The Whispering Train Programme

The search for effective and cost neutral noise reduction measures for existing freight wagons.

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Introduction

In the near future the growth of freight traffic on the European railways will be hampered by new regulations on noise emission. These measures are becoming more and more stringent. Freight traffic in particular produces a lot of noise, and it is growing fast in Europe! In order to keep environmental damage as well as road traffic chaos under control the new regulations are aimed at encouraging the general increase of freight traffic moves from road to rail. However, if the noise emissions of freight trains are not reduced, the growth of freight transport by rail will be hampered.

The new European TSI Noise sets strict limits for noise generation for new freight train wagons. As a result the use of composite K-blocks for new wagons has become standard. Composite blocks polish the wheel’s tread thereby reducing noise emissions. The life cycle of a freight wagon is rather high (more than 40 years) and the introduction of new – whispering – wagons will take a few decades. An adequate solution is necessary to reduce the noise of a complete fleet of existing wagons to the desired level in a short span of time. The use of K-blocks is, however, not very cost effective and it will take a long time to introduce them on existing wagons. To install K-blocks the brake system of the wagons must be modified. However, the newly developed LL-blocks are assumed to be able to replace today’s cast iron blocks entirely without having to modify the brake system. It is anticipated that the installation of LL-blocks will be an effective as affordable, measure for noise-reduction on existing freight-wagons.

To be able to introduce the use of LL-blocks as an effective noise reducing measure, the homologation of those blocks for international use in Europe is a requirement that has to be complied with first. But also more practical experience is needed on the operational behaviour under various conditions. More knowledge is necessary about the acoustical performance of those LL-blocks. But also the influence of the use of these blocks on safety and LCC is very important.

Therefore, all over Europe in-service tests with LL-blocks have been performed under supervision of the UIC. At the moment the Dutch Whispering Train program is contributing to this development by funding and executing a substantial part of all pilot projects with LL-blocks. Also in Germany, the government is planning to start a number of projects to speed up the development of composite blocks and solve some noise constraints in the Rhine valley.

The Whispering Train Projects

Especially in countries like the Netherlands, noise is a very significant problem. Therefore the Dutch Government has initiated the “Noise Innovation Program” in 2002. Within the framework of this programme six pilot projects were started in order to gain that desired experience on operational behaviour of composite brake blocks. Because of its experience in the management of these kinds of projects and its knowledge and experience on testing, engineering, life cycle costing and certification of railway vehicles, Lloyd’s Register Rail was contracted to do these projects.
In the Dutch pilot projects a number of wagons were equipped with noise reducing measures. ProRail (the Dutch infrastructure manager) Railion Netherlands and other European operators (Hupac, ACTS) and owners (AAE, VTG, Cobelfret) are participating in these projects. The Dolomite-Shuttle project was the first project and started in 2002. In this project K-blocks and wheel absorbers were installed on an existing fleet of 29 wagons (type: Tapps). A noise-reduction of 16 dB (A) was measured on TSI reference tracks. 2 dB (A) of the total reduction was ascribed to the dampers. In 2005 the program was extended with six other pilot projects to gain more experience in practice with LL-blocks. Nearly 200 wagons of different types were included.

Noise Reduction with LL-blocks

It has been determined that in this project that the effectiveness of LL-blocks to reduce noise is 7 to 9 dB(A) on a track with average rail roughness, which is comparable to that of K-blocks. This has been found out in a series of sound measurements on several wagons equipped with LL-blocks. This sound measuring program was set up in such a way that it could be determined:

- If the noise reducing effect of LL-blocks could be determined on different types of wagons (in comparison to cast iron braked wagons)
- If differences in noise reducing effect of several kinds of LL-blocks could be determined
- If any potential degradation in the noise reducing effect of the LL-blocks could be determined
- How much time is needed before the smoothening effect of LL-blocks appears on rough wheels. This is measured to determine if it is possible to retrofit a wagon without reprofiling the running surface.

The sound-measuring programme was performed by TNO on two test trains. The first test train consisted of 3-axled freight car transport wagons (type LAEKS), the second of 4-axled container wagons (type SGNS). The train composed of LAEKS wagons is being measured five times during one year to monitor changes in the noise emission and wheel roughness over time. The train composed of SGNS wagons was measured only once.

All the measurements were performed on a normal service track with concrete monoblock sleepers, stiff railpads and rail roughness compliant with EN ISO 3095 at a site between Roosendaal and Bergen op Zoom. The pass-by sound pressure levels and the total effective roughness of all the wagons and all the test runs were determined from sound measurements using TNO’s Pass-by Analysis technique (PBA). To date, measurements have been repeated four times for individual LAEKS wagons. The mileage of all wagons in between the measurements was registered.

The pass-by levels of the LAEKS wagons averaged over all runs at 80 km/h at 7.5 m distance from the track centreline was found to be 90 dB(A) for cast-iron block braked wagons and 82 dB(A) for LL-block braked wagons (see Fig. 2). For the SGNS wagons, the average measured pass-by level at 80 km/h at 7.5 m was 93 dB(A) for the cast-iron block-braked wagons, for the LL-block-braked wagons reductions of 7 to 9 dB(A) were found at different speeds. The higher overall dB(A) levels for the SGNS wagons can be explained by the difference in axle density. Lower

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1 Dutch organisation for Scientific Applied Research
levels can be expected on smoother tracks and if the wheels are reprofiled and subsequently run in.

Figure 2 Level history of the A-weighted sound pressure level of the LAEKS test train at 80 km/h measured at 7.5 m from the track centreline, on concrete-sleepered track

On average, pass-by levels of the LL-block braked wagons measured were found to be 7 to 9 dB(A) lower than the cast-iron block-braked wagons on a track with average rail roughness. Observed differences in pass-by levels are consistent with the differences in roughness levels. The C952 brake blocks tend to be around 1-2 dB quieter than the J777 blocks. Compared with K-block braked vehicles, the results are similar for tracks with an average rail roughness level.

The observed pass-by levels of the wagons with different types of LL-block are similar, to within about 2 dB. The spectra for the total roughness levels are similar in level and shape. This is the case for retrofitted wagons with reprofiled and non-reprofiled wheels.

Comparison of measured noise levels over time revealed a fast smoothening effect of the LL-blocks on the wheel surface, after relatively low mileage of the wagons since retrofitting. So far, the observed noise reduction of LL-blocks seems to be retained over time.

Comparable noise measurements were done on a TSI reference track very recently. It was confirmed by those measurements that the pass-by levels of the LAEKS wagons was 82-83 dB(A); depending on the type of LL-block. The TSI Noise limit for retrofitted wagons with an axle density lower than 0.15 (like the LAEKS wagons) is 82 dB(A) for new wagons and 84 dB(A) for renewed or upgraded wagons [3]. This means that wagons with LL-blocks fulfill the TSI noise limits for upgraded wagons. Comparable results were gained with other types of wagons and other types of LL-blocks.

**Life Cycle Costs**

One of the main targets of this project is to determine the effects of the various noise-reduction measures on the Life Cycle Costs (LCC) of the wagons. LCC’s are of prime importance to operators or owners of wagons. The thickness of the brake block and wheel profile of the test wagon wheels were therefore regularly checked. The measured wear can then be extrapolated to the lifespan of the blocks and wheels for cast iron, LL and K-braked wagons respectively. A LCC model, developed by Lloyd’s Register Rail, is used for this. By comparing the specific lifespan of blocks and wheels, the difference in LCC becomes evident.
It is a fact that the composite blocks in use (K and LL) have a longer lifespan compared to cast iron blocks. However, the initial purchasing costs of composite blocks are also higher in comparison to cast iron blocks, so that the actual cost of wear on brake blocks is cost-neutral. A difference in costs due to the periodic changing of brake-blocks is, however, not the main and most important fact influencing LCC. Since the maintenance costs of the wheelsets of a freight wagon is twice or thrice that of the blocks, a more thorough analysis of the behaviour of the wheels is called for.

The Behaviour of the Wheels

Use of composite blocks has a significantly higher wear on the tread of the wheel. As shown in Table 1, the abrasion of the wheels in the Dutch pilots is about 2 to 3 times as high when K or LL blocks are in use.

![Figure 3 LCC measurement on wagon](image)

<table>
<thead>
<tr>
<th>Wagon Type</th>
<th>Running capacity after Rebuild</th>
<th>Wear of Wheels with Cast Iron Blocks (Abrasion in mm per 100.000km)</th>
<th>Composite Blocks</th>
<th>Wear of Wheels with Composite Blocks (Abrasion in mm per 100.000km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAPPS</td>
<td>300.000 km</td>
<td>1.0</td>
<td>Cosid 810 (K)</td>
<td>3.6</td>
</tr>
<tr>
<td>LAEKS</td>
<td>70.000 km</td>
<td>0.8</td>
<td>Cosid 952 (LL)</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jurid 777 (LL)</td>
<td>2.2</td>
</tr>
<tr>
<td>SGNS</td>
<td>70.000 km</td>
<td>1.3</td>
<td>Cosid 952 (LL)</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jurid 777 (LL)</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Table 1 – Measured wheel abrasion with various block types

Figure 4 shows an example of the wear of wheel profile. There is a notable increase in the thickness of the wheel flange. In order to ensure that the wheels are not prematurely worn away, a wheel-profile with a reduced flange was used. It should also be noted, that after a longer run, hollow wear of the wheelprofile occurs due to higher wear on the tread. Because of the different wear of the two wheels of a wheelset it may even happen that the wheel diameter of one wheel differs from the other after some time. The combination of both phenomena may lead to an increase of the equivalent conical properties of the wheelset. Dynamic run simulations, which were carried out during this project showed that these changes in the contact geometry of wheel and rail can have an extremely negative effect on running stability. This could lead to increased wear of the infrastructure and vehicles. In extreme cases, it may increase the risk of derailment. However, internationally agreed limits on hollow wear and differences in the diameters of freight wagon wheels are as yet non-existent. They would, however, be worthwhile.
The higher wear on the tread also has some advantages. The wheels of the wagons in this programme are regularly measured by the wheel tread monitoring equipment “Gotcha”. This system, which is integrated at 41 points with the Dutch infrastructure and which was developed by Lloyd’s Register Rail, measures the tread characteristics and axle-weight of each wheelset on passing trains. Results show that wheels with K- or LL blocks have a significantly lower chance of developing tread defects, like irregularities, flat spots etc. Whenever flat spots appear, they are quickly reduced by the polishing effect of the blocks. And this is of great significance, as flat spots, whenever they occur, are counterproductive to the noise reduction effect of composite blocks. The increased wear also prevents spalling on the wheel tread due to metal fatigue.

The use of composite blocks greatly affects the wear mechanism, which results in due course in the operating limits of the wheels being exceeded. Table 2 shows the reasons for reprofiling of the Dolomite-Shuttle. While these wagons were still equipped with cast iron blocks there were various reasons for reprofiling them. When K-blocks were in use, excessive tread roll over (see figure 5) was the dominant wear-mechanism causing the limits to be exceeded.

<table>
<thead>
<tr>
<th>Reasons for reprofiling</th>
<th>GG-Blocks</th>
<th>K-Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat spots on the wheel</td>
<td>28 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Spalling due to rolling contact fatigue</td>
<td>16 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Wear of profiles</td>
<td>32 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Tread roll over</td>
<td>23 %</td>
<td>100 %</td>
</tr>
</tbody>
</table>

Table 2 Reasons for reprofiling

The shift in the reasons for reprofiling results in a shift in reprofiling periods. The maintenance of the wheels of the Dolomite-Shuttle was always defect-dependent. The average running capacity with cast iron blocks was 350,000 km, but there was a great variation in these figures. Some wheels were already reprofiled after 100,000 km, others only after 600,000 km. When using K-blocks, the average value decreased to 230,000 km, but with little variation in the figures. The wagons in this program equipped with LL blocks have, until now, been in operation for too short a time to draw any final conclusions. However, considering that their wear characteristics are similar to those of the K-blocks, similar results are to be expected.

This is a rather useful development, as the necessity for reprofiling will become predictable. This may actually reduce costs, since inspection costs can be limited as unplanned removal of wagons from service can be eliminated.
Not only has the wear of the tread determined the life cycle of a wheel, but also the decrease in diameter which occurs during reprofiling in order to bring the wheel back into shape. The installation of cast iron blocks requires, on average, a reduction of 13mm in diameter. With K-blocks, when following the usual procedure, an average of 9mm is taken off. Experience in this project has shown, however, that optimization is possible. Due to the change in wear it is no longer necessary to remove as much. Using intelligent methods, it should be possible to achieve an average decrease in diameter of only 2 to 4 mm. For wagons with LL-blocks, comparable results are expected.

Conclusions

As a centre of competence in railway technology and experienced in these kind of complex and innovative projects, Lloyd’s Register Rail is working on a series of pilot projects on noise reduction on existing freight wagons. In these projects is found out that to reduce noise levels of existing vehicles the use of composite brake blocks is very effective. The developed K-blocks are not so cost efficient for existing vehicles, since the brake system has to be modified. The results of the whispering train projects show that the newly developed LL-blocks are as effective as K-blocks in reducing rolling noise. Wagons with LL-blocks fulfill the TSI noise limits and thus the noise reduction targets will be met with the use of those blocks on freight wagons. But since the LL-blocks do not need any modification of the brake system, they are expected to be much cheaper to use.

The use of composite K and LL-blocks significantly influences the behaviour of wheels. Higher wear and more frequent reprofiling have a negative effect on LCC. However the maintenance of wheels can be better planned and optimisation of the reprofiling procedures is possible. Only if this possibility is used will LCC not increase. It should therefore be noted, that the use of composite blocks requires a different maintenance strategy for freight wagons, which must affect the workshops. Lloyd’s Register Rail has the knowledge and experience to survey the consequences of new innovations on the LCC and the maintainability of railway vehicles. It will use this to help fleet owners and operators of freight wagons to reduce noise emissions of their vehicles.

*For more information on this program, please refer to [www.whisperingtrain.eu](http://www.whisperingtrain.eu)*