers. Also, the installation and deinstallation proceeding was improved. Therefore, repeated acoustic measurement runs became necessary.

The project funding enables the application of these wheelsets at two freight wagons. Hence, eight wheelsets had been produced and were installed in two container wagons of type “CTW light” Sgnss (bogie type Y25) of wagon rental company Wascosa.

To allow a fast loading, both vehicles were loaded with so called “E-type swap bodies” of the Wascosa flex freight system®. These open-roof swap boxes are designed for bulk loads.

Related to these boxes, the noise emission from the large steel plates had been a second focus of the project team. First trial tests of a vibrational isolation of the boxes from the wagon structure were executed. From these tests, an initial specification of the elastomer bearings was derived. Specific challenges are, beside the rough freight railway conditions, enormous load difference by a factor of about ten, combined with the absolute level of 15 t for the loaded box.

3. TECHNOLOGY AND DEVELOPMENT

The wheels are designed by innovative approaches in terms of weight, mechanical and thermal strength and also acoustic parameters, see Figure 1 left. The optimal combination of all parameters like shape, material and coating is leading to a maximum in availability, reliability and lifetime – with positive impact on the LCC. Of course, all relevant standards are met and therefore the homologation according TSI WAG [6] is confirmed.

The interfaces of wheel design BA 308 are compatible with standard freight wagon wheel sets.

Independent of the application, the purpose of “wheel absorbers” is the reduction of wheel vibration. In general, two common damping principles are applicable:

- absorption (by internal viscosity or friction)
- tuned mass damper

For these principles, different commercial products are available on the market. However, today none of these are in a widespread use in freight cars. To reduce the noise emission of the wheels effectively, Schrey & Veit vibration absorbers of type VICON RASA RSI (see Figure 1 right) are placed at the wheel rim. Here, the absorbers back are laid in a circular notch and are tangentially preloaded by screwing devices. This prevents the absorbers from losing the wheel contact, also at high mechanical impulses. Furthermore, the system can resist temperatures up to about 500 °C, caused by the block brake system, by avoiding any glued connection.

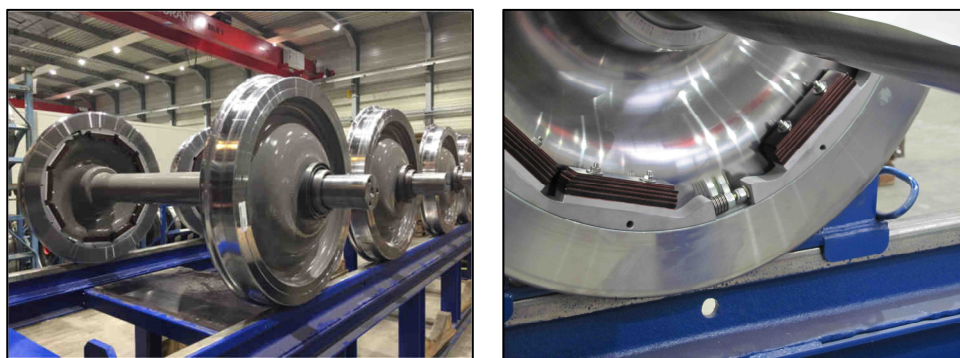


Fig. 1: Production of BA 308 wheelsets and absorbers VICON RASA RSI

Due to special selected materials the absorbers withstand high temperatures. In the related confirmation tests, their constant vibrational performance was quantified. From the results of a constant impact on the wheel vibration, it became clear, that neither the temperature impact nor the repeated load is limiting the absorber performance. However, the standardized temperature impact is linked to the long-time braking scenario at the Swiss Gotthard slope, which is today avoided due to the 2016 opened base tunnel.

4. MEASUREMENTS AND VALIDATION

According the call of BAFU, all project results have to be transformable to Swiss railway conditions. In general, the wheel together with the absorber, has free access to the Swiss railway network due to the conformity with TSI WAG (no additional national requirements). Thus, the acoustic performance validation was set up to meet Swiss conditions – but also standard condition should be considered for comparable results. Beside standard requirements (train speeds, acoustic free field conditions, measurements procedure etc.), two track related parameter are relevant: Roughness of the rail head and vibrational behaviour of the whole track, quantified in the “track decay rate”. Both parameters have to be assessed according DIN EN 15610 [7] resp. DIN EN 15461 [8].

Further advantage of the standardized measurement conditions is the usability of the results for a technology qualification in public funding schemes. Examples are the German „Förderrichtlinie „TSI Lärm+“ of BMVI [9] or Swiss „Investitionsbeihilfe an besonders lärmarmen Güterwagen“ of the BAFU [10].

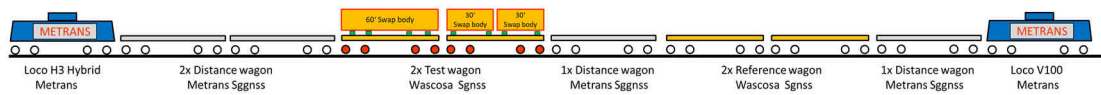


Fig. 2: Test train configuration, BA 308 wheelsets in red

Test sites which are meeting these demands, are seldom throughout Europe and mainly located at state railway networks with dense traffic. To enable a quick and flexible test operation, a ‘private’ network was preferred, considering the mentioned demands. Also, to assess the swap body isolation, a nearby station with crane access was necessary to place the boxes at test and also reference wagons. Furthermore, the cranes were needed to load and empty the boxes.

An appropriate site (see Figure 3 left) was found at the German Railway Network “Eisenbahn-Verkehrs-Betriebe” (EVB) between Bremen and Hamburg.



Fig. 3: Test runs (left: straight track, right: curve section)

Additionally, the impact of this wheel/absorber combination on the probability of curve squealing became relevant in the assessment process. This extended the mentioned test site requirements by the accessibility of a ‘sharp’ curve with similar acoustic conditions like free field. For this, a section with a 200 m radius double bended curve was found inside the nearby station, see Figure 3 right.

The test train (see above Figure 2) was arranged by each one locomotive at the train ends, the two test wagons and two reference wagons (similar type, but no improvement). For a trustable noise source separation, silent ‘distance wagons’ were located between each of the mentioned vehicle groups.

The TSI NOI refers to ISO 3095 for pass-by noise measurements. This standard specifies at least three pass-bys for each relevant train speed, here 80 and 100 km/h.

5. RESULTS

The acoustic performance of the improvement measure “wheel BA 308 together with absorber VICON RASA RSI” was assessed according DIN EN 3095 and therefore TSI NOI. All specification on free field condition, background noise, rail roughness and track decay rate had been met.

The reduction in $L_{Aeq,Tp}$ is 3.9 resp. 4.3 dB at 80 resp. 100 km/h at the wagon without any box/load (compared to the reference wagon, see Figure 4 left). If the wagon is loaded with the (empty) swap body, the reduction in $L_{Aeq,Tp}$ is 2.5 dB at 80 km/h. The reason can be seen in the additional noise emission of the swap body, covering the rolling noise.

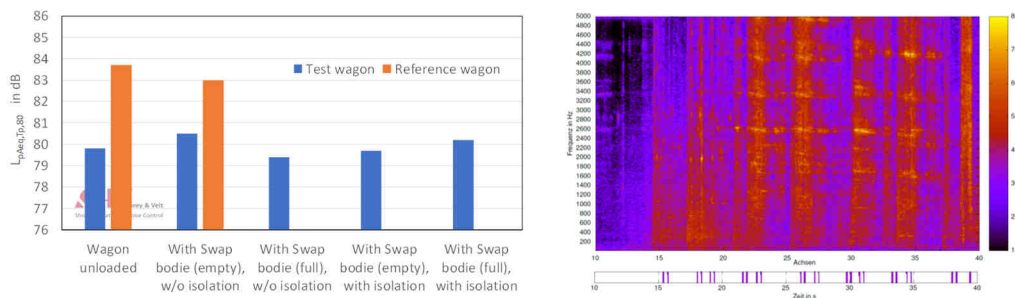


Fig. 4: Measurement results, left: straight track, right: curve section

Curve squealing test results are also showing advantages for the BA 308 wheel together with the absorbers: Compared to the reference wagons, which are starting to squeal at a speed of 20 km/h, the test wagons had shown no squealing (test speeds up to 40 km/h). Figure 4 (right) clearly shows the increased noise levels at the single time points and 2.6, 3.4 and 4.2 kHz, when the reference wagon wheels are passing the microphone. At the early passing times, no sound levels are emphasize compared to other frequency ranges. This confirms the expectation of squeal avoidance at this vehicle-track constellation. By a high possibility, similar results would be found at similar curved tracks.

Further tests aimed at the vibrational isolation of the swap bodies. Here, no significant difference in the $L_{Aeq,Tp}$ were observed. The marginal differences are also not plausible from the specific load scenario. This can point on only a small influence of the swap body emission on the overall noise level or the differences are in the range of the natural measurement uncertainty.

6. NEXT STEPS

The overall result is a rolling noise reduction of about 4 dB from the wheel type BA 308 together with wheel absorber VICON RASA RSI, assessed according TSI NOI conditions. This allows to get financial funding for the wheelset purchase from e. g. Swiss BAFU (see above). Due to the confirmed homologation according TSI WAG, the free operation at the European standard gauge network is possible. This is eased by standardized interface to the bogie structure.

The swap body noise emission was not significantly reduced. Further investigation in the vibrational interaction is necessary to understand the determination in the overall noise emission and to develop appropriate measures. However, the limited material assortment will be a challenge.

All eight tested wheelsets are in regular service since September 2017 at Wascosa freight wagons. This will lead to further operational experiences.

From the financial frame in the freight railway business, a stronger focus on supporting the real implementation of innovative measures is welcome. Only by this guidance the wagon owners are able to introduce innovations which focus on environmental issues improving instead of increasing the wagon profit.

5. ACKNOWLEDGEMENTS

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