MADRID
inter.noise 2019
June 16 - 19
NOISE CONTROL FOR A BETTER ENVIRONMENT

# Calmmoon Rail web shielding – field and lab tests

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**ABSTRACT**

**Calmmoon Rail was approved by the German authority EBA in 2010 as a rail web shielding technology. By the end of 2014 more than 80 km of German Railway track were fitted with it. Measurements as part of the German economic stimulus programme II yielded a noise reduction effect of 3 dB(A) in average for Calmmoon Rail. Calmmoon sheet in the form of 1.3 mm thick noise reduction sheeting glued onto a steel plate (cover). Then noise-absorbent foam from the automotive industry is applied. At the worksite, this L-shaped "shielding" is attached to both sides of the rail by hand and finally secured reliably and lastingly with two rail fasteners per rail compartment. It weighs around 4 kg per metre of rail. At the second noise symposium 26th and 27th June 2012 in Berlin, the measurement results announced by DB – German railways and German Ministry of Infrastructures was that the mass spring rail web damper (RWD) technologies showed an effect of only 2dB(A). The rail shielding showed an effect of 3 dB(A). Calmmoon Rail fulfils the requirements of Schall 03 (2012).**

**Keywords:** Noise, noise source protection
**I-INCE Classification of Subject Number:** 32

## 1. INTRODUCTION

In Europe the Calmmoon Rail web shielding system has been in use since 2008. Up until 2019, German Railways (DB AG) has already shielded more than 80 km of track with this technology. In the course of an economic stimulus programme, the German Ministry for Infrastructure and DB AG declared in 2012 that Calmmoon Rail was the most effective, economical and user-friendly technology to reduce noise emitted by rails. Field trials in Germany and Switzerland have shown reductions in the overall noise level of the rail infrastructure of up to 4.4 dB. Laboratory tests on a freely oscillating rail, in accordance with Stardamp, have shown results of up to 19 dB. Calmmoon Rail is far more effective than rail web dampers when the track decay rate (TDR) is high.

## 2. GERMANY – ECONOMIC STIMULUS PROGRAMME II (KP II)[1]

Between 2009 and 2012 an economic stimulus programme (KP II Lärm) was implemented in Germany to trial innovative measures for noise and vibration mitigation on the permanent way. A total of 14 innovative technologies, including the Calmmoon Rail web shielding system, were deployed on 82 projects.

For this trial, Calmmoon Rail was installed on approximately 40 km of track and DB AG (German Railways) found this technology was able to achieve an average noise mitigation of 3 dB and should be recognised as being valid for the noise calculation model Schall 03 [2012]. This technology, which reduces noise directly at its point of emission, was to be applied in combination with other technical noise mitigation measures in future projects.

Fig.1: Calmmoon Rail - Boppard station

Fig.2: Calmmoon Rail on UIC 60 rail

The programme extends the "conventional" noise mitigation techniques for reducing noise emitted to the surrounding area. The following results were achieved by the trialled rail web dampers and Calmmoon Rail web shielding:

| Technology | Effect [dB] acc. to calc. methodSchall 03 [2012] | Rating |
|---|---|---|
| Rail web damper (RWD) | 2 dB (RWD) | 4 Manufacturers |
| **Rail web shielding (RWS)** | **3 dB (RWS)** | **1 Manufacturer** |

Tab.1: KPII trial results for RWD and RWS

### 2.1. How Calmmoon Rail works

The Calmmoon Rail web shielding reduces airborne noise from the rails, not the oscillatory energy of the rail. Low mass elements are one of the main characteristics of this technology. Approximately 4 kg of material is installed per metre of rail. The oscillatory energy of the rails induced by a train passing over them is emitted unattenuated as airborne noise. However, the rail web shielding effectively reduces radiation of the airborne noise into the surroundings. Calmmoon Rail technology achieves this by effectively placing a "housing" around the rail. The rail is surrounded by elements of thin steel plate onto which Calmmoon sheet technology is bonded to reduce airborne sound energy and the vibrational energy of the steel plate. A sound-absorbing acoustic foam is permanently bonded onto this. Upon installation, an air gap then results between the rail and the Calmmoon Rail material. The energy of the airborne noise emitted by the rail is reduced by reflection cycles between the rail and shielding, and by absorption in the elements of Calmmoon noise suppression sheeting and foam material. Calmmoon Rail prevents the emission of airborne noise from the rail web and foot. The mechanism of action resembles that of a mini sound barrier. The track decay rate [dB/m] remains unaffected by this system.

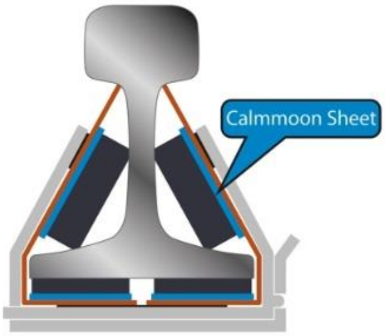

Fig.3: RWS cross section- Calmmoon Rail

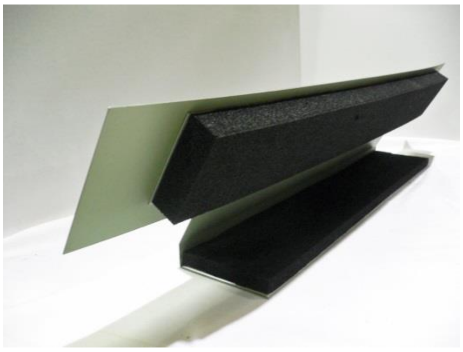
Fig.4: Close-up of RWS cover

As part of the KP II stimulus programme, the rail web shielding system was installed and tested in 12 highly diverse locations on a total of 39.820 km of track. The sites were at Hamburg Harburg, Hamburg Hausbruch, Hamburg Rahlstedt, Hamburg Tonndorf, Hamburg Mariental, Leipzig Güterring, Leipzig Wahren, Emmerich-Oberhausen, Bremen, Löf an der Mosel and Gau-Algesheim.

### 2.2. Acoustic effect of Calmmoon Rail

The reduction in airborne noise level ascertained by the measurements relates to the total noise of trains passing by, with contributions from the rail bed and track, rolling noise, drive noise, unit noise and aerodynamic noise. Calmmoon Rail acts to reduce the level of only the rail rolling noise component. The trial results here relate solely to speeds ≤ 160 km/h and sleeper track in a ballast bed. When averaged over the train types, the reduction obtained in A-weighted cumulative noise level is 3 dB for Calmmoon Rail. This is taken as the basis in the Schall 03 [2012] model with the rail web shielding technology.

### 2.3. Cost considerations

The specific annual construction costs for the RWS under the KPII programme were on average 12,600 euro/km, this being for an estimated (accounting) service life of 13 years. No running costs are incurred with this technology. At this stage, predictions about the maintenance costs are difficult to make. Since the rail web dampers and Calmmoon Rail are both attached directly to the rails, maintenance may be affected, depending on the technology. The following possible effects should be mentioned here:

- Mechanised maintenance of the track, such as ballast tamping
    - Where Calmmoon Rail is used, track maintenance can be carried out using conventional machinery. Maintenance is performed in exactly the same way as on track without Calmmoon Rail.
- Fitting and removal of the shielding when rails are replaced, track is renewed and taking permanent possession of the adjacent track for reasons of work safety, as well as when attaching earthing clamps.

If commercial prudence is exercised when estimating the follow-up cost of maintenance measures, the Calmmoon Rail web shielding comes out at:

- 2,900 euro per year and km (Calmmoon Rail - fitted 2012 onwards)

Fig.5: Fitting Calmmoon Rail web shielding

It should be mentioned here that the way in which Calmmoon Rail is attached has already been further developed so that the technology does not extend beyond the immediate profile space of the rail. Conditions for unrestricted mechanised track maintenance are now fulfilled under the DB AG regulation TM 2013-1024 I.NVT 4.

Fig.6: RWS – boltless Calmmoon Rail on DB AG track in the Rhine Valley

## 3. CALMMOON RAIL OPTIMISED FOR RAIL MAINTENANCE WORK

The findings from the KPII programme as well as the exchange of experiences with DB AG, prompted SEKISUI, the manufacturer of Calmmoon Rail, to develop the existing technology in such a way that the maintenance work of the infrastructure operator is affected as little as possible.

To this end, a number of field trials were carried out in 2012 on DB track as well as on track in Holland. The newly developed fastening method as well as the better optimised rail shielding components were mounted on the rails and their impact on track maintenance was observed. The field trials took place with conventional ballast tamping/lining machines and ballast ploughs with sweepers and were able to confirm unrestricted maintenance of the track system.

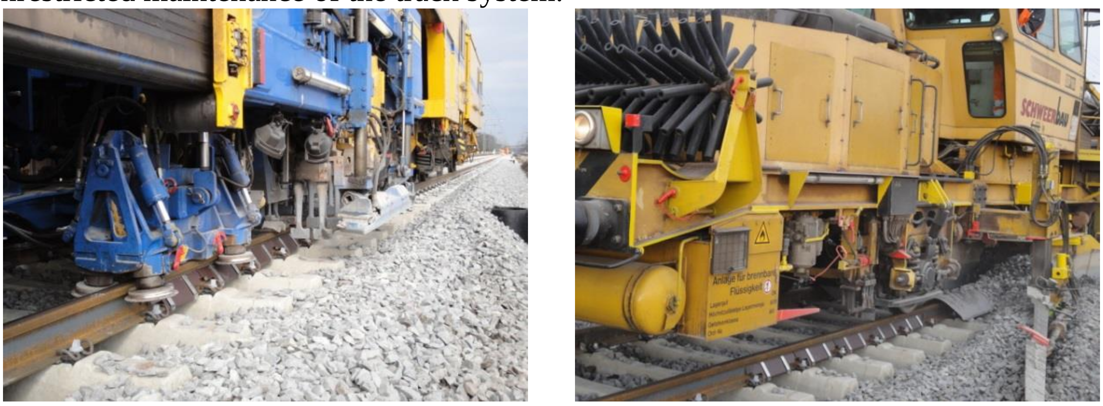

Fig.7: Field trial of mechanised maintenance on track fitted with RWS

Final approval of Calmmoon Rail for use on the rail network in Germany was granted on 25 January 2019 by the German Federal Railway Authority (EBA).

## 4. GERMANY – IBP II NOISE AND VIBRATION MITIGATION

The IBP II programme to promote infrastructure to mitigate noise and vibration was utilised during 2013 and 2014 through the application of innovative technologies for noise prevention on rail-borne infrastructure. Particular preference was given to areas already subject to high noise pollution where there were limited possibilities for the use of conventional noise barriers.

Following the invitations to tender, the provider of Calmmoon Rail, as the best tenderer, succeeded in getting orders totalling more than 40 km of track.

The projects were implemented at locations on the left and right banks of the river Rhine, such as Linz/Rhein, Boppard, Trechtingshausen, Niederheimbach, St. Goar etc., in accordance with DB AG's specified deadlines, in the course of overnight track possessions.

## 5. FIELD TRIALS OF CALMMOON RAIL IN GERMANY AND SWITZERLAND

### 5.1. Field trial of Calmmoon Rail in Germany – at Löf[2]

After the Schweerbau-SEKISUI bidding consortium was awarded the contract for the line section 3010 – Löf/Mosel project, the contractual target specifications defined in the annex of the invitation to tender had to be processed. It had been stipulated that payment would be made only if a noise reduction of 2 dB(A) or higher was achieved.

The TDR (track decay rate) had to be measured before the rail web dampers were fitted. The TDR had to be on average less than or equal to 2 dB/m (500 to 2,000 Hz) in order to guarantee the required noise reduction of 2 dB(A).

The existing noise situation already indicated that the noise level was very low when compared to other line sections (approx. 6 to 10 dB quieter). The TDR measurements showed a value of 8.1 dB/m on average for the frequency range 500 to 2,000 Hz using the TSI-method of AEIF, i.e. a figure significantly higher than the predefined 2 dB/m.

This showed that the DB AG has an excellent track for its transport and movements, which has been achieved by DB AG's own perfect and thorough maintenance.

With regard to the contractual target specifications though, it meant that no rail web dampers had to be installed on this project. This is because these specifications are known limits of DB AG for rail web dampers.

After consultation with Deutsche Bahn, a test section of 100 m in length was fitted with Calmmoon Rail and measured acoustically. The noise reduction achieved for an existing TDR of 8.1 dB/m is shown in table 2.

| | Number of trains passing by | | Average noise level reduction Measuring point = 7.5/1.2 m referring to v=80km/h |
|---|---|---|---|
| Train type | Zero measurement | Calmmoon Rail | |
| Freight train | 51 | 57 | 1.9 |
| Passenger train | 39 | 47 | 2 |

Table 2: Trial results – Reduction in rail traffic noise for project Löf

### 5.2. Field trial of Calmmoon Rail in Germany – at Gau-Algesheim[3]

DB AG's test track for measuring rail web dampers and shielding is located in Gau-Algesheim. At this location all the boundary conditions for acoustic field measurement of rail/vehicle noise radiation are perfectly met according to the standard. The test section on which Calmmoon Rail was to be installed had a length of 200 m. The acoustic measurements were made at a distance of 7.5 m from the track centre and 1.2 m above the top of the rail. A further measurement was made at a distance of 25 m from the track centre and 3.5 m above the top of the rail. Before Calmmoon Rail shielding was fitted, the TDR, rail roughness and acoustic zero measurements were carried out. On this project, an unexpected (for us) tamping of the ballast bed of the track system took place on the final day of the zero measurement. The track situation was now different due to the tamping operation. The TDR was measured once again and was found to have improved significantly as a result of the tamping. A new acoustic zero measurement was also made.

Finally, Calmmoon Rail could be fitted at the specified time and the planned measurements with rail shielding fitted could be carried out. The track was now in outstanding condition with an excellent TDR (5.1 dB/m) and had a roughness that was consistently below TSI and ISO specifications.

Table 3 shows the results of the field measurements, which start at 1.9 dB for freight trains and range up to 4.4 dB for passenger trains.

| | Number of trains passing by | | Average noise level reduction Measuring point = 7.5/1.2 m, 25/3.5m referring to v=80km/h | |
|---|---|---|---|---|
| Train type | Zero measurement | Calmmoon Rail | 7.5 / 1.2m | 25 / 3.5 m |
| Freight train | 6 | 11 | 1.9 | 1.4 |
| Pt-mix – Passenger | 38 | 41 | 2.1 | 2.1 |
| 80-33–Passenger train | 23 | 21 | 4.4 | 3.9 |
| DB460-Passenger train | 103 | 112 | 2.4 | 2.2 |

Table 3: Trial results – Reduction in rail traffic noise for project Gau-Algesheim

### 5.3. Field trial of Calmmoon Rail in Switzerland[4]

In October 2015 two 80-metre-long straight sections of the single-track line between Kerzers and Müntschemier were fitted with Calmmoon Rail web shielding from SEKISUI to measure their acoustic effect. Following renewal of the track in 2014, the section of line was in excellent condition with very low rail roughness throughout. Both passenger and freight trains are running on the line. This track is ideal for acoustic measurements since neither high vegetation nor reflecting surfaces influence the propagation of sound.

Table 4 shows the noise level reductions with Calmmoon Rail on both sections, MQ1 (TDR is 15.2 dB/m) with a hard rail pad and MQ2 (TDR is 2.6 dB/m) with a soft rail pad, in each case to the reference track MQ0. On the test track MQ1 with hard rail pads, the average reduction is around 1.8 dB, while on the test track MQ2 with soft rail pads it is around 3.1 dB.

| Type of train | Noise level difference [dB] effect measurement - zero measurement | |
|---|---|---|
| | ΔN(MQ1)-ΔE(MQ1) hard rail pad | ΔN(MQ2)-ΔE(MQ2) soft rail pad |
| Lötschberger | 1.8 | 3.9 |
| EW3 with Re420 / Re465 | 1.3 | 2.4 |
| Freight train | 1.5 | 2.5 |
| Nina | 2.4 | 3.7 |
| **Average value** | **1.8** | **3.1** |

Table 4: Noise level reduction due to RWS on MQ1 (hard pads) and MQ2 (soft pads)

## 6. Laboratory investigation according to Stardamp test for Calmmoon Rail[5]

The effectiveness of SEKISUI's Calmmoon Rail web shielding was investigated on a freely supported rail. The test was carried out in line with DB Standard 918 290 (Stardamp) on a 6m long freely supported UIC60 rail, whereby an impact hammer was used at both ends to excite the rail in a vertical and horizontal direction. The focus here was not on the TDR of rail web dampers (RWD) but on the acoustic insertion loss (IL). The sound radiation was measured via microphones in the centre of the rail at various lateral distances 0.1m, 1m and 2m at top of rail level.

Fig. 8: Excitation at the ends of freely supported rail by impact hammer

Fig. 9: Microphone position plus Calmmoon Rail

The results of the laboratory investigation are shown in figures 10 and 11. If these are compared against the field measurements on an actual track, one can see that the values are disproportionately far higher than the results from the field trials. One reason for this seems to be that the 6 m rail is freely tensioned and gently supported almost frictionlessly. In the field trials with Calmmoon Rail, the rail was clamped by the sleepers every 60 cm and thus had hardly any discernible free arc of oscillation compared to this laboratory trial.

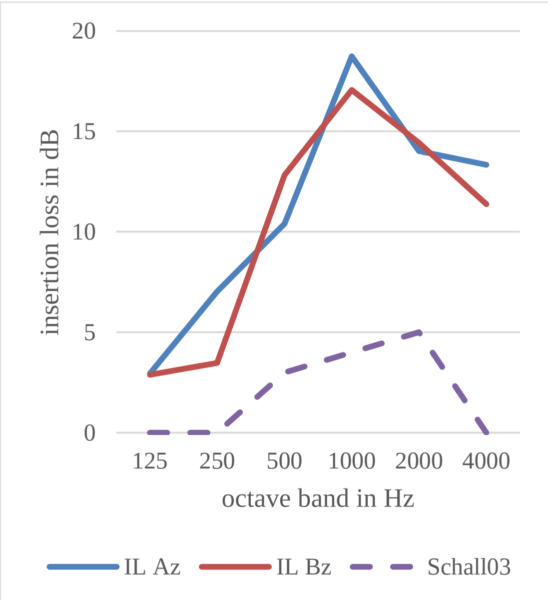


Fig.10: Insertion loss, vertical

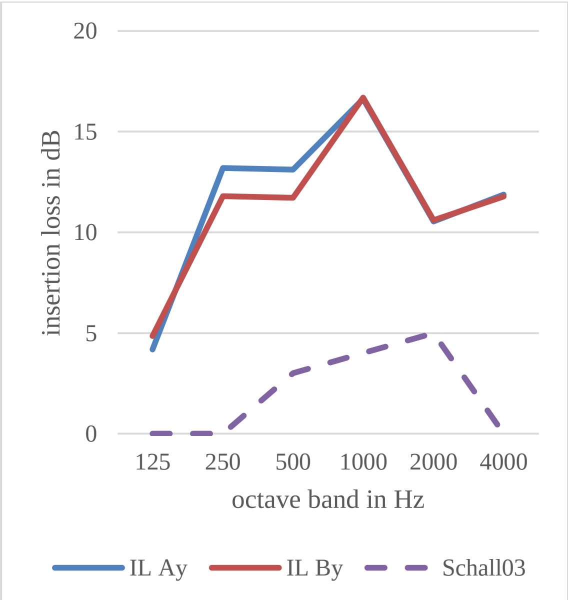


Fig.11. Insertion loss, horizontal

## 7. HIGH EFFECTIVENESS OF CALMMOON RAIL AT HIGH TDR

A characteristic difference between rail web dampers and Calmmoon Rail is their principle of action.

Rail web dampers are of high mass and include elastic elements to form a mass/spring system - only in the damping element itself, not in the track system - in order to alter the decay rate and oscillatory behaviour of the rail.

For some years now, investigations and scientific evaluations confirm that even with an existing low track decay rate of just 2 dB/m, a noise reduction of only 2 dB or less is to be expected with rail web dampers.

If the TDR value of the track system increases (i.e. the acoustic quality of the rails), the effect of this technology is reduced even more.

Italy, Switzerland and Austria have so far not installed rail web dampers because apparently their track systems usually have a TDR greater than 2 dB/m.

The above field trials indicated track decay rates of 2.6 dB/m for soft rail pads and up to 15.2 dB/m for hard rail pads. If the values from the field trials with Calmmoon Rail are now entered into the diagram[6] for the potential attenuating effect of rail web dampers, we obtain figure 12.

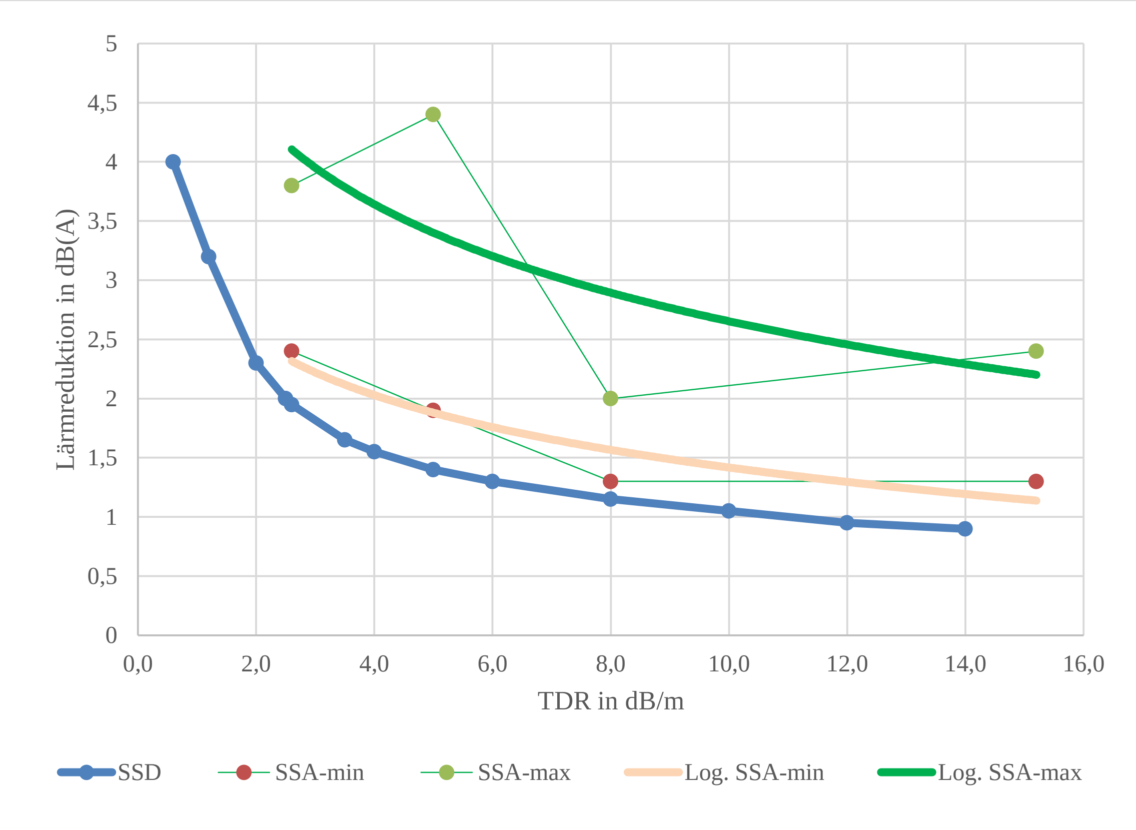


Fig.12: Noise reduction of Calmmoon Rail at high TDR compared to rail web dampers

Figure 12 shows the limitations of the individual systems. It can be seen that even when the TDR is 15.2 dB/m, Calmmoon Rail offers greater noise reduction than rail web dampers when the TDR is 2 dB/m.

## 8. SUMMARY

In Europe the Calmmoon Rail web shielding system has been in use since 2008. Up until 2019, Deutsche Bahn has already shielded more than 80 km of track with this technology. In the course of an economic stimulus programme, the German Ministry for Infrastructure and DB AG declared in 2012 that Calmmoon Rail was the most effective, economical and user friendly technology for the reduction of noise emitted by rails. Field trials in Germany and Switzerland have shown reductions in the overall noise level of the rail infrastructure of up to 4.4 dB. Laboratory tests on a freely oscillating rail, in accordance with Stardamp, have shown results of up to 19 dB. Calmmoon Rail is far more effective than rail web dampers when the track decay rate (TDR) is high.

When the TDR is 15.2 dB/m, Calmmoon Rail is able to offer greater noise reduction than rail web dampers can when the TDR is 2 dB/m.

Similar to a noise barrier, Calmmoon Rail acts solely by shielding to reduce the radiated noise.

Rail web dampers alter the oscillatory behaviour of the rails and, in a test on the Konzert curve in Innsbruck, Austria, very quickly led to corrugation of the surface of the rails.

Based on the experience gained from these field trials, Calmmoon Rail ought to be highly effective in reducing railway infrastructure noise for almost all existing track systems of the railway operators.

Italy, Switzerland and Austria have so far not installed rail web dampers because apparently their track systems usually have a TDR greater than 2 dB/m.

This effectiveness of the lightweight Calmmoon Rail web shielding calls above all for a willingness on the part of current specialists to accept it and other possible approaches to a solution. It is an approach rooted in "lived" everyday practice not pursued hitherto that contrasts with decades of highly specialised theoretical research and accumulations of knowledge on rail noise reduction using rail web dampers.

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