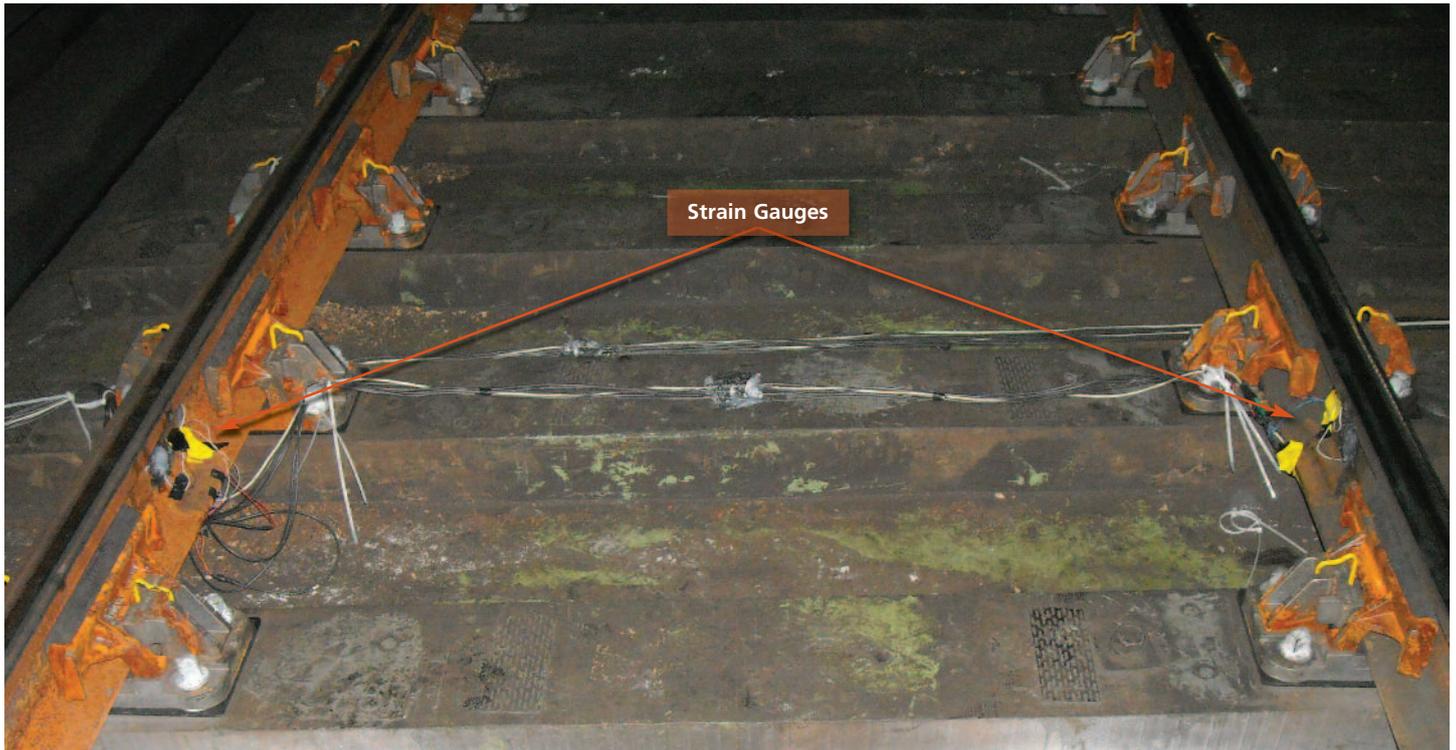


# VANGUARD on São Paulo Metro, Brazil

Vibration and Secondary Noise Reduction with PANDROL VANGUARD



The PANDROL VANGUARD fastening system was recently installed in a section of Line 1 on the Metro São Paulo in Brazil. A total of 1,600 units were installed, 900 on concrete slab track and 700 on timbers (embedded in concrete), substituting Landis and Vossloh plates respectively.

As part of the homologation procedure requested by Metro SP, vibration measurements were performed on the track and in nearby buildings both before and after installation of the VANGUARD fastenings (Figure 1).

The section where these fastenings were installed is a slab track without floating slab or ballast, therefore any reduction in vibration is due exclusively to the performance of the fastenings. Alongside the vibration reduction requirement, the track gauge had to be guaranteed, even in extreme conditions, such as when rails break.

In order to prove the performance of the fastenings, trials in the track under loaded

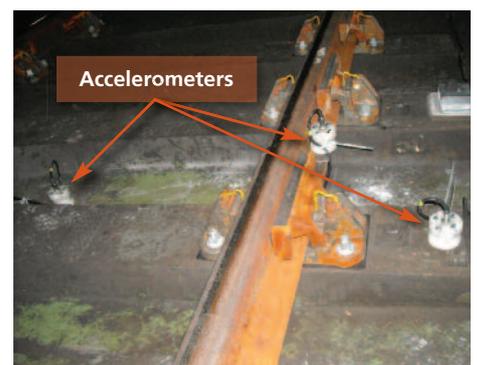
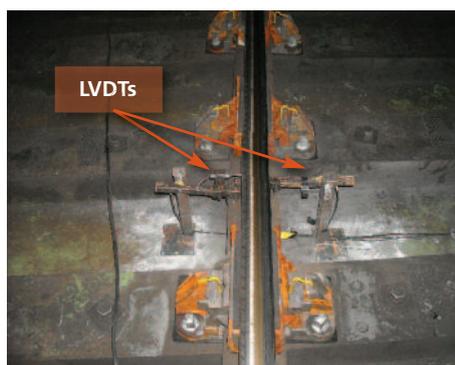


Figure 1 Track measurements

trains, and measurements in nearby buildings were performed as part of an extensive investigating program. In addition, a computerized numerical model was prepared to simulate a rail break. The aim of the trials was to measure the acceleration against the time, the speed and sound pressure level in the frequency field.

As well as vibration trials on the track, rail strains, vertical and horizontal displacement, gauge widening and dynamic stiffness were recorded. These measurements were used in the numerical model, based on finite elements, for the case of a supposed accidental rail break.

## NUMERICAL MODELING

The first step for analysis is to establish the dynamic stiffness of the track. This was derived from the rail foot strain and the "Beam on Elastic Support" theory by an interactive process. The result was a vertical axle load of 15,5 ton. For this load, the maximum vertical displacement between two fastenings with a spacing of 750mm was 4,38mm downwards, as shown in Figure 3.

Also, it is very important during fastenings homologation to satisfy the requirement for gauge widening (lateral displacement) which is limited to 3mm in normal working conditions. With PANDROL VANGUARD the gauge widening measured obtained in the trials was approximately 1,2mm, complying perfectly with the requirement.

Now simulating the accidental rail break between two fastenings (Figure 2), the gauge widening predicted by the numerical model was around 8,00mm. So for this safety critical factor, a horizontal strength equal to 15% of the vertical strength was derived, which was also deemed acceptable.



Figure 2 Broken rail simulation

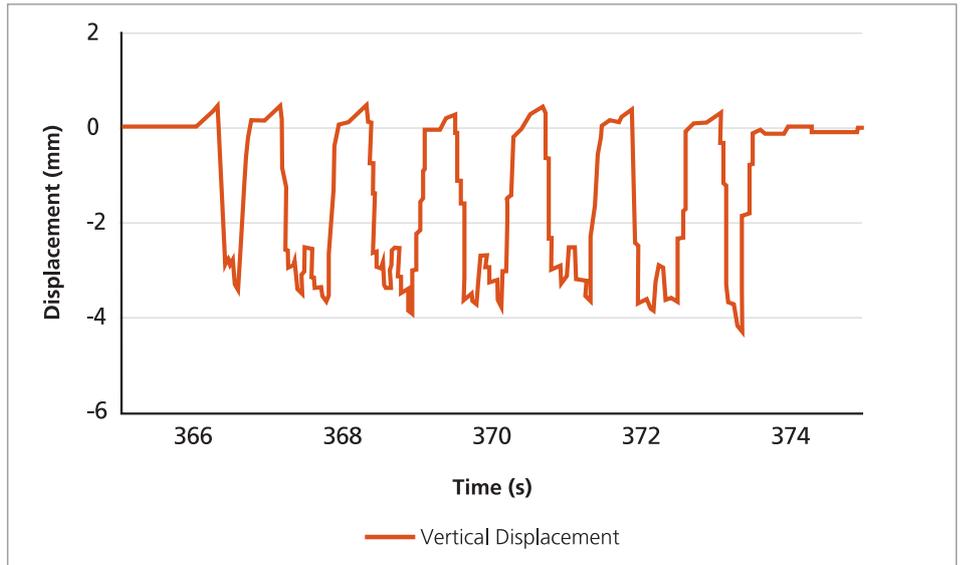


Figure 3 Regular rail displacement

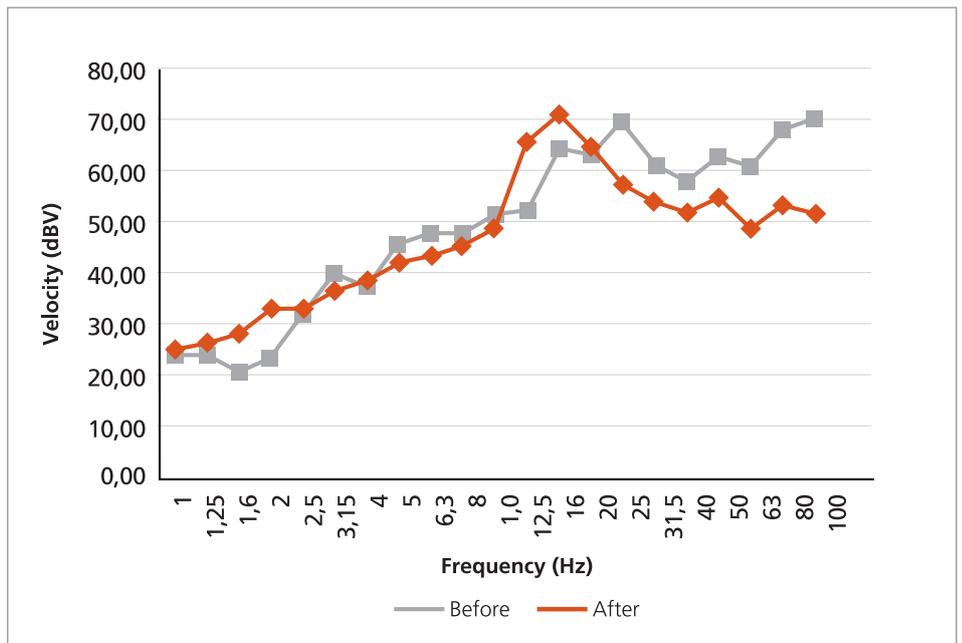


Figure 4 Vibration measurements

## CONCLUSION

One of the main reasons to change the original fastenings to PANDROL VANGUARD was the high vibration level. That was around 78,8dBV at 25Hz in the nearby buildings, at 25 meters from the tracks. After the VANGUARD installation, the global vibration level was reduced to 66,2dBV at the same frequency and location (Figure 4).

Regarding the secondary noise measured in the nearby buildings, the trial results showed that after installation of PANDROL VANGUARD, the noise measured was less than the limit value given in Brazilian law.

A final analysis was possible regarding the

natural frequency of the system before and after. Prior to replacement, the natural frequency was approximately 25Hz. After, the natural frequency changed to approximately 16Hz as a result of the lower track stiffness, causing a vibration diminution in frequency bands between 16Hz and 25Hz that was not previously present.

Based on the obtained results, it can be concluded that PANDROL VANGUARD showed a fully satisfactory performance. ■



Fig 5 Finished track