
Subject Advice on rail dampers for Oxford City Council

Date 2 September 2016

Job No/Ref H04-OB

- [1] Oxford City Council (OCC) has sought advice from Arup relating to planning Condition 2 of 15/00956/CND which relates to the use of 'Tata SilentTrack' in Section H of the East West Rail Link phase 1 (EWR) scheme and Condition 2 of 15/03503/CND, which relates to its use on Section I.
- [2] Tata SilentTrack is a type of 'rail damper' which is a mitigation measure for reducing train noise. Arup have experience of evaluating the performance of this mitigation measure during the planning, design and construction stages of rail projects which include High Speed 2 and the Network Rail Thameslink Programme.
- [3] OCC have asked specific questions about the performance of rail dampers and the effect that these measures could have on mitigation and insulation proposals defined in the two Noise Scheme of Assessments (NSoA) for section H and Section I.
- [4] Our responses to OCCs specific questions are provided in the following sections of this document.

1 What is At Source Mitigation?

a. Set out measures such as rail damping that could be applied at source in specific circumstances to mitigate noise where it is predicted to be problematic.

- [5] Airborne noise from railways comprises the following sources:
 - Rolling noise generated by wheel and rail vibrations that are induced at the wheel/rail interface. Rolling noise is generally the most predominant source of railway noise.
 - Curving noise generated by unsteady transverse forces in the wheel/rail interaction during curving. This type of noise is very different in character to rolling noise.
 - Aerodynamic noise caused by unsteady airflow over the body of the train. This source of noise becomes important at very high speeds (generally above 300 kph)
 - Traction noise from diesel engines, intake and exhaust, traction motors and fans, gearboxes, turbocharges etc. Traction noise is an important source of noise at low speeds and for diesel locomotives on full power.
- [6] Across the East West Rail Link phase 1 (EWR) scheme the predominant source of noise is likely to be rolling noise except at those parts of the route where:
 - Diesel locomotives are operating on full power where traction noise may be important; or
 - On curves of tight radius where curving noise may be important.
- [7] When considering mitigation options we often think in terms of the source-path-receiver system. Table 1 summarises recognised mitigation measures and identifies where they lie in the source-path-receiver system. The table also identifies which source of train noise will be reduced by each mitigation measure.

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Table 1: Recognised train noise mitigation measures for surface running trains

Source of train noise	Source based mitigation	Path based mitigation	Receiver based mitigation
Rolling noise generated by wheel and rail vibrations that are induced at the wheel/rail interface	Maintaining a low level of rail roughness through maintenance such as rail grinding	Noise barriers	Noise insulation
	Maintaining a low level of wheel roughness		
	Optimisation of track design parameters such as rail pad stiffness		
	Rail damping		
	Wheel damping		
Curving noise generated by unsteady transverse forces in the wheel/rail interaction during curving	Flange and top-of-rail lubrication	Noise barriers	Noise insulation
	Wheel damping		
Aerodynamic noise caused by unsteady airflow over the body of the train	Aerodynamic design of rolling stock	Noise barriers	Noise insulation
Traction noise from diesel engines, intake and exhaust, traction motors and fans, gearboxes, turbocharges etc	Rolling stock traction design		

b. Advise on measures which as a matter of good modern construction would be expected for the track form specified in Oxford and which mitigate noise compared to existing track

- [8] The most important parameter for limiting rolling noise that is within the control of Network Rail is the rail roughness. As indicated in Table 1 rail roughness can be controlled by rail maintenance. Grinding is a maintenance activity rather than a design activity. Assuming that the existing lines have continuously welded rails (CWR) and are subject to the same procedures as the proposed lines, then rail roughness levels, and hence rolling noise, on the new lines are unlikely to be significantly different to the existing lines. If the existing lines contain welds, repairs and other discontinuities, then the new lines should be quieter than the existing lines.
- [9] Ballast track is the most common type of track on lines in the UK. In terms of wayside noise, ballast track is relatively quiet compared to the alternative which is slab track. Track design parameters of ballast track are reasonably well optimised for reducing noise. This means that additional track based mitigation measures are not usually ‘expected’ on new ballast tracks.
- [10] One parameter that will affect rolling noise is the rail pad dynamic stiffness. The rail pad is a resilient pad placed directly below the rail. All other parameters remaining equal, a track

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with ‘soft’ rail pads will radiate more noise than a track with ‘stiff’ rail pads. Considering standard track components available to Network Rail (NR), choice of rail pad could influence noise radiated by the track by a few decibels.

- [11] Because of the relatively small effect of rail pads stiffness on noise from ballast track, rail pads are not normally considered as a noise mitigation measure. Choice of rail pad stiffness is usually an operational consideration rather than a noise consideration. The rail pad stiffness will also affect the performance of the rail dampers. The reasons for this are described in more detail in Section 2b below.

2 What rail damping products are available?

a. Compare these with ST in the context of this track

- [12] NRs evidence¹ states that they are aware of other damper systems but also states that “*the performance of their systems is unlikely to be significantly better than SilentTrack nor are they likely to be cheaper*”.
- [13] Regarding the difference in performance of different rail damping products, an International Union of Railways (UIC²) report³ provides a review of rail damping technologies. It acknowledges that the most common dampers in use are those by TATA steel and Schrey and Veith. The report also describes products by Vossloh, STRAIL, CDM, Edilon and Tiflex.
- [14] The study states that one difficulty with rail dampers is the large range of effectiveness seen in practice:
- “The problem of rail dampers consists in the quantification of its efficiency. Different trials have shown strong variation in the effects, usually ranging from 0 dB to 3 dB with rare maxima of 7 dB. The effects are dependent on traffic and construction parameters. However, the influence especially of construction has not been quantified satisfactorily”.*
- [15] The report references experience of dampers in Austria, Czech Republic, Germany, Finland, France, the Netherlands, Norway, Sweden and Switzerland. A summary of the performance of the different damping systems is presented. There is no clear evidence that other damping products will provide benefits which are significantly better than SilentTrack. The UIC study concludes that the maximum noise reduction achieved with dampers is about 3dB.
- [16] Regarding the costs of different rail damping products, we note that no evidence is provided to support NRs assumption that other damping products are unlikely to be cheaper than SilentTrack. There are potentially significant cost differences between the available types of product.

¹ Statement Setting out Network Rail’s evidence that the installation of silent track in sections H and I/1 in Oxford is not reasonably practicable – 13th July 2016

² International Union of Railways (<http://www.uic.org/>)

³ Enzo Scossa-Romano and Jakob Oertli. Rail Dampers, Acoustic Rail Grinding, Low Height Noise Barriers – A report on the state of the art. UIC report October 2012

(http://www.uic.org/IMG/pdf/2012_dampers_grinding_lowbarriers.pdf)

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b. Comment on experience of ST (Blackfriar's etc) and Arup's recommendations for HS2

- [17] Arup's main experience of SilentTrack is on the Thameslink project. We measured the performance of rail dampers installed at Blackfriars Station. The report has been included in NRs evidence.
- [18] HS2 track is in the very early design stages. No detailed specifications for track have been produced. Rail dampers are being considered as a potential mitigation option. However the benefits that can be achieved from rail dampers and the feasibility of their use depends on the properties of the railway system as a whole (the trains, the track and infrastructure). Given that HS2 is still undergoing extensive design, no firm decision will be made on their use until the later stages of the project.
- [19] Based on the available evidence it is clear that the performance of a rail damper is highly dependent on the operating parameters of the railway (rolling stock type, wheel roughness, speed etc) and the design and quality of the track on which they were installed (rail roughness, rail fastener stiffness etc). This is clear from the range of performance data presented in the UIC study. In 9 of the 12 case studies presented a rail damper performance of less than 3dB was measured under some circumstances.
- [20] The performance of dampers on the East West Rail project will be highly dependent upon the design of the track. A key parameter is the rail fastening stiffness. It was described above that a track with 'soft' rail pads is likely to radiate more noise than a track with 'stiff' rail pads. This is because the track decay rate (the rate of decay of noise-generating vibration along the rail), will be higher on the track with the stiff pads. This also means that the benefits of rail dampers are likely to be greater for track with soft rail pads (low decay rate) and limited on track with stiff rail pads (track which already has a relatively high decay rate).
- [21] NR have advised Oxford City Council⁴ that the ballast track to be installed on EWR will incorporate relatively soft 'Type A' pads with a dynamic stiffness of about 120MN/m. This is the same rail pad that was installed at Blackfriars station. However there is a key difference between the track at Blackfriars Station and that proposed for EWR because Blackfriars station is constructed on a bridge. Hence the Blackfriars track incorporated a sleeper soffit pad (an additional pad inserted beneath the sleeper) to help control structure radiated noise from the bridge. It should be noted that it is possible that this additional pad reduced the decay rate of the track (before dampers were installed) so that the rail dampers appeared to give relatively high performance of about 3dB. Further testing or modelling would be needed to confirm this possibility.

3 If ST were used where would this be?

- [22] The overall cost/benefit ratio of rail dampers could be improved by limiting the use of rail dampers to parts of the route where:
1. There is a residual impact at sensitive properties even with noise barriers installed; and/or

⁴ Email from Mike Fraser to David Stevens on 18th August 2016

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2. In the vicinity of properties where the trigger levels for statutory noise insulation are exceeded according to the Noise Insulation Regulations for Railways and other guided transport systems (NIRR).
- [23] NRs evidence presents the results of a WEBTAG assessment where it was assumed that SilentTrack would be installed across the whole route. In this case the Benefit to Cost Ratio (BCR) was significantly less than 1. Comments received during consultation queried the basis of this assumption given that there are many parts of the routes where noise mitigation is not deemed necessary according to the project's Noise and Vibration Mitigation Policy (NVMP). NR therefore adjusted the costs to assume that SilentTrack was used up to 100m either side of a noise sensitive receptor (Approximately 80% of the route). Even with this change the BCR was still less than 1.
- [24] The EWR Noise Scheme of Assessment for Section H⁵ presents the predicted noise levels at receptors across route section H. The report presents predictions for 26 noise sensitive receptors. At 16 receptors the residual impact of the scheme with noise barriers ('Predicted Mitigated Impact') is 3 dB or less. We suggest that rail dampers are not considered for the parts of the route near these properties as this will reduce the cost of the mitigation measure and potentially improve the cost to benefit ratio of the measure.
- [25] With the exception of Receptor PI 17 (396 Woodstock Road) all properties subject to residual impacts of greater than 3dB and/or in excess of the statutory NIRR trigger criteria are limited to the part of the route between Wolvercote Roundabout and Quadrangle House. This section is approximately 500m in length (12% of the route). If the WEBTAG assessment is limited to this part of the route, and properties affected by this part of the route only, the BCR of the mitigation measure should increase.

4 How would Silent Track perform on the track in question with no other mitigation?

- [26] A discussion on the performance of rail dampers on at Blackfriars Station was provided in Section 2b above. It was noted that the tracks proposed for EWR will have the same rail pads as were installed at Blackfriars station, however there is a key difference between the tracks because the Blackfriars tracks incorporate a sleeper soffit pads.
- [27] NR have also provided a paper⁶ which predicts the performance of a Schrey and Veit rail damper on ballast tracks with different rail pad stiffness including 'soft' pads with a dynamic stiffness of 120MN/m and 'stiff' rail pads with a dynamic stiffness of 800MN/m. The overall reduction in noise predicted to occur from installing the dampers was 2.5dB and 0.7dB for 'soft' and 'stiff' rail pads respectively. While it is for a different damping product, the former result is a reasonable estimate of the performance of the SilentTrack dampers on EWR.

⁵ Noise Scheme of Assessment for Route Section H. Report for Chiltern Railways/Network Rail by ERM. February 2014.

⁶ M. G. R. Toward et al. Estimating the performance of rail dampers using laboratory methods and software predictions. Proceedings of the 11th International Workshop on Railway Noise, 9-13 September 2013 at Uddevalla in Sweden

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- [28] Further prediction work, undertaken according to the methodology defined in [6], would be required to provide the best estimate of the performance of SilentTrack on EWR.

5 How would Silent Track perform on the track in question given that barriers are being used?

- [29] NRs Evidence states that:

“If SilentTrack were installed as well as the other measures, the additional noise reduction achieved would be marginal and less than the 3 dBA L_{eq} that likely to be obtained without barriers, because of the interaction with the screening already being provided by the noise barriers and noise insulation.”

- [30] We would expect any noise reduction at source to be seen in addition to the performance of a noise barrier. We are not aware of any published evidence to suggest that the benefit of rail dampers is reduced in conjunction with noise barriers. The Blackfriars rail damper study referenced in NRs evidence did show a reduction in performance of rail dampers installed on the southbound track because the rails/wheels were screened from the microphone in the tests. This meant traction noise was likely to become the important component of noise. This is however a very different situation to EWR. At Blackfriars trains were pulling away from stationary when they passed the microphone. At very low speeds traction noise is relatively high compared to rolling noise.
- [31] We therefore consider that it is incorrect to assume that the performance of rail dampers would be ‘marginal’ when used in conjunction with noise barriers.

6 What difference would 3. And 4. make to noise sensitive receptors?

- [32] The quantitative criteria for determining the requirements for mitigation according to the NVMP is summarised in the NSOA as follows:

“[2.3] The assessment of noise uses technical terms, which are described in Annex A (of The Policy). The provision for noise mitigation will be based on two sets of absolute noise levels. The first are ‘Noise Impact Threshold’ levels, below which noise impacts are never significant. The second set of levels are the ‘Noise Insulation Trigger’ levels. These are the noise levels predicted at the most exposed windows to noise sensitive rooms in noise sensitive buildings, and are free-field noise levels.

Noise Impact Threshold Levels: Day - LAeq, (0700-2300 hours) 55 dB

Night - LAeq, (2300-0700 hours) 45 dB

[2.4] Where train noise is predicted to be above either of these threshold levels, but where the level is still less than that set out in the Noise Insulation Regulations requiring noise insulation to be provided, the Promoter will provide mitigation measures to reduce the adverse impact of noise. These will vary according to the extent to which the train noise level exceeds the threshold levels and the extent to which overall noise is increased above the existing or ambient noise level, as follows:

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- *exceedances of 3 dB or greater and increases of 3 dB or greater – mitigation at source through rail infrastructure solutions will be implemented where reasonably practicable;*
- *exceedances of greater than 5 and up to 7 dB and increases of greater than 5 dB and up to 7 dB - at source and/or in the form of noise barriers if reasonably practicable and have no other negative effects; and*
- *exceedances of greater than 7dB and increases of greater than 7dB – at source through rail infrastructure solutions and where these cannot be reasonably practicably achieved, noise barriers will be provided, where reasonably practicable.*

[2.5] Noise barriers or other noise attenuating infrastructure solutions will achieve noise reductions in most areas, to near to the existing noise levels. However residual noise impacts may still occur at particular locations. If, after consideration of the effects of noise mitigation measures at source, any of the Noise Insulation Trigger levels is still exceeded, then noise insulation to relevant properties will be offered, provided the corresponding existing or ambient noise level is routinely exceeded by at least 1dB. Noise insulation will be provided in accordance with the Noise Insulation (Railways and Other Guided Systems) Regulations. The noise level thresholds at which this will be offered are shown below in terms of free-field noise levels that are equivalent to the façade levels provided for in the Regulations.

Noise Insulation Trigger Levels Day > LAeq, (0600-0000 hours) 66 dB (1)

Night > LAeq, (0000-0600 hours) 61 dB

[2.6] Even with the mitigation in paragraph 2.5, some of the properties close to the railway may still experience residual noise impacts that may be classed as 'high'. A 'high' impact is the equivalent of a noise impact of greater than +10 dB. If these properties are not already to be provided with insulation under the Noise Insulation Regulations, they will be offered additional mitigation, which is likely to be in the form of noise insulation.

[2.7] If maximum pass-by free-field noise (L_{Amax}, the instantaneous 'peak' as the train passes) regularly exceeds 82 dB (free-field) at night, this is considered to be a significant impact, based on guidance on the prevention of sleep disturbance, except where ambient maximum noise levels are already above the predicted train noise level. One or two events per night would not be interpreted as regular, but the 8 assumed freight movements each night in Phase 2B are considered to be regular. In those very few locations likely to have such noise effects, additional noise attenuation measures will be taken to include the offer of noise insulation to affected properties. This form of mitigation is particularly effective in addressing night-time noise impacts when noise levels inside buildings are the key factor as regards sleep disturbance. The following additional criterion for noise insulation is therefore being applied.

Significant impact, need for further mitigation likely to be noise insulation: Night > L_{Amax} 82 dB"

[33] The wording of the NVMP is similar to other mitigation hierarchies that have been adopted for other schemes where source based measures are preferred to transmission based measures and that source based and transmission based measures are preferable to sound insulation. In other words, sound insulation measures should be regarded as measures of last resort. The underlying reasons for this order of preference commonly include that:

- All else being equal, the benefits of noise reduction measures at source are universal i.e. not limited to particular directions or orientation;

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- Barriers are limited by physical factors so don't always provide sufficient mitigation.
- The installation of noise insulation is intrusive and its take up cannot be relied upon (the rate of uptake of offers is typically in the order of 50% but can vary significantly from scheme to scheme);
- The benefits of noise insulation are time limited and are not permanent and the noise reduction provided by secondary glazing diminishes over time.

[34] In terms of the outcome for properties along route H, the application of the NVMP has resulted in:

- The provision of noise barriers where properties are expected to be exposed to train noise impacts of between 3 and 7dB above the Noise Impact Threshold Levels without mitigation (Paragraphs 2.3 and 2.4 of the NVMP).
- The provision of noise insulation for properties predicted to be exposed to noise levels (once noise barriers are provided) in excess of the statutory NIRR criteria defined in paragraph 2.5, the non-statutory noise insulation criteria defined in paragraph 2.6 and the maximum criteria defined in paragraph 2.7.

[35] According to Table 5.3 of the NSOA for Section H, noise insulation (in addition to noise barriers) is proposed at 12 receptors (two statutory and 10 non-statutory). Assuming that SilentTrack would provide a benefit of 3dB at all receptors, the effect on the mitigation proposals would be as follows:

- The two Quadrangle House receptors, where statutory and non-statutory noise insulation is proposed, would still qualify for statutory and non-statutory noise mitigation with rail dampers installed, because noise levels would still be in excess of the criteria defined in paragraphs 2.5, 2.6 and 2.7 of the NVMP.
- The following four receptors where non-statutory noise insulation is proposed would still qualify for non-statutory noise mitigation with rail dampers installed: PI 18 (7 First Turn), SoA 11 (4 Bladon Close), PI 19 (3 Bladon Close), SoA 12 (Cedar House, Bladon Close). This is because noise levels would still be in excess of the criteria defined in paragraphs 2.6 and/or 2.7 of the NVMP.
- The following six receptors where non-statutory noise mitigation is proposed would *no longer* qualify for non-statutory noise mitigation with rail dampers installed: SoA 1 (Peartree Hill Farm), SoA 7 (8 Carey Close), PI 17 (396 Woodstock Road), SoA 9 (1 Upper Close), SoA 10 (15 Sheriffs Drive), ES 14 (Wolvercote Primary School). This is because noise levels would *no longer* be in excess of the criteria defined in paragraphs 2.6 and/or 2.7 of the NVMP.

[36] According to Table 5.3 of the NSOA for Section I, non-statutory noise insulation (in addition to noise barriers) is proposed at five receptors. Again assuming that SilentTrack would provide a benefit of 3dB at all receptors, the effect on the mitigation proposals would be as follows:

- The following three receptors where non-statutory noise insulation is proposed would still qualify for non-statutory noise mitigation with rail dampers installed: ES 16 (Cox's Ground), SoA 21 (25 Cox's Ground) and SoA 22 (30-47 Cox's Ground). This is because noise levels would still be in excess of the criteria defined in paragraphs 2.7 of the NVMP.

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- The following two receptors where non-statutory noise insulation is proposed would *no longer* qualify for non-statutory noise mitigation with rail dampers installed: SoA 23 (58 to 92 Stone Meadow) and SoA 25 (94 to 110 Stone Meadow). This is because noise levels would *no longer* be in excess of the criteria defined in paragraphs 2.7 of the NVMP.

Rail dampers could therefore have the beneficial effect of removing the need to provide non-statutory noise insulation, according to the NVMP, at six receptors in Section H and two receptors in Section I.

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