

LEADING THE WAY ON URBAN RAIL

'Noise and vibration' is a term used as though they are one and the same thing. But they are not, and this article aims to give a very brief overview of how they differ. We will also show how a wide range of Pandrol Track Systems group products have a role to play in solving railway noise problems, railway vibration problems, and in situations where both railway noise and railway vibration are both an issue at the same time. Understanding the issues leads to making the best choices.

Let's look first at transmission of vibration into the ground on which the railway track is built. From there, these ground borne vibrations may find their way into adjacent buildings and cause nuisance and annoyance. They may lead to parts of the building (often windows and doors) and its contents shaking and giving off noise. But the aim here has to be to control that vibration and prevent it from getting into the building in the first place. Do that, and any resulting ground borne noise will also be eliminated. Now, the vibrations that we want to control originate at the hard and uncompromising steel-steel wheel-rail contact, as a result of the roughness on the wheel and the rail. We can reduce the roughness by making sure that the wheels and rails are as smooth as possible. But if we need more, then the most commonly employed method of vibration control is to reduce the stiffness of the track or add to the mass of that part of the track that is resiliently

NOISE AND VIBRATION BACKGROUND

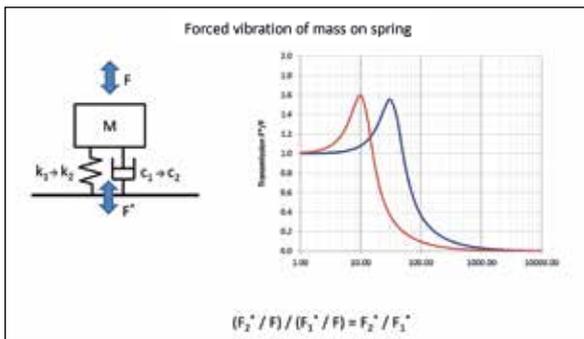


supported. The basic physics is that there will be a 'natural frequency' or resonance at which the mass bounces on the stiffness, with a high level of vibration. At frequencies that are significantly higher than this, it's not possible to transmit much vibration energy through the track and into the

ground. So as we increase track mass or reduce stiffness, the natural frequency reduces, and so does the frequency above which vibration control becomes effective. We eliminate the higher frequencies from our building, because they can't be transmitted through the track structure.

We're off to a good start in applying this method, because most trains have quite a high unsprung mass (below the suspension), which plays a part in the system and is useful in reducing the natural frequency. So we can get quite a long way just by making our track softer, and using the unsprung train mass that we already have at our disposal. The softest track fastenings that Pandrol can supply can be very effective in controlling





ground vibration. In many cases, this is all that is needed to effectively eliminate ground vibration from buildings. But in some special circumstances, for example near theatres and concert halls, we may need to do more, and will need to begin adding mass to the track to reduce the natural frequency further. Small additions of mass will have a limited effect, but resiliently mounted blocks and sleepers have a role to play. These can be mounted on resilient materials supplied by the Pandrol Group company Pandrol CDM Track. For very low natural frequencies and the best performance in controlling ground vibration, we need large heavy concrete slabs, sitting on resilient elastomer bearing. These are 'floating track slabs', which can also be designed and supplied by PCT.

So far, so (relatively) simple. The more mass that is added and the softer the track, the better the reduction in ground vibration. But there are some constraints. Firstly, of course, all this extra mass and resilience has to be designed in such a way as we still have a safe, maintainable operating railway. Secondly, adding mass and resilience tends to increase cost. And thirdly, that extra material and lower stiffness implies that the track itself

may contain more material, which is vibrating at a higher level. And that leads to extra noise being emitted directly from the track itself. Now in some circumstances, that may not be too much of a problem. For example, in a tunnel, the noise from the track won't escape from the tunnel (unlike vibration, which will — unless controlled). As long as the trains are well sound proofed, the extra noise from the track is a problem we can live with. Here we can focus entirely on solving the vibration problem, without concerning ourselves too much with the effects of noise from the track.

But suppose the track is mounted on a structure, and in open air? Then any 'airborne' noise from the track itself has a direct path to anyone standing or living nearby. That adds to noise from the structure, which is what we were aiming to control by reducing track stiffness and adding track mass. Generally, and without going into detail that is beyond the scope of this article, railway airborne noise tends to be controlled by applying the measures that are the opposite of those used to control railway vibration — that is by increasing rather than reducing track stiffness. So to get the best overall solution, with the lowest total of noise from the track plus noise from the structure, we may need to compromise on track stiffness. Pandrol has a whole range of fastening products at different stiffness levels that allow the best solutions to be adopted in each circumstance.

The above is an example in which both 'secondary noise' from a structure and 'airborne' noise from the track (and train) are present. Where tracks run at grade rather than on

structures, secondary noise becomes insignificant and airborne noise is likely to be the biggest issue. Here, an important consideration is how far along the track vibrations are transmitted, and therefore over what length of rail significant airborne noise is emitted. Stiffer track, giving a stiffer connection to the ground, reduces the length of vibrating rail. To reduce airborne noise, tracks with stiffer fastenings and stiffer resilient elements may therefore be required, and Pandrol can provide these. However even here, a compromise in track stiffness will often be required, since the levels of dynamic force generated in the track and transmitted into the sleepers and ballast increase as track stiffness increases. Excessively stiff track can lead to increased rates of development of the roughness and irregularity that leads to noise and vibration in the first place.

Selecting the optimum stiffness for the rail fastenings is an important consideration for standard ballasted track with sleepers. It is also possible to provide additional resilience below the sleepers (under sleeper pads) or below the ballast (ballast mats), which in different ways and to different extents protect the ballast from degradation and affect the overall noise emission from and vibration transmission through the track. Where track is constructed without ballast (as slab track or non-ballasted track), an important source of resilience and damping is no longer available, and the track fastenings plus any additional resilient elements specified have an even more important role to play in determining the overall performance of the track with respect to noise and to vibration.





Catenary-free tramway pioneers light rail in Taiwan

Kaohsiung is Taiwan's second largest city with a population of 2.7 million, and it is investing heavily in modern light rail to support urban growth. Pandrol Track Systems is involved in its first tram project, which will be one of the first in southeast Asia where no catenary is to be installed. The subsidiary involved is Pandrol CDM Track, a company that recently joined the Pandrol group.

The first of two construction phases comprises 8.9 km of double track and is due to be completed in 2015; the second phase should be ready for service in 2017. Work began in the summer of 2013 and the first deliveries of CDM-QTrack® were completed in December of that year. Installation of the track started in January 2014. The technology chosen is a continuously-supported embedded track system without fastenings.

This is one of the first tram lines to be built in Taiwan and as a result some major challenges have been presented. One of them is the absence of local standards applicable to the technology used. To resolve this, European standards had to be applied and adapted for local conditions. The technology used is relatively recent (15 years old) and Taiwan is technologically a very conservative country.

The metropolitan area comprising Seoul and surrounding cities has a current population exceeding 20 million and traffic problems are always highlighted as a major social problem as the city continues to grow.

To improve accessibility of transportation and to promote regional development of suburbs with chronic traffic congestion, several metro projects are being studied and implemented. In the northeast suburbs of Seoul, the UI Metro line is under construction as part of the 'private investment for infrastructure projects' by Seoul City.

The business model employed is BOT (Build-Operate-Transfer); the ownership transfers to Seoul city council after construction, and the UI Trans Co Ltd consortium, formed of 10 construction companies or construction-related partners, will manage and operate it.

Pandrol Korea worked closely with the both the designer, Saman, and KRTC (Korea Railroad Technical Corporation) from the initial design stage to enable a design suited to the project requirements, by suggesting and supporting the optimal technical solution. As a result the Pandrol brand VIPA-DRS assembly was selected as the rail fastening assembly to

SEOUL'S UI METRO SELECTS VIPA-DRS FASTENING TECHNOLOGY

Project Overview

- Total length: 11.4 km (13 stations)
- Scheduled speed: 33.8 km/h
- Designed maximum speed: 80 km/h
- Rail type: KS 50 kg N
- Construction period: September 2009 – November 2016

be installed on the project.

This is the first project installing Pandrol VIPA-DRS in Korea. The total length of the projects is 11.4 km of double track and Pandrol Korea will supply of a total of around 65 000 assemblies of VIPA-DRS from January to July 2015. The trackworks contractor, Sampyo E&C, has constructed 300 m of track using pre-cast slab with 1 620 assemblies of VIPA-DRS, with the rest being erected as in-situ poured concrete plinth track.

The construction method has changed as the project has evolved, from initial installation of pre-cast concrete slab panels to directly-



poured concrete plinth track due to the logistics involved in handling the large panels in the confined tunnel environment. Pandrol has continued to work closely with the trackworks contractor, Sampyo E&C, in order to optimise the construction method now being employed and the construction is now running smoothly.

Installed rail with VIPA-DRS fastening assembly.

INTRODUCTION TO PLASTIC BASEPLATE ASSEMBLIES FOR URBAN TRANSIT SYSTEMS

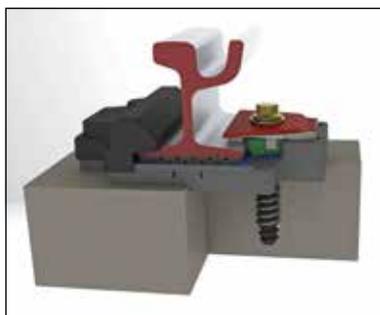
Pandrol Track Systems has almost a decade of unparalleled experience in the field of high-performance plastic baseplates. This is derived from a combination of a strong and ongoing Research & Development programme and a large installed base in urban slab trackforms.

A key example of this pedigree is the Nabla Tram baseplate, which has been developed as the optimised rail fastening choice for tram networks. It is suitable for standard top-down installation, and also for mechanised installation into fresh concrete.

Nabla Tram baseplates have demonstrated their quality and effectiveness many times over, from the first installations in the French cities of Reims and Orleans. Following these initial developments, the product range of urban plastic baseplates has been continuously enlarged and now includes, in addition to the standard Nabla Tram, SEE-SD and DEE-SD assemblies that are designed to give a typical vertical dynamic stiffness of around 60 MN/m and 30 MN/m respectively.

Approaching half a million fastenings

Approximately 250 000 fastening systems with Nabla Tram plastic baseplates have been sold and installed on the networks in Reims, Orleans, Paris, Brest, Le Havre, Lyon, Nice, Besancon, Toulouse, Bordeaux (France); Nottingham (UK), Casablanca (Morocco), Sidi-Bel-Abbes (Algeria) and Kaohsiung (Taiwan). In addition, more than 5 000 DEE-SD plastic baseplates have been installed on the second phase of modern tram construction in Nottingham's second-phase expansion, known as



Nabla-Tram baseplates.



Paris Nabla-Tram baseplates.

NET2 (UK). Last but not least, more than 200 000 fastening systems SEE-SD plastic baseplates are currently being delivered for Santiago metro lines 3 and 6 (Chile).

Proven thanks to the years of commercial service on track with similar systems, the fastenings have been validated in various homologation tests, including those performed by independent laboratories. Our SEE-SD and DEE-SD fasteners maximise the use of common components – for instance the same anchoring design, in order to facilitate installation and future maintenance operations.

SEE-SD and DEE-SD fasteners

In terms of performance and technical validation, the SEE-SD and DEE-SD options have successfully met all the requirements of the latest updates of the EN 13146 and EN 13481-5 standards. In addition, their performance related to electrical insulation complies with EN 13146-5:2012. The level of insulation is at least 30 k Ω between two rail-seats.

A wide range of pad stiffness levels is available for these systems, depending on traffic conditions, track design

as well as requirements on noise and vibration mitigation. They are also compliant with NF F 50-025 and UIC 864-5-0, and can be designed to meet various stiffness requirements.

Baseplate design

The baseplates used in the SEE-SD and DEE-SD designs are made from glass-fibre reinforced polyamide material, in order to provide maximum resistance to lateral loads. The baseplates in both systems also include bespoke vents and channels to ensure optimal insertion in the concrete. These are essential to ensure that the baseplate is correctly embedded in the fresh concrete. The fact that the baseplate is 'locked' into the concrete ensures excellent resistance to lateral forces. Tightening to refusal ensures both the insulated blocks and the SD clips are locked in position effectively. The baseplate is not 'laid' on the concrete but 'anchored' and integrated into the slab. There is consequently no risk of slippage.

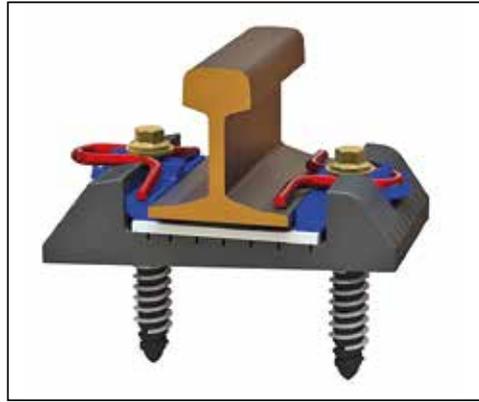
In addition, the stress level in the screws is significantly reduced and as a result the anchoring system is based on the use of two screws, even on tight curves.

SD clips & insulated blocks

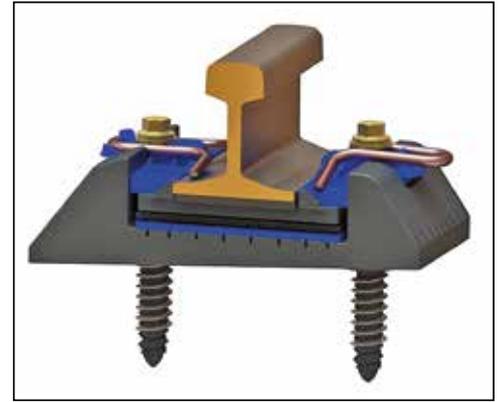
Both SEE-SD and DEE-SD use the SD clip, which had been developed by Pandrol Track Systems to offer a screwed design that optimises track construction costs and offers very high technical performance. SD stands for 'Safely Driven', referring to the controlled clip guidance from the parked to the in-service position. Tightening to refusal is the standard method used on SD systems. Together with this feature, the high elasticity of the SD clip ensures a regular clamping force and consequently a consistent longitudinal restraint. SD clips are manufactured using spring quality silicon manganese steel with standard bar diameter of 13 mm. The static deflection of the clip is more than 10 mm, and this leads to a typical toe load of 9 kN per clip, or 18 kN per railseat.

The SD2 clip is able to withstand a dynamic deflection of approximately 2 mm, thanks to its shape, which is designed so that it works in torsion. This allows the clip to be used on DEE-SD assemblies.

The insulated block is the key component in the interface between the baseplate and the other key track components. Mechanical, electrical and functional features of the fastening system and also its level of performance are directly affected by the design parameters of the insulated blocks. SD insulated blocks are designed using a deep-post insulator, in order to maintain track gauge. This special design combined with the use



SEE-SD E364068c



DEE-SD E364069a

of glass-fibre reinforced polyamide material improves the behaviour of this component under lateral loads.

The major innovation brought by SD fastening systems is based on the design of the insulated blocks: it ensures the optimised guiding of the clip from its parked position to the in-service position. The shape of the block has been specifically developed in order to guarantee an excellent clip translation movement. It also avoids the risk of unreliable clip position during the installation phase.

SD insulated blocks are designed to offer lateral adjustment of the track gauge in increments of 1.25 mm. The

method to adjust the gauge is managed simply by adapting the insulated block combination. Vertical adjustment is achieved through plastic shims enabling level correction up to 30 mm.

Conclusion

Approved through validation tests in laboratory, and also thoroughly proven after years of commercial service, the state-of-the-art plastic base-plates offered by Pandrol Track Systems — Nabla Tram, SEE-SD and DEE-SD — meet the requirements for all urban rail networks, from tram lines to modern light rail and high-capacity metro applications.

Focus on Santiago Metro, Chile

PTS is responsible for the delivery of more than 200 000 SEE-SD fastening systems to a consortium of French rail infrastructure construction and maintenance companies working on the Santiago metro (Chile). This package is part of a 20-year contract for construction and maintenance of lines 3 and 6. Tracklaying and other railway fit-out is due to start by the end of 2015.

Metro crosses the Golden Horn

Pandrol UK supplied Vanguard fastenings for the Golden Horn Bridge in Istanbul, which extended metro line M2 (Taksim – Haciosman) to the Yenikapi interchange with light metro line M1 (Ataturk Airport – Aksaray) and the Marmaray suburban railway. The prime contractor on the project was Alarko.

Over several years Pandrol was involved in discussions with architect Hakan Kiran and Alarko on the track engineering side. Based upon a previous Vanguard installation at London's St Pancras International station, tests were completed to assess the effects of lateral and vertical movement of the structure on the fastening system.

After an extensive review of all options, during which time Pandrol provided technical and design support, Alarko selected the Vanguard system for all track sections on the extension, including steel bridges, the concrete viaduct and in the approach tunnels.





CTA Chicago

Over the past few years, Pandrol USA has been awarded a series of projects at CTA Chicago, and they have been successful in landing the most recent, Ravenswood Loop. CTA continues their efforts to update their track and the Single Resilient (SRS) assembly is the fastener of choice. This latest project includes 20 000 SRS assemblies. Over the past three years Pandrol USA have supplied more than 70 000 SRS assemblies and over 100 000 rolled tie plates. The Ravenswood project is scheduled to complete in 2015.

SUCCESS IN SINGAPORE

Pandrol has been supplying the Singapore metro network with fastenings since the initial construction of two lines in 1987.

One of the latest lines under construction in Singapore is the Downtown Line, the fifth in the city state. The 4.3 km first section of the line opened on December 22 2013 with second and third phases due to open in 2016 and 2017 respectively. When fully completed, the line will be 42 km long with 34 stations and will serve more than half a million commuters daily.

Alstom and CTCL of Taiwan won the contracts for the trackwork for DTL phases 1 and 2 in 2009 and for stage 3 in 2012. Pandrol then signed contracts for the supply of its DFC rail fastening system to both contractors.

The Pandrol DFC System is a double

resilient fastening system designed for slab track applications. The baseplate is held down with clips by using cast-in-shoulders, rather than with bolts. This makes for very easy baseplate removal and replacement.

The sixth new Mass Rapid Transit Line to be built in Singapore is the Thomson Line, running for 30 km from the northern Woodlands area to the Gardens by the Bay attraction. Serving 22 stations, the line will open in stages between 2019 and 2021.

Civil engineering work is now well underway and in 2014 a trackwork contract was awarded to CTCL. Pandrol and its welding specialist partner Railtech were able to make an offer for the supply of fastenings and third rail electrification under very strong competitive pressure. For the first time in Singa-

pore, the Vanguard fastening assembly will be used on those sections of track where an enhanced level of noise and vibration isolation is required. This follows the successful trial on Singapore's Circle Line in 2009.

Singapore also has a substantial programme of work to refurbish the trackwork on the North South and East West lines that were installed in 1987. The North South Line has just had all of its timber sleepers replaced with concrete sleepers and baseplated Pandrol e-clip fastenings. The sleeper refurbishment contract was carried out under very demanding circumstances. Engineering possessions are very short at only 3 h per night over five nights with no weekend access. Physical access to the track is also very limited. In spite of these challenges, 90 000 concrete sleepers have been installed.

A further 90 000 sleepers for the East West Line will also feature Pandrol fastenings; these will use cast-in inserts to accelerate the sleeper replacement process.

Dubai metro

Pandrol's VIPA-DRS assembly is installed along the entire route length of the Dubai metro system. The VIPA-DRS assembly utilises a highly resilient baseplate pad, a single cast baseplate with Pandrol e-clip fasteners and a resilient rail pad, configured so that the assembly is able to provide the required level of noise and vibration attenuation.



MAINLINE THROUGH BELGRADE CENTRAL

The first two mainline tracks through Belgrade Central have been installed using Pandrol's Vanguard, Vipa and

Fastclip FE products. The station development consists of ten platforms on a lower level, with

a large commercial development on the upper level. It was a key design concern that any vibration caused by passing trains would not cause disruption to the retail units above. It was this brief that led to the decision to install 3000 Pandrol Vanguard baseplates on a concrete slab through the main station area.

Belgrade Central also saw the largest installation to date of Pandrol's new Fastclip FE product. These sleepers were used on the sections of track leading up to the station building, where vibration isolation was not as important.



The first phase of Kuala Lumpur's three-line Klang Valley MRT construction programme is the Sungai Buloh to Kajang Line. Running roughly northwest to southeast across the city, it forms the first tranche of an integrated transport system. The programme envisages completion of 51 route-km of metro and two depots.

Pandrol Track Systems is supplying all the rail fastenings for the line and depots. The third rail power supply is also being delivered by Pandrol.

Fasteners

Approximately 320000 VIPA DRS fasteners will be supplied for Line 1. This system is well proven in many metro projects worldwide. It offers low vertical stiffness and is ideally suited to applications where a medium level of track support resilience is required. It combines the proven technology of the Pandrol e-clip in a baseplated system that offers ease of adjustment and maintenance.

The areas of track that are subject to high vibration sensitivity require special treatment. These are predominantly in the underground sections beneath domestic dwellings, offices and other locations where re-radiated noise must be minimised.

Here the Pandrol Vanguard baseplate fastener will be used. As this is the first time this product has been used in Malaysia, Pandrol have been giving on-site demonstrations on how

UPDATED VANGUARD TO SERVE THE KLANG VALLEY METRO



Pandrol has undertaken demonstrations of how to install Vanguard fastenings at a training school in Kuala Lumpur.

to install and maintain the fastener.

A new configuration of Vanguard has been designed that can be retrofitted in place of the VIPA-DRS baseplate without disturbing the rail po-

sition or inclination. This means that in the future, if the track requires an upgrade to provide more vibration protection, this can be done speedily, easily and economically.

PANDROL CDM TRACK: LEADING THE WAY IN LIGHT RAIL AND METRO

CDM-QTrack® technology for trams in Firenze

Firenze, the city that gave the world the Italian renaissance, is experiencing a facelift. With a population of nearly 400 000 and more than 1.8 million visitors each year, Firenze has reached the point where an effective mass transport network is needed.

The city's first modern tramline opened five years ago. Operated by RATP subsidiary GEST, Line 1 is a 14 stop route comprising 7.4 km of double track. Thanks to the success of the first line, a two-line expansion programme is now underway, with Alstom acting as lead contractor.

Pandrol CDM Track will supply nearly 17 km of single track to its CDM-QTrack® specification, a continuously supported and fastened embedded slab trackform where the rail is completely encapsulated by elastic, pre-fabricated, resin-bonded rubber profiles.

In a city where construction time and space is limited, CDM-QTrack® offers several advantages: prefabricated rubber profiles give the option to assemble the trackform far from the worksite. The product is fully compatible with all road finishing so the tramway does not spoil the urban environment of the city, and a completely embedded design provides safety and flexibility to people and vehicles passing over the tracks.

Moreover, QTrack® technology is fully compatible with floating slab



CDM-QTrack® system in Florence.

construction. This method is needed where a high sensitivity to noise and vibrations applies. Pandrol CDM Track is also supplying CDM-FSM technology, a continuous resilient mat installed directly underneath concrete slab tracks and designed to provide insulation. CDM-FSM decouples the track from its surrounding superstructure, thereby protecting street elements, monuments and buildings in proximity to the track. Thanks to vibration isolation levels up to -25dBv, the nearly 34 000 m² of CDM-FSM now being delivered by Pandrol CDM Track will contribute to the preservation of Firenze's historical centre and iconic architecture.

Slab mats appeal to Indian metros

When you talk about the fourth largest city in the second most populated country in the world, then you know mobility is an issue. Chennai is famous for hosting several big players in the automobile, software services, petrochemicals, financial services, textiles and manufacturing industries.

Having previously been the only one of India's five largest cities to lack a mass transit rail network, the first

section of the Chennai metro opened on June 29 2015, with the first train being flagged off by Tamil Nadu Chief Minister J Jayalalithaa.

The first 10 km section of Line 2 runs north on an elevated alignment from Alandur to Koyambedu with five intermediate stations. Construction of the standard gauge line began in June 2009. When completed, Line 2 will extend for 22 km from Chennai Central to St Thomas Mount with 17 stations, with 12.3 km running on elevated alignment and 9.7 km underground. Phase I of the metro also includes Line 1, a 23.1 km route that will link Washermanpet to the airport.

Chennai marks another milestone for Pandrol CDM Track, which is supplying a high performing floating slab mat. The selected option is the CDM-FSM-L06, a two-layer resin-bonded rubber mat used to isolate the noise and vibration by up to -20dBv. The slab mat is intended to limit noise and vibration at several sensitive locations including hospitals and laboratories located above the tunnels.

Want to know more? Visit our website www.pandrolcdmtrack.com or contact us at info@pandrolcdmtrack.com.

