**Innovation in urban integration**

Pandrol’s latest innovations in track design are helping residents in towns and cities to live in harmony with the railways.

Over the past century, the world has experienced a dramatic growth in urbanisation. The number of people living in towns and cities rose from 751 million in 1950 to 4.2 billion by 2018 – over half the world’s total population. Inevitably, these communities need transport, and train, tram and metro networks offer the most sustainable, efficient solution. However, their associated noise and vibration can create issues for the people living and working alongside them, particularly when services are frequent and run 24 hours a day.

WHAT CAUSES NOISE AND VIBRATION?

The founding principle of rail transport is the low-friction, steel-to-steel solid contact between wheel and rail. It is this which makes rail transport so efficient, resulting in low maintenance and high axle load. However, it is also the cause of its greatest problem – noise and vibration.

In urban rail networks, direct noise is primarily due to the rolling sound produced by train wheels and track as they vibrate. This noise travels through the air, from the railway line to the ears of anyone nearby.

In addition, the vibration produced by the solid contact between the steel of the wheels and the steel of the track goes into the ground and travels to nearby buildings, where it is converted into secondary, ‘structure-borne’ noise. Walls and floors vibrate and act as giant loudspeakers, creating a problem for trackside neighbours – even with closed windows!

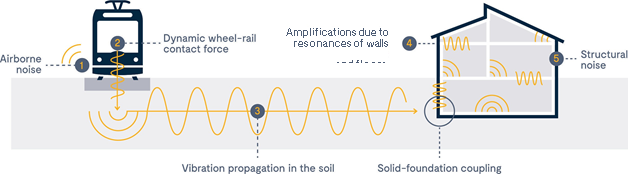
With brand new track and rolling stock the noise is likely to be minimal. However, as soon as there are even slight imperfections in the geometry and surface of the wheel or of the track, vibrations arise and local residents’ complaints grow.

The most common noise is the ‘tac-tac’ sound produced when a train runs over a local defect on the track. There are several potential causes: wheel slips creating a small indentation in the rail; a poorly welded or ground rail; or a rail fixed with fish plates leading to a rail head defect.

Wheel slips – often caused by drivers braking too hard and leaves on the line – can also lead to wheel flats, which create a ‘thump-thump-thump’ noise as the damaged wheels run over the hard rail.

In addition, curves in the track and bridges and viaducts can create noise and vibration issues for those living nearby. In the case of bridges and viaducts, vibration is transmitted into the structure, producing noise that then travels through the air to the people below and alongside. Inaccuracies in the track geometry and the gaps and alignment changes created by switches and crossings can also become a significant source of noise and vibration.

Whatever the cause of the problem, once residents are sensitised to the noise and vibration levels affecting their properties, there needs to be a significant step change to mitigate the disturbance.



**Tackling the problem**

At track level, there are four ways to limit noise and vibration annoyance for neighbours:

• Deliver a new state-of-the-art rail system.

• Monitor and maintain the rail system.

• Reduce track degradation by adding track resilience.

• Mitigate noise and vibration.

In general, prevention is far better than cure! The best way to mitigate the impact of noise and vibration is to integrate countermeasures into the design of any new or upgraded track.ecting their properties, there needs to be a significant step change to mitigate the disturbance.

As this suggests, noise and vibration mitigation should always be a key consideration when building new tramways, railways and metro systems. Construction needs to be carried out carefully to avoid local defects generating noise and vibration, with a focus on smooth track geometry, good wheel design and rail interaction, and effective welding and grinding of the rails. In addition, some resilience is generally built into modern track to attenuate the transfer of dynamic forces from the wheel and rail to the track support, and this provides an initial quality that helps to avoid generating vibrations.

MONITORING TRACK AND WHEEL QUALITY

Maintaining the quality and geometry of the track is essential for the mitigation of noise and vibration. To achieve this, the condition of the track needs to be constantly monitored and any maintenance and repairs carried out efficiently. This reduces the vibration and prevents faults worsening and causing secondary issues. Solutions like Pandrol’s Head Wash Repair welding process are proving particularly successful in this context, enabling the quick, cost-effective repair of defects and flash butt welds.

In addition, active wheel monitoring must be carried out to ensure train wheelsets are in a good state of repair and will not damage the track.

USING RESILIENCE TO CONTROL TRACK QUALITY

Introducing an elastic medium with specific spring characteristics – a resilient system – can also help to maintain high quality over the lifetime of the track. Pandrol’s Under Sleeper Pads (USP), for example, increase the quality of ballasted track by improving ballast contact, reducing maintenance and providing vibration mitigation through fixing elastic elements to the bottom surface of the sleepers.

Having a well-defined stiffness and/or continuous support for the rail also reduces rail corrugation, the subsequent increase in vibration and the need for maintenance grinding. This can be achieved by utilising the continuous support offered by the Pandrol QTrack system®, or high resilience baseplate systems like Pandrol’s Vanguard and Bonded DFF solutions.

ISOLATING TRACK TO REDUCE VIBRATION TRANSMISSION

Creating a mass spring system can further mitigate noise and vibration. As a result of the introduction of an elastic medium with specific spring and damping characteristics, vibration energy remains in the track and is not transmitted to neighbours.

Various levels of vibration reduction can be achieved, using methods ranging from the introduction of soft fasteners through to the integration of very soft floating slab track, depending on specific design requirements and conditions.

Pandrol’s soft solutions include Vipa, Bonded DFF and DEE baseplates, and Booted Block and Under Sleeper Pads. These help to reduce impact and vibration in urban areas with low to medium requirements. Soft Under Ballast Mats offer an alternative for ballasted track.

For many metros, the preferred solution is Pandrol’s Vipa DRS system, which is suitable for installation on non-ballasted track and in areas where a reduction in vibration and secondary noise is required. This features a Pandrol e-Clip baseplate mounted on a studded natural rubber pad that provides the system resilience. The configuration can be tuned within limits to meet requirements for axle loads and stiffness. Vipa DRS has been installed in major cities around the world, including Bangkok, Chennai, Delhi, Dubai, Hong Kong, Istanbul, Kolkata, Kuala Lumpur, Sao Paulo, Seoul and Singapore.

For higher attenuation requirements, Pandrol’s Vanguard and Floating Slab Mat (FSM) systems are recommended.

To monitor the effectiveness of our solutions, Pandrol developed Track Elastic Model (TEM) software. This can be used to simulate conditions at the transition between two different types of track, enabling us to smooth the design and avoid local degradation and resultant increased vibrations.

Products in focus

PANDROL VANGUARD

Our Vanguard rail fastening system has very low vertical dynamic stiffness, resulting in high levels of vibration isolation. A low- profile system, it can easily be retrofitted with various footprint designs and offers high levels of lateral and vertical adjustment. Cities worldwide – including Barcelona, Madrid, Milan, London, Stockholm, Sydney, Sao Paulo, Philadelphia and Boston – have implemented retrofit installations on their railways using Vanguard. In many cases, this has been enough to reduce noise and vibration to a barely perceptible level, eliminating residents’ complaints completely.

PANDROL FLOATING SLAB MATS AND PADS

Floating Slab Mats (FSMs) are installed below the slab track to create a very efficient mass spring system. Working perfectly with both fully-loaded vehicles in daytime and empty vehicles at night, FSMs provide excellent noise and vibration mitigation.

A number of cities have implemented the FSM solution, including Chennai, Sydney, Portland, Los Angeles, Toronto, Athens, Lisbon, Madrid, Roma, Milan, Florence, Bergen, Budapest, Szeged, Sofia, Algiers, Casablanca, Rio and Santiago. In Belgium, for example, the Brussels Tramway STIB- MIVB installed over 150,000m2 of FSMs in its busy urban sectors. Demands were extremely high, as local residents regularly complained about tram noise and vibration in the city’s busy, narrow streets. Since the solution was implemented, complaints have been minimal.

Floating Slab Pads offer an alternative solution for the most demanding areas, with softer pads being substituted for the resilient mats to create an even more efficient mass spring system. This solution is more expensive as it requires the use of precast slab track, but it provides a premium level of vibration mitigation and a system that is easy to install and renew. In use in Barcelona since the late 1990s, the system is particularly appropriate for highly demanding tunnel projects.

CONCLUSION

As urbanisation continues to increase, rail transport lies at the heart of the need to reduce traffic congestion and help the four billion people who live in towns and cities move around in a sustainable way. As a result, minimising the noise and vibration created by urban railways, trams and metros is essential.

As this article suggests, good design and maintenance are key. Moving forward, our industry needs to ensure effective noise and vibration solutions are integrated within new and existing rail networks from the outset, to enable people to live peacefully alongside the railway.