SYOPE® APPLICATIONS FOR HIGH SPEED AND REGIONAL TRAINS: DEVELOPMENTS AND FEEDBACKS

Cervello, S[1], Bracciali, A[2], Borrelli, A[3], Manzi, N[4], Mancini, G[5], Neri, S[5], Chiusa, M[6]

[1] *Lucchini RS SpA, Lovere, Italy*
[2] *Università di Firenze, Italy*
[3] *Circumvesuviana srl, Napoli, Italy*
[4] *Alstom Ferroviaria SpA, Savigliano, Italy*
[5] *Trenitalia SpA, Firenze, Italy*
[6] *SAD SpA, Bolzano, Italy*

INTRODUCTION

Lucchini started the development of low noise Syope wheels around mid nineties and the product is now spread on different rolling stock typologies.

This paper reports about the noise levels obtained with some recently entered in service rolling stock for high speed and regional trains, focussing on the application of a derived concept that originated the Syope Braw® wheel.

At the last International Wheelset Congress in Prague the story of the Syope (damped wheel) developed by Lucchini Sidermeccanica was described and their use rapidly grew also thanks to the positive considerations on Life Cycle Cost published there.

At that time there were still some open applications and projects that this paper will report on:

- feedback from Circumvesuviana railway in Naples about the application of Syope wheels on the narrow-gauge EMU manufactured by Firema;
- feedback from Italian Railways (Trenitalia) about the application of Syope on high speed (250 km/h) ETR600 Pendolino trainset manufactured by Alstom Ferroviaria;
- feedback from SAD (Ferrovia della Val Venosta, Italy) about the application of the Syope Braw disc-braked damped wheel on the regional GTW2/6 DMU manufactured by Stadler.

THE APPLICATION OF SYOPE WHEELS TO ETR600/ETR610 TRAINS

During 2008 and 2009 the tests on the new tilting train manufactured by Alstom Ferroviaria for Trenitalia and SBB were conducted.

The European Directive on the Interoperability of Rolling Stock (2008/232/CE, TSI – Technical Specifications for interoperability – High Speed) requires that the A-weighted equivalent level averaged over the buffer-to-buffer distance ($L_{eqA,Tp}$) of a high speed train measured at 25 m from the track axis and at 3.5 m from the top of rail should be $L_{eqA,Tp} \leq 87$ dB(A) with 1dB tolerance.

Tests were conducted by the Technical Division of Trenitalia on the TSI-compliant site in Anagni, on the high-speed line Rome-Naples. The results of the pass-bys at 250 km shown in Figure 1, Figure 2 and Figure 3 show that the train fulfils the requirements of the European directive as the average of $L_{eqA,Tp}$ is equal to 87 dB(A).

The Italian law in force (DPR 458 of 18.11.1998) requires that the maximum A-weighted level measured with the "FAST" time constant of the sound level meter ($L_{pAmax,F}$) is such that $L_{pAmax,F} \leq 88$ dB(A) at 250 km/h for rolling stock built after year 2002. Also in this case the regulations are satisfied.

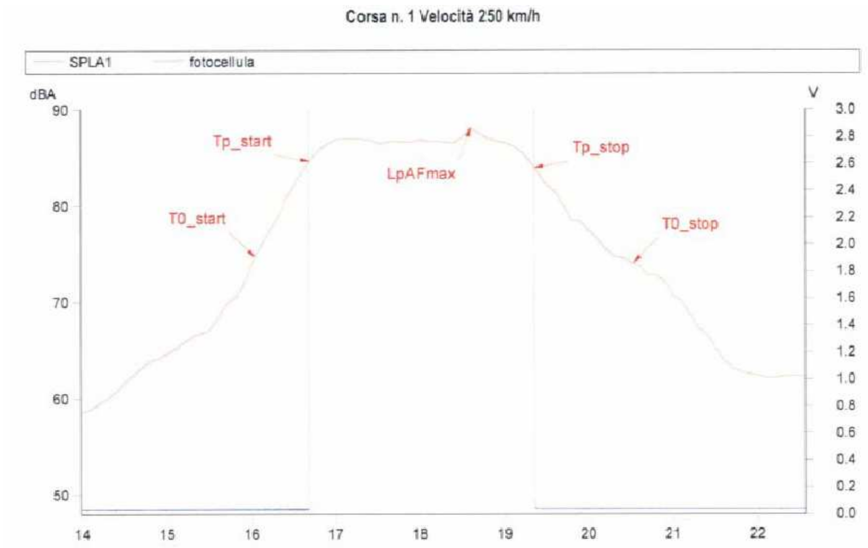


Figure 1: pass by number 1 in Anagni at 250 km/h. $L_{eqA,Tp}$ = 86.7, $L_{pAmax,F}$ = 88.1 dB(A)

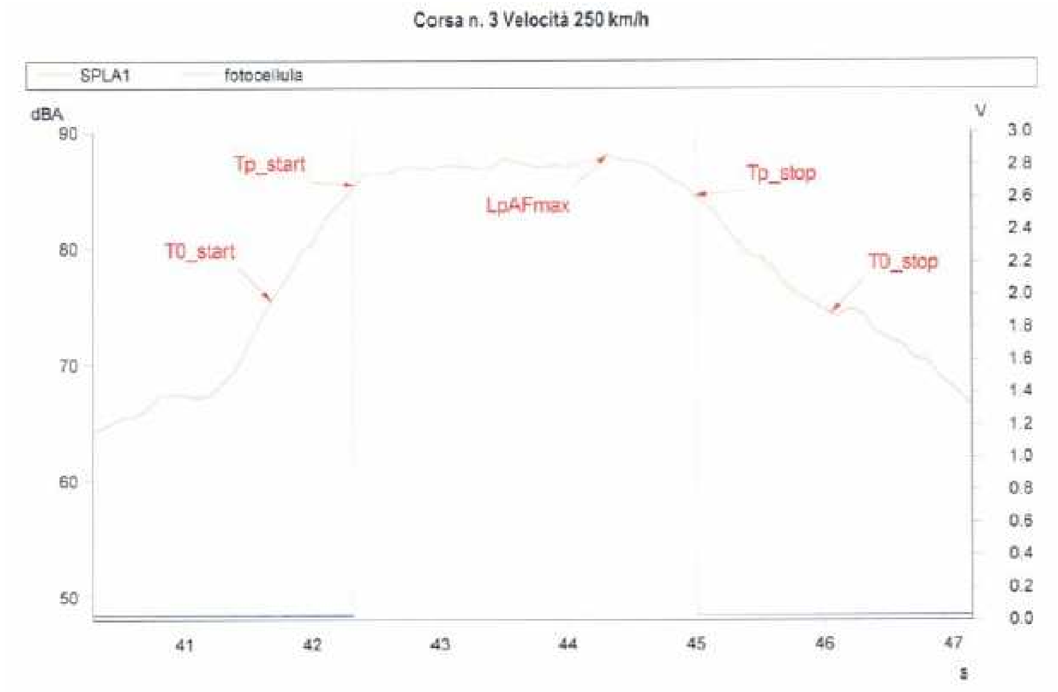


Figure 2: pass by number 2 in Anagni at 250 km/h. $L_{eqA,Tp}$ = 87.1, $L_{pAmax,F}$ = 88.1 dB(A)

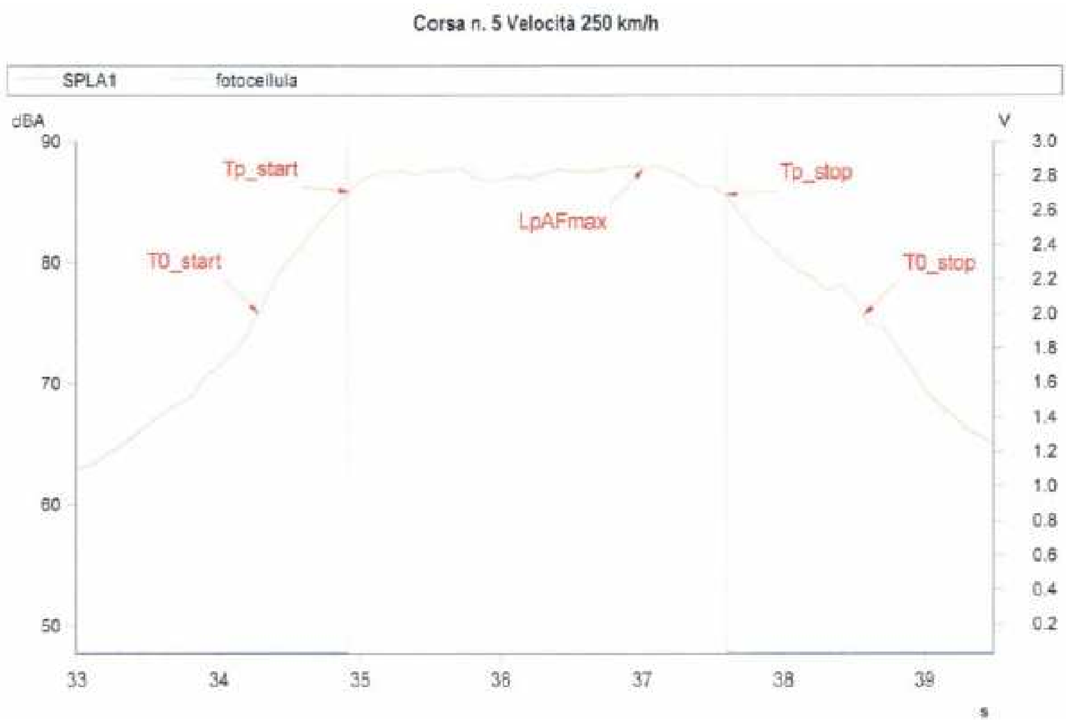
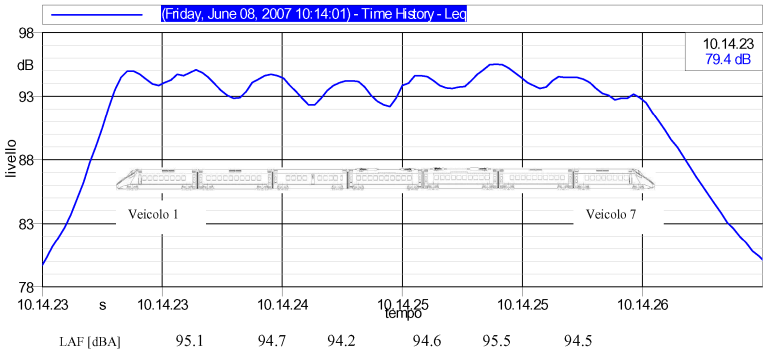
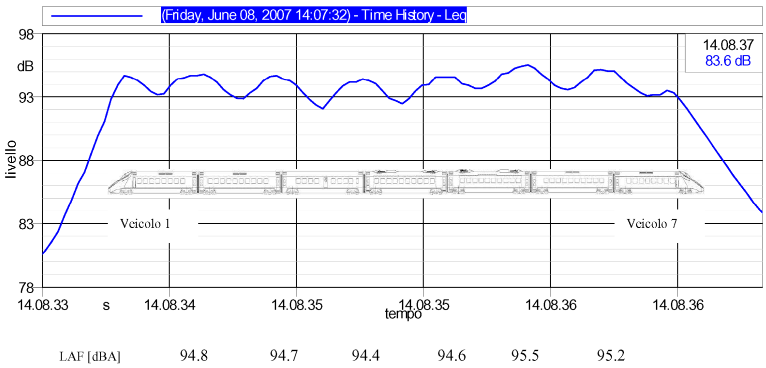


Figure 3: pass by number 1 in Anagni at 250 km/h. $L_{eqA,Tp}$ = 87.4, $L_{pAmax,F}$ = 88.0 dB(A)

To underline the importance of the track conditions on the results, other tests performed on a transition on the Florence-Rome high speed line are shown in

Figure 4. Note that the track here was not characterised in terms of decay rate and of roughness; moreover, the wheels have a straight web and contact conditions with lateral shift of the wheelset can excite modes which are not present on a straight track. All these reasons can explain why local values are higher than those measured in Anagni, highlighting the absolute need to keep track parameters under control.





Data Misura	08/06/2007
Sito di Prova	Linea DD Firenze – Roma PGR km 232+689 Binario Dispari
Velocità di Transito [km/h]	250
Rotabile in Prova	ETR 600.002
Distanza Microfono [m]	7.5
Altezza Microfono [m]	1.2

Figure 4. Pass bys on the Florence-Rome line at 250 km/h

THE APPLICATION OF SYOPE WHEELS TO CIRCUMVESUVIANA EMUs

A regional railway administration in the area of Naples, Italy (Circumvesuviana srl, narrow gauge 950 mm) decided to change the maintenance cycle of wheelsets passing from shrink fit to cold press fit to retrofit the entire existing fleet with the Syope damped wheel. Moreover, a new EMU train was fitted already from the beginning with Syope wheels.

Clearly for this type of rolling stock, which is not interoperable by definition as it can be used only on the narrow gauge network, therefore only the Italian regulations apply (DPR 458 of 18.11.1998). They require that for this type of rolling stock ("automotrice", i.e. self-propelled vehicle or EMU-DMU) the maximum A-weighted level measured with the "FAST" time constant of the sound level meter ($L_{pAmax,F}$) is such that $L_{pAmax,F} \leq 83$ dB(A) at 80 km/h for rolling stock built after year 2002 and $L_{pAmax,F} \leq 81$ dB(A) at 80 km/h for rolling stock built after year 2012.

Tests were conducted at 60 km/h and at 90 km/h and the limit of 81 dB(A) at 80 km/h was adapted with the usual law $Lp=81+30*\log_{10}(v/80)$. Also in this case it is possible to see (Figure 5) how the levels were absolutely satisfactory and well below the limits.

Speed km/h	Test #	$L_{eqA,Tp}$	$L_{pAmax,F}$	Limit $L_{pAmax,F}$ from DPR 459	Distance to the limit
60	1	73	74.3	77.3	**-3.0**
	2	71.8	73.5	77.3	**-3.8**
	3	72.9	75.0	77.3	**-2.3**
90	1	78.1	80.0	82.5	**-2.5**
	2	78.3	79.6	82.5	**-2.9**
	3	78.1	79.7	82.5	**-2.8**

Figure 5. noise values measured during pass-by on Circumvesuviana network at different speeds compared to Italian limits.

THE APPLICATION OF SYOPE BRAW WHEELS TO SAD DMUs

One kind of wheels on which the Syope solution was not yet applied was the one with the disc brake mounted on the web. Web braked wheels optimise the space occupied by the wheelset inside the bogie, but the residual space for mounting acoustic dampers is very limited; nevertheless, the Syope solution with its limited thickness appeared to adapt very well to this condition.

The innovation consists in applying on the surface between the rim and the web, not taken up by the disc brake, a metallic profile with a special visco-elastic material.

This solution, as for the standard Syope wheel, does not require any mechanical fixing to the web that could reduce the wheel structural resistance. While the mounting of a disc brake will contribute to damp the wheel radial modes that deform the web, the Syope Braw solution applied to this kind of wheel contributes to damp the bending rim modes. The combination of Syope Braw with the disc brake enables therefore to obtain a particularly low noise wheel.

The results obtained from the tests in the Lucchini RS semi-anechoic laboratory show that it is possible to foresee a reduction of the rolling noise of at least 4 dB in service.

The proposed idea results in good performance also against the squealing noise generated by the wheel when running through tight curves where rim modes are normally excited.

Laboratory acoustic tests were carried out in the semi-anechoic room to compare acoustic emission from different wheel configurations (Figure 6 and Figure 7).

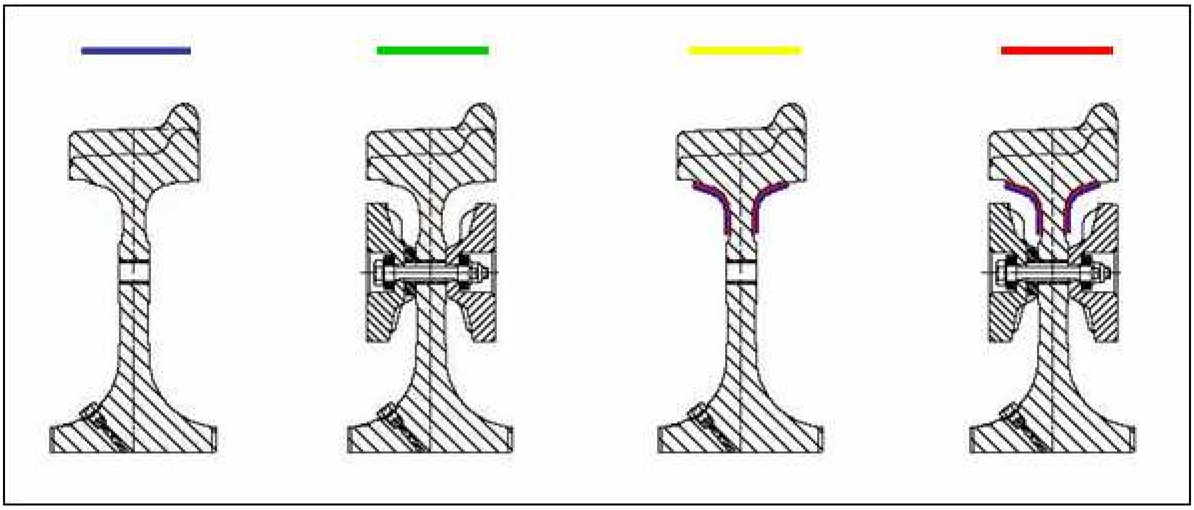
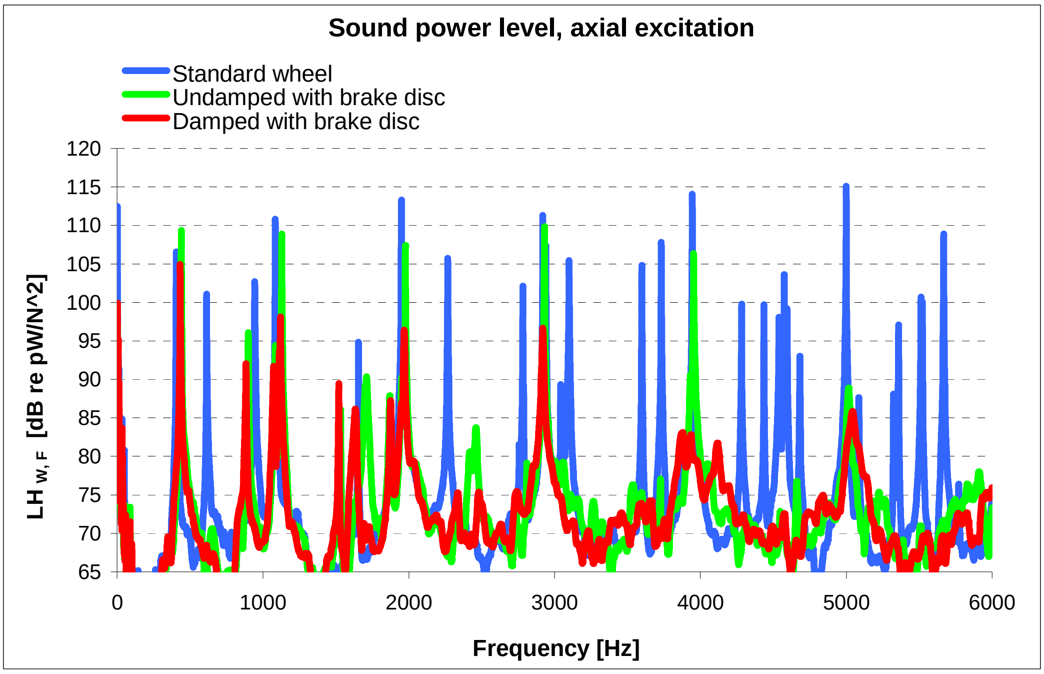


Figure 6. Syope Braw development: wheel tested configurations. From left to right: standard, with a web mounted disc brake, with the Syope Braw application, with both the disc brake and Syope Braw.



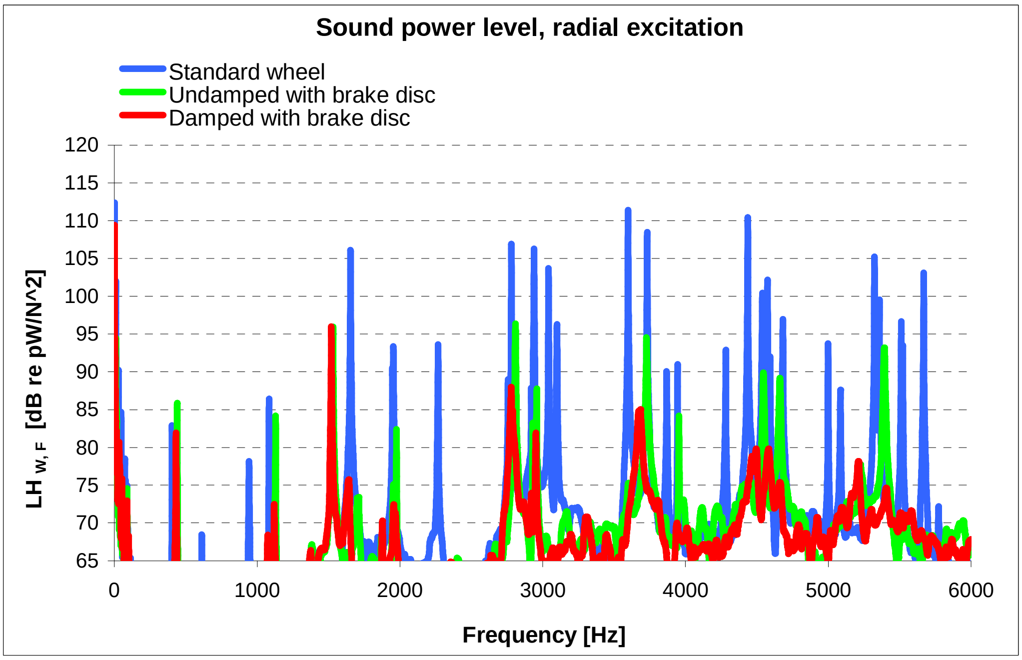


Figure 7. Comparative Normalized Sound Power Level for three wheel configurations with axial (top) and radial (bottom) excitation.

It is interesting to see how for the axial excitation, in which especially the rim modes are excited, in the case of the disc brake mounted wheel, the rim resonances are not damped but they are when the Syope Braw solution is installed. For this reason it is expected that a good effect of the Syope Braw solution can be seen when approaching curves: that is the case in which the tread is more excited.

In 2008 one motor bogie of a GTW 2/6 of Val Venosta regional railway operated by SAD SpA was equipped with the Syope Braw wheels. The trailer wheelsets of this vehicle were already running with standard Syope wheels from 2002, but because the motor wheels where of the kind with web mounted disc brakes, at that time they remained unchanged.

It was an important occasion also to verify the actual temperature induced by the braking during normal service; this was done by applying thermal stickers that would record the maximum temperature in a range of 60 to 150 ℃ (Figure 8).

Figure 8. Position of the thermal tapes on the Syope Braw wheel to verify the maximum temperature reached in service

After almost two years the maximum temperature was 88 ℃ and no alteration or detachment of the panel was observed. Actually the measured maximum temperature was considered to be fully acceptable as, during the design stage of the Syope Braw solution, it was required to stand a temperature of 150℃

During the summer of 2009, an acoustic test campaign was organized along the Val Venosta railway line (Figure 9). Near to each wheel of the two powered bogies (one with standard wheels and the other one with Syope Braw wheels) a microphone was installed (Figure 10 and Figure 11). The goal was to compare the noise emission from the wheels during the normal service running through the hole line.

By listening to the measurements, it was possible to observe, specially when going through curves, the so called flanging noise in which the wheel flange (normally the outer wheel with respect to the curve) would scratch against the rail. In many cases this interaction excites the vibration modes of the wheel rim producing a high squealing noise.

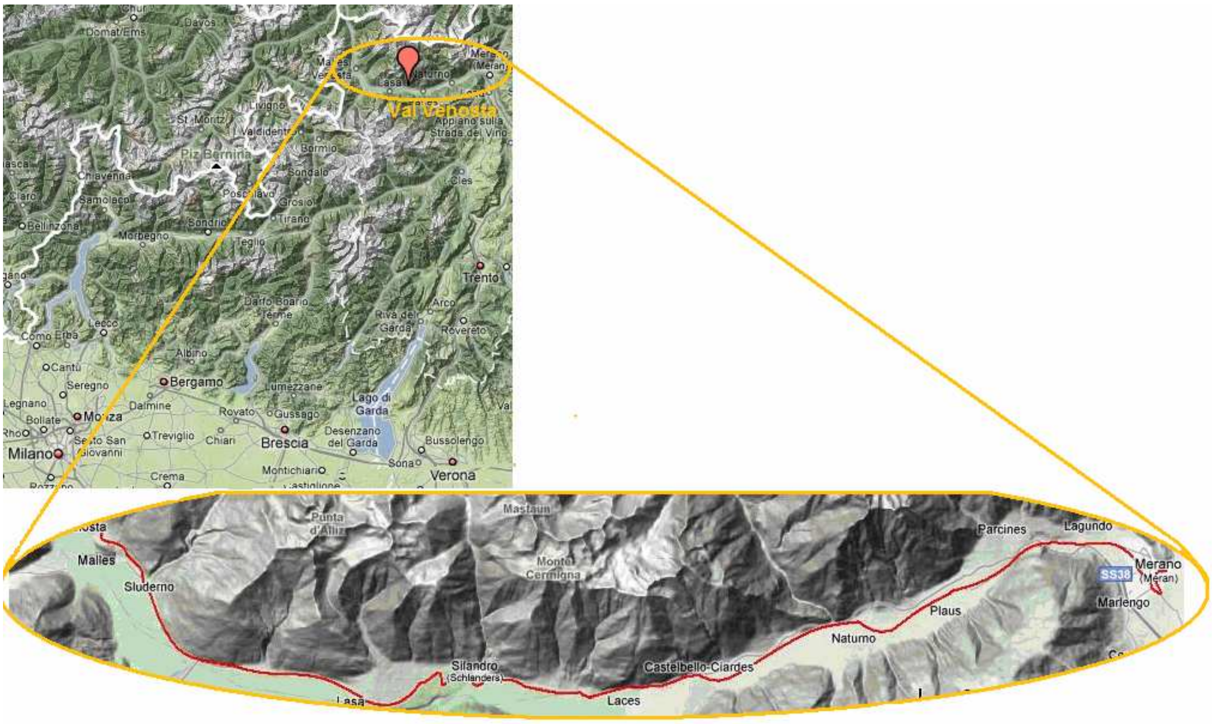


Figure 9. The Val Venosta railway line where the acoustic tests were made

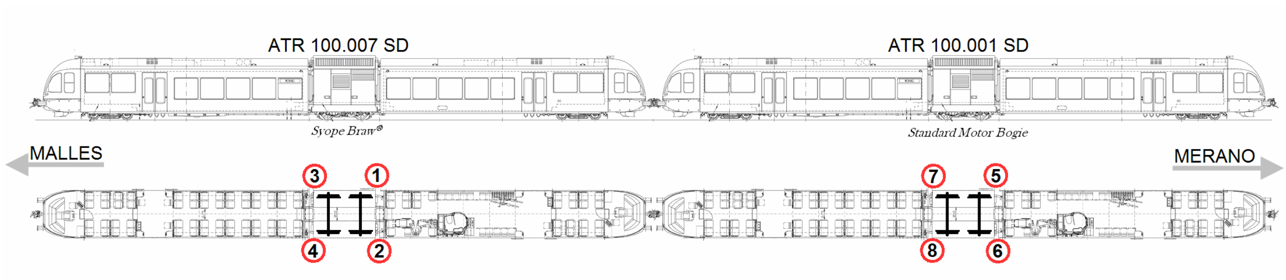


Figure 10. Trainset configuration during the acoustic tests; position of the powered wheels

Figure 11. Powered bogie. Position of the microphone.

By performing a simple power spectra of the sound pressure measured by the microphones and averaging the calculated spectra along the complete distance a graph like the one shown in Figure 12 can be obtained. From the comparison of the noise spectra produced from the standard and Syope Braw wheels, it can be seen that the tones that are excited are above 3.5 kHz, the level of the tones is about 30 to 40 dB over the background noise for the Standard wheels; the levels of the Syope Braw wheel are from 10 to 40 dB lower. The shift in the resonance frequencies between the standard and the Syope Braw wheels is probably due to the different diameter as the standard wheels were older ad reprofiled.

The test campaign demonstrated that the Syope Braw wheels are actually capable of damping the rim bending modes that are not damped by the presence of the disc brake and that tend to be excited when approaching curves producing high tonal noise (see also Figure 13).

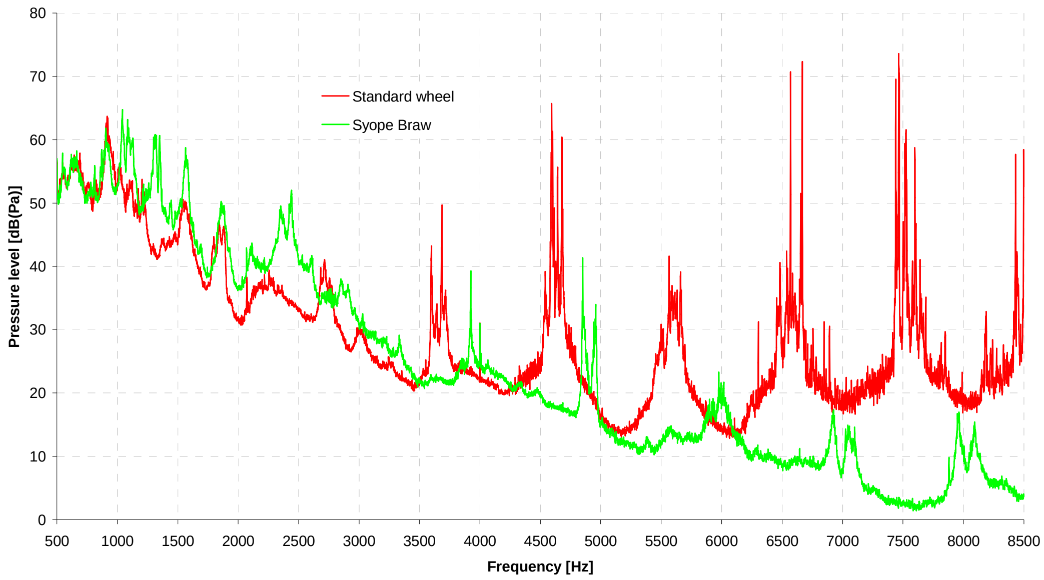


Figure 12. Averaged pressure spectra through the Val Venosta railway line from standard and Syope Braw wheels

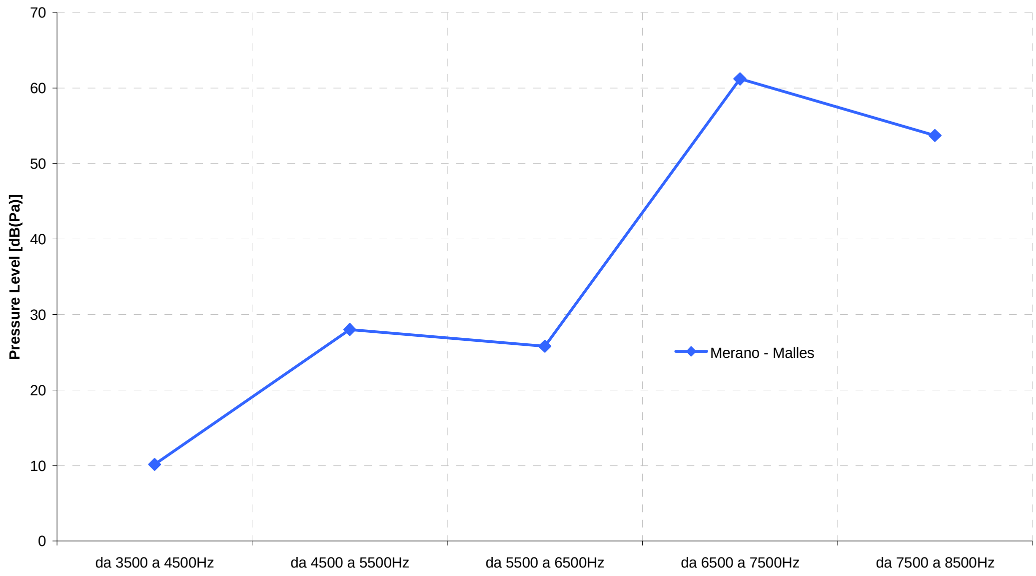


Figure 13. Average level reduction obtained by the Syope Braw wheels for different frequency ranges above 3500Hz

CONCLUSIONS

The applications of Syope wheels shown in this paper confirm the validity of both the concept and the industrial solution. Noise reduction at the source is therefore nowadays available at limited cost and with effective results.

The application of the Syope treatment to web-braked wheels originated the Syope Braw treatment that proved its validity during tests on a regional railway subjected to serious flanging noise phenomena.

Lucchini RS would like to thank all its industrial and operator partners who made available their results and who gave the authorization for publication.