

2014

# TRACK REPORT

The Journal of Pandrol  
Track Systems

 **PANDROL**  
TRACK SYSTEMS

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# Pandrol Vanguard in Japan

Pandrol Ltd, the world leader in the rail fastenings industry has been involved in their supply and design since 1937. Over this time, Pandrol Ltd has developed a number of new products to advance rail technology and improve the materials used in rail fastenings.

Since 1987, Pandrol has been supplying products to Japanese railways. The focus has always been on improving designs, track safety and the introduction of new technology. Many new and unique types of fastener have been successfully introduced into Japan by Pandrol.

## Slab Track Fasteners

Concrete slab track, has evolved considerably in recent decades, particularly in Japan and it comes in many types. Slab track is favoured due to its durability and low maintenance cost. There are a number of rail fastening options available to the slab track designer including the resilient baseplate which anchors the rail to the concrete by means of a resilient fastener.

Conventional rail fasteners use spring clips which apply load to the rail foot. There are limits to the lowest vertical stiffness that can be provided using this method. The vibration performance of the fastener is directly dependent on low vertical stiffness. Therefore spring

clip fasteners are useful to a point, but for improved vibration performance, alternative track support products must be used.

Typically the Japanese standard Direct 8 fastening system has a vertical static secant stiffness of around 20 to 30 kN/mm. In order to significantly improve the vibration performance of such a fastener, a significant reduction in that value of vertical stiffness is required.

## Pandrol Vanguard

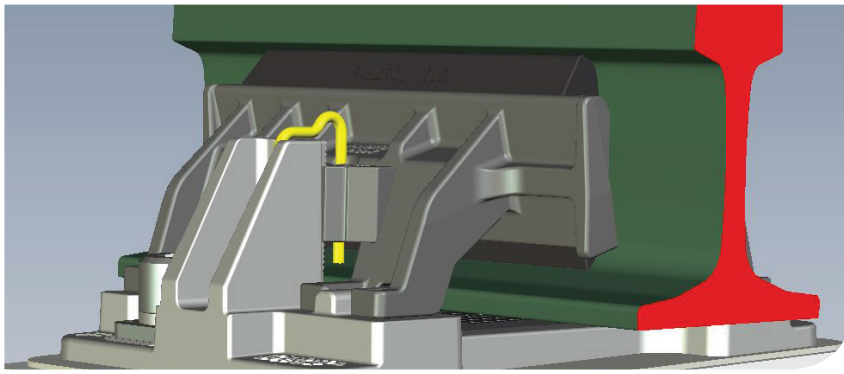
It was on recognising the limit of conventional baseplate technology during the 1990s that Pandrol developed the Pandrol Vanguard system for control of rail vibrations. Pandrol Vanguard

works on a quite different principle to conventional baseplates, by suspending the rail at the web and under its head rather than clamping the rail foot.

Wedge-shaped elastomeric elements are held in compression against the rail, so that as well as being supported, the rail is secured to the track foundation. This clamping force also provides adequate resistance to contain longitudinal loads in the rail. The principal advantage of Pandrol Vanguard over more conventional rail fastenings is that it allows much greater vertical deflections under traffic without excessive rail roll. The low track stiffness leads to improved attenuation in the dynamic forces generated at the wheel-rail interface, thus reducing the level of dynamic forces transmitted through the fastening and into the track foundation and beyond.

The rubber wedge supporting elements deflect in the shear mode, rather than in compression. Natural rubber, known for its outstanding dynamic performance is the elastomer chosen for the wedge. Pandrol Vanguard delivers a vertical static stiffness of 5 kN/mm and a dynamic stiffness of around 7 kN/mm in a safe manner whilst restricting rail roll and maintaining track geometry.

Pandrol Vanguard delivers high levels of vibration attenuation, but at a much lower installed cost than floating slab track. The exceptional vibration attenuating performance of



Pandrol Vanguard has been measured in numerous locations and documented in published technical papers and journals globally.

Since successful early trials on London Underground Victoria Line in the year 2000, Pandrol Vanguard has been installed in more than 14 countries in at least 80 locations. There are more than 70 track kilometres of Pandrol Vanguard in operation worldwide, most of it in Asia.

Against intense competition Pandrol Vanguard was selected for use throughout the St. Pancras high speed rail terminus in London, UK. It was also selected for use in the high speed rail terminus at Kowloon in Hong Kong.

### Pandrol Vanguard in Japan

A retrofit version of Pandrol Vanguard was developed by Pandrol for Japan that directly fits onto the T-bolt anchoring system occupied by standard Direct 8 baseplates on J-slab track. The tight bolt spacing and low rail height presented a challenge to Pandrol's designers, since these two geometrical constraints have to remain constant for a successful Pandrol Vanguard retrofit. A version of Pandrol Vanguard that fits onto 50N rail was successfully developed.

In March 2013 Pandrol Vanguard baseplates were retrofitted in place of existing Direct 8 baseplates on a 100m section of viaduct track between Otori and Hagoromo stations on West Japan Railways' suburban lines in Osaka.

Under live traffic loading Pandrol Vanguard deflects vertically by up to 4mm, which is about three or four times greater than a Direct 8 fastener. Special Pandrol Vanguard "stiffness transitions" were introduced at either end of the 100m trial section where the rail support changes back to standard fasteners.

The viaduct was formed of J-slab on tangent track. Fastener spacing was 625mm, rail inclination 1:40, rail section 50N and the average track speed approximately 60kmh.

The rolling stock was a three car shuttle train that travels between the two stations about five times each hour.

The original track was installed in 1973 and little work or maintenance had been necessary since then. The rail was original and there were few signs of excessive or unusual wear.

The switch from regular to Pandrol Vanguard fastener was conducted during night closures of the track. This ensured that there was no disruption to regular operating services.

Planning work by West Japan Railways was excellent and each operator knew their function well. Training sessions had previously been held, which meant that despite some unfamiliarity with the Pandrol Vanguard assembly there were no unforeseen problems.

Existing Direct 8 baseplates were completely removed, but the bolts were left in situ for anchoring the new Pandrol Vanguard assemblies.

A team of 10 operators worked on the first night installation, a number that was reduced to five for subsequent nights (the extra workers were initially

needed for unloading baseplates from the works locomotive). Over a period of four nights a total of 324 Pandrol Vanguard assemblies were fitted into the entire 100m trial section of the track.

West Japan Railways (WJR) had undertaken wayside noise measurements several days prior to installation. These measurements were taken in three locations – (i) adjacent to the track at about rail height (ii) under the viaduct and (iii) approximately 12.5 metres away from the viaduct. Further noise measurements were taken once the Pandrol Vanguard installation was complete. Track deflection figures as well as vibration readings inside the driver's cab of the shuttle train were also recorded.

WJR are conducting a full investigation into the noise levels emitted by the viaduct and they will publish a full report in due course. The findings of that report are expected to confirm the preliminary recordings made shortly after traffic started running over the trial section of track. Sound readings immediately under the viaduct give the insertion loss for the switch over to Pandrol Vanguard. They record structurally radiated noise and are thus a direct measure of the vibration efficiency of the track support. Data supplied by WJR shows that there have been noise level reductions of between 6dB(A) and 8dB(A) measured for traffic travelling in both the up and down directions. Total noise levels for a single train pass event under the viaduct have been reduced down to around 70dB(A).

As well as noise levels, WJR continue to monitor the track and rail condition at regular intervals. This gives assurance that all aspects of normal operations remain unaltered. The only noticeable change in track performance to date is the reduced vibration and structural noise that Pandrol Vanguard delivers. This provides a real benefit for nearby residents.



# Pandrol VIPA

On Reading Station, Network Rail, UK



Map data: Google © 2014 Infoterra Ltd & Bluesky

The expansion of the station at Reading has been a major project for Network Rail that has extended over nearly 6 years from design preparation to conducting the works programme. The need to extend the station was identified when Network Rail pinpointed the main bottlenecks to further expansion of passenger and freight services around the network.

The objective of the Reading expansion was to improve the flow pattern of trains both through and into the station. Careful consideration was given to the demands of freight services, which can inhibit flow and were restricted to night time operations. The aim was to create a new layout in and around the station and improve the flow for both passenger and freight services. This was the largest single project for Network Rail over the period, costing over £850 million and involving new platforms, new bridges, expansion of the station buildings, new signalling, new turnouts (S&C) and changes to both train and pedestrian flow patterns.

The pedestrian routes around the station have been changed and improved, including the refurbishment of an existing subway beneath the track. The route of the subway leads under one of the altered platforms, with alterations to the vertical alignment requiring a new 'lid' for the subway in order to lower the track. This was further compounded by the need to change rail sections at a later stage, so that the design had

to provide the ability to swap the rail section following the initial installation.

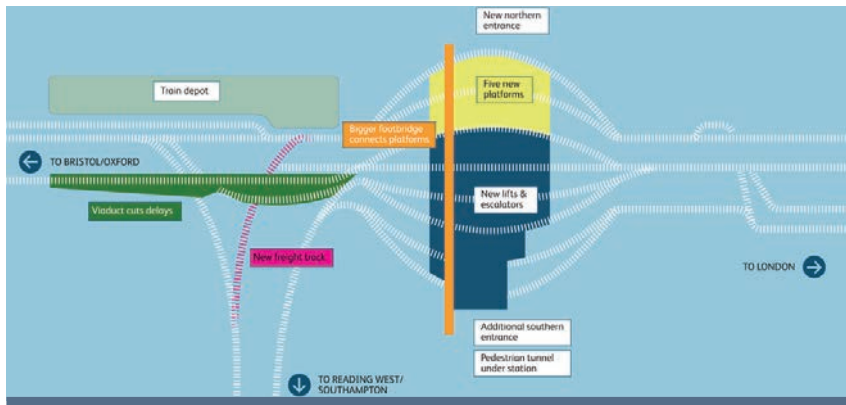
The 'lid' design became a prefabricated concrete element to bridge the two sides of the subway walls, providing a very thin structure between the trains and pedestrians. This needed to have vibration mitigation to ensure that the walking route was cushioned and quietened from the trains moving overhead. The prefabricated nature of the 'lid' also allowed the complete unit to be craned into its final position during a weekend possession, keeping disruption of service to a minimum.

The Pandrol VIPA-SP system was selected by the consulting engineers, Corus, to provide both the vibration attenuation and the necessary degree of adjustments, both vertically and laterally. The Network Rail team led the main JV contractor Costain / Hochtief to undertake the planning and control the work. The specialist subcontractor Cleshar was appointed to install the structural 'lid' and track works. The 'lid' itself was cast by the Irish prefabricator

Concast Building, and was delivered to site ready to install the Pandrol VIPA-SP baseplates in-situ prior to the date of the possession. It would then be lifted by crane into position. The adjustment range of the baseplates was used both to adjust the alignment following the installation of the structure, and in the longer term to provide for the replacement of the rail, which was to change from 56E1 to 60E1.

The vertical alignment achieved with the new track had to remain in the same position following the exchange to the larger rail section. In order to achieve this result, on initial installation the baseplates were fitted with underlying removable shims that allowed the baseplate to be lowered and the taller rail section to be installed without altering the position of the head of rail.

The double resilience of the baseplate assembly provides a dynamic stiffness of about 20 kN/mm, and is considerably softer than the ballast track at either side. The location is on a 'through platform' at Reading station and



**Improved flow pattern through Reading station**

The photographs and illustrations are reproduced from the Network Rail website for the project.



**Artist's impression of the expanded Reading station**



**The prefabricated concrete 'lid' during the delivery and training of the installation team**



**The interior of the pedestrian subway with high surface quality finishes and vibration attenuation provided by Pandrol VIPA-SP baseplates supporting the track overhead**

bi-directional movement of trains had to be considered. Additionally, the line speed varies between passenger and freight trains, which also have different axle loads, and loading is made more complex by braking and acceleration forces. It was decided to adopt a transition length on each side of the subway 'lid', over which the stiffness of the track could be increased in small steps to approximate that of the normal ballasted track. In this way the stiffness transition could be smoothed, reducing the impact loads and moving them along the track and away from the structure.

The transitions were created using pre-stressed concrete bearers supplied by Cemex Rail, which were delivered to site fully fitted with the Pandrol VIPA-SP baseplates. These baseplates included rail pads selected to increase the stiffness of the assembly and provide the necessary small step changes in the overall resilience of the track. This resulted in the track stiffness changing progressively over the various track structures. The change in the stiffness of the track as trains pass along the

platform area starting from the standard G44 sleepers in ballast is from about 60 kN/mm, to 30 kN/mm on bearers of the transition, to 20 kN/mm on the 'lid' of the subway, then returning to 30 kN/mm on the opposite transition and finally back to 60 kN/mm on ballast.

Advice and training was provided on site to the specialist subcontractor Cleshar on best practice for the installation of the baseplates following the delivery of the precast concrete 'lid' unit, and also an adjustment to the track after the positioning by crane.

The expanded station opened to the public in Spring 2013, although some areas outside the station continue to be improved and the final completion of the project is scheduled for Spring 2015.



**The concrete 'lid' of the subway after installation and opening to traffic**

# Pandrol VIPA

On the Coleraine Bridge, Northern Ireland



The bridge over the River Bann at Coleraine in Northern Ireland forms part of the rail route between Belfast and Londonderry. The route to Londonderry has been described among the most scenic railway journeys in the UK, ranking alongside Fort William to Mallaig, and Settle to Carlisle.

The refurbishment of the Bann Bridge, a well-known landmark and lifting bridge, is a key part of the upgrade for the Belfast to Londonderry route, in order to increase line speed over the bridge, as part of the route improvements prior to the appointment of Londonderry as the 'European City of Culture for 2013.'

The current activity, the first of three phases, includes bridge works, track refurbishment and a total renewal of the two end sections of line. The Coleraine to Londonderry section of track dates back to the 1970s and its condition had deteriorated significantly due to age and other factors.

The purpose of these works was to carry out a renewal of the track to ensure that services can continue to operate for the next 30 years.

The bridge is a multi-span steel structure with a central bascule lifting span to permit access of river traffic into Coleraine.

The track on the fixed spans comprises shallow ballast in the trough of the bridge, which is reinforced with transverse steel ribs creating fluctuating ballast depth and irregular sleeper spacing making tamping difficult.

The lifting span is an open lattice steel structure decked with timber planks.

The increased mass of new trains and the stiffer bogies increases the impact and vibration forces. This resulted in the choice of the Pandrol VIPA-SP system to mitigate the vibrations and attenuate impact strains in the structure.

The Pandrol VIPA-SP baseplate was fitted to timber sleepers prior to delivery for the ballast sections, and fitted directly to the timber deck on the bascule lifting span.

The successful conclusion of the refurbishment has permitted the increased line speeds over the bridge, and extending the life of this 89 year old structure for another 30 years. The route between Belfast and Londonderry has been saved for a further generation allowing the coastal route to be enjoyed through the period of the Londonderry European City of Culture, and into the future.



Route between Coleraine & Londonderry



Bridge before the refurbishment, April 2012



Fixed spans with Pandrol VIPA-SP on timber sleepers in ballast



Bridge after refurbishment, April 2013

## BANN BRIDGE FACTS

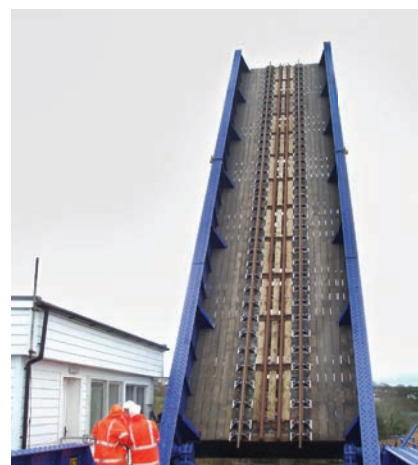
- Opened March 1924 by LMS
- Original Design Engineer: Joseph Strauss (American Structural Engineer, who also designed the Golden Gate Bridge in San Francisco)
- Refurbished July 2012 to March 2013
- 11 Span viaduct
- Spans 1 to 5: length 77 feet (~23.5m)
- Spans 8 to 11 are curved. The centre line spans each 75 feet (~22.9m)
- Spans 6 and 7 comprise the pivoting deck, where span 7 of 85 feet (~25.9m) lifts upwards, and span 6 of 20 feet (~6.1m) houses the counterweight and drops downwards
- Contractor for the refurbishment McCann BAM Rail Joint Venture
- Civil Engineering Consultants: Mott MacDonald
- Client: Northern Ireland Railways; Translink
- Project and Cost Manager: Arup Associates



Detail of lifting joint and receiving blocks



Train from Londonderry to Coleraine and Belfast on the lifting span



Lifting spans with Pandrol VIPA-SP fixed to the timber deck



# Pandrol Fastclip FE Installation, Malaysia

Author: Ross Simpson, Track Manager (Technical)  
MMC Gamuda Joint Venture, Malaysia

The 330km Ipoh – Padang Besar route in Malaysia forms an important part of the Bangkok – Singapore rail connection. Currently the infrastructure consists of a single metre gauge non-electrified track on a sinuous alignment. The infrastructure is life expired and a major improvement programme is now underway.

The line is being doubled, electrified and curves eased. The trackform is being renewed with new concrete sleepers, rail and ballast. When this work is completed, new electric train units will travel the route at speeds of up to 140km/h.

Sleepers with Pandrol Fastclip FC are being used but the opportunity has been provided by KTMB to install a short test section fitted with the latest Pandrol Fastclip FE system during the construction staging and migration works.

Like the older Pandrol Fastclip FC, the Pandrol Fastclip FE system is a resilient, threadless rail fastening system with the unique Pandrol Switch On – Switch Off System that enables fast efficient track installation and reduced maintenance costs.

Pandrol Fastclip FC sleeper moulds were modified by Mastrack who have been producing concrete sleepers in Malaysia since 1982. This mould was then used to produce 100 sleepers for the test installation.

Pre-assembly of the fastening components was carried out at the factory using a Factory Assembly Tool. The opportunity was also taken to fit a Studded EVA Pad which offers low stiffness with high durability and low cost instead of a studded natural rubber pad.

Installation of the sleepers took place just south of Bukit Mertajam Station under the supervision of MMC-Gamuda Joint Venture who are the main contractor for the project. Laying of the sleepers was carried out by an excavator fitted with special lifting hooks. Rail threading was easily accomplished and it was found that the revised design of sidepost insulator made this process even easier than it is with the Pandrol Fastclip FC system.

Clipping up was by hand using latest standard Fastclip handtools provided by Pandrol, and comments from the crew were that it was easier and quicker to clip up than the earlier system.

A return visit was made to de-stress the track length. The opportunity was taken to use Vortok Stressing Rollers. These are rollers that combine the function of underroller and side roller in one easy to use unit.

The sleepers are now under traffic and the test section is expected to remain under main line traffic for a period of one year at which time it will be recovered, componentry inspected and a performance report produced. An interim inspection after six months of traffic has confirmed that the components remain in excellent condition.



Finished Pandrol Fastclip FE sleepers being checked at the Mastrack factory



Installation of sleepers at site



Clipping up after destressing



Handtool close up



Vortok Stressing Rollers



Completed installation

**The Pandrol Fastclip FE system develops on the Pandrol Fastclip FC system and offers:**

1. An innovative seal plate system that simplifies the sleeper moulding process
2. Robust insulator components
3. Efficient use of materials leading to lower overall cost
4. Pandrol Fastclip FE hand tools are also compatible with Pandrol Fastclip FC

# Pandrol Fastclip FE

On London Underground Limited, UK



Track Partnership, a collaboration between London Underground and Balfour Beatty Rail, has successfully launched the first new sleeper on London Underground in the last 30 years.

The new 1502 is a high quality sleeper, produced by Cemex Rail Solutions which provides improved reliability, greater longevity and offers faster installation of new track.

The major innovation of the new sleeper is that it is pre-assembled incorporating the Pandrol Fastclip FE fastening system, using the highly efficient FE1404 clip, which is designed for automated installation.

This new system is a bespoke solution for London Underground and has been developed in response to the growing need to construct track faster, safer and at a lower cost with reduced maintenance requirements. It comes complete with all insulators and pads installed into the 'parked' position, which mechanically hold the side post insulators and pads in place. This allows five existing on-site steps to be reduced to just one as the sleepers arrive on site

complete with all components ready to thread the rails onto the sleepers and automatically drive the clips onto the rails.

The first installation was a ballasted track renewal on the Metropolitan line between North Harrow and Harrow on the Hill, on the Southbound Local (SBLO).



## Sleeper Installation

Approximately 800 NTF1502 Cemex concrete sleepers fitted with the Pandrol Fastclip FE system were installed using a Harsco Rail New Track Construction (NTC) machine. The NTC machine is capable of laying 1.5km of track per day in continuous operation, improving productivity, safety, efficiency, and quality. The NTC can work with concrete, pre-plated wood, or steel sleepers and provides an efficient and effective method of laying new track.

The NTC machine started laying sleepers on a Sunday morning at 8.45am and finished at 11.00am.



## Stressing

Stressing of the site commenced at 11.00am on Monday four hours ahead of schedule and was completed by 4.00pm. Sleepers were unclipped and re-clipped using a combination of Robel 34.01 machines, with no problems encountered during this process.

Vortok Stressing Rollers (VSR's) were also used during the distress.

During re-railing trials the system was proven to be twice as quick as the previous system in use on the London Underground network.

Introducing the new sleeper has been no simple task. It has required extensive co-ordination across the whole network and the supply organisations. When installed with the New Track

Construction (NTC) train, the new system will enable the Track Partnership team to make huge steps towards increasing productivity and efficiency on London Underground as part of its drive for a world class underground for a world class city.



# Rail Fastenings for Heavy Haul Applications

Author: David Rhodes, Former Technical Director  
at Pandrol Ltd, UK

The following article summarises work which has been presented recently in more detail at the International Heavy Haul Association (IHHA) meetings in Calgary in 2011 and New Delhi in 2013 and at the "3rd Railway Gathering" organised by ANTF at Juiz de Fora, Brazil, at the end of 2011.

On the face of it, rail fastenings are not required to do anything more in Heavy Haul applications than they are in any other railway. Heavier rail sections and closer sleeper spacing can compensate for higher axle loads and the loading on the fastenings does not need to be any higher than usual. However, in practice the demands of the specialist

Heavy Haul operators are such that quite different approaches to track component design are usually necessary.

The detail design of rail fastening systems affects parameters such as track gauge, track stiffness and rail inclination, all of which affect, in turn, wheel-rail interface mechanics. Of course that

all makes the fastening specification a critical factor in keeping railways running smoothly, but in the case of the Heavy Haul railways three additional factors are highlighted which combine to make these requirements even more challenging.



## High Annual Passing Tonnage

Firstly, compared with conventional railways, the annual passing tonnage of Heavy Haul railways can be very high. In conventional applications 20 million tonnes per annum constitutes quite a busy line. In Heavy Haul operations 200 million tonnes per annum is not unusual. The obvious effect of that is that if components still require maintenance or replacement after the same accumulated passing tonnage, that maintenance requirement is reached in a much shorter elapsed time. What is less obvious is the effect which that has on life cycle cost analysis. Maintenance

activities which would be discounted to negligible net present value on a conventional railway, because they would occur so far in the future, are much more significant on the Heavy Haul railway.

At the detailed level of the rail fastenings the cost of maintenance and replacement does not lie in the cost of the components themselves but in the cost of labour and track closures. There are considerable economic benefits in replacing small track components only when other maintenance work, such

as re-railing, is being carried out. That suggests that considerable savings can be made by ensuring that the life of fastening components exceeds the life of the rail – and that becomes more of a challenge as rail lives are extended, with the major US Heavy Haul railways now expecting rail to last for 3 billion tonnes of traffic in tangent track. In the case of a Heavy Haul line with high annual passing tonnage the net present value of such savings is high enough to justify investment in more durable components.

## High Traction Forces

Secondly, the effects of traction forces on longitudinal track stresses can be very significant. For most railways, once track has been designed to cope with forces due to thermal expansion and contraction of the track and the maximum expected braking forces then it will by default be strong enough to withstand the applied traction forces. In Heavy Haul applications that is not the case. On uphill grades the sustained application of high traction forces,

train after train, can induce track failure modes not seen elsewhere. Usually the first sign of failure is uneven movement of sleepers which become skewed and displaced relative to the rails and the ballast.

The solution to the problem lies in the design construction and maintenance of a high quality track bed and in attention to the selection of rail fastenings with appropriate longitudinal shear elasticity.

Tests carried out on several railways over a number of years have shown that different types of rail pad which have similar performance in conventional type-approval tests do, nevertheless, give quite different performance in terms of mitigating the effects of high traction forces.



## Extreme Climates

Finally the Heavy Haul railways are unusual in demanding all of these things in some of the most hostile environments our planet has to offer. As deposits of minerals - especially iron ore – are exploited in ever more inaccessible places it becomes necessary to construct railways which can be built, operated and maintained in extreme climatic conditions. For components made from steel and concrete that is not too difficult, but there are two things in particular which function quite differently at extremes of temperature and humidity. The biggest technical problems are those associated with

plastics. Within the rail fastenings system plastics are used to provide electrical insulation, resilience and sometimes sacrificial wear elements. Materials such as nylon function well in most climates but are softened in hot, wet conditions and become brittle in dry conditions. A significant amount of work is being undertaken to find additives which can mitigate these effects or to evaluate the use of completely different engineering polymers which may not give the best performance in “average” conditions but which work acceptably well across a wide range of extreme environments.

The other thing which does not function so well in extreme climates is the human body! This may not sound like a technical issue but the fact is that we still expect to use a great deal of manual labour for track construction and maintenance. When Heavy Haul lines are built in inaccessible and inhospitable places the pressures to introduce more automation and to extend maintenance intervals are increased because of the additional human factors which must be taken into account.

## Specifications and Standards

Most Heavy Haul railways which are being planned or built today are being planned or built today are proposed not by established railways but by mining companies. The railway becomes a part of the mining project because it is the most economical and reliable way to move bulk commodities from source to consumer and so in most cases the whole job of designing, building and even operating the railway is put out to competitive tender in the same way as any other capital investment. That process requires a specification of technical performance which can be written into a commercial contract. The problem is that no

established technical standards take into account the kind of factors which have been discussed above. To make it even more difficult, technical standards which exist within individual railway networks are closely interdependent. For example, the calculation of the loads which are applied to test a sleeper or rail fastening system is based on assumptions about the stiffness and consistency of the track bed. That in turn is based on another assumption, that track maintenance limits specified elsewhere in the system will be observed – and those limits are based on empirical assessment of particular track and traffic conditions.

Simply adopting technical specifications from one railway and applying them to another in a different part of the world is rarely sufficient. The Heavy Haul railway industry has an enviable record of sharing technical knowledge through organisations such as IHHA. It is through that process that best practice can be ‘exported’ to new and more challenging projects.





# Pandrol ZLR (Zero Longitudinal Restraint)

For Kellingley Colliery, UK

Author: Nigel Keightley, Senior Asset Engineer (Track)  
Network Rail, UK

Continuous Welded Rail (CWR) has provided great benefits to railways all over the world by eliminating rail expansion joints and hence reducing maintenance costs. In order to account for the removal of these expansion joints, rails are usually pre-tensioned at installation, so that rails are stress free when their temperature is circa 27°C. This is referred to as the stress free temperature (SFT), and when combined with a good ballast profile and a robust fastening system the track should be resistant to buckling during the peak summer temperatures.

Engineers manage their 'safety of line' responsibilities by understanding the SFT and track condition across the routes under their control. For most railway engineers this is a routine and well understood engineering concept.

However, introduce nearly 1.5m of ground movement beneath the track from mining subsidence, and the tracks resistance to buckling can change remarkably quickly. In order to keep trains running safely, maintenance teams have to be available around the clock to carry out preventative and remedial works as they arise.

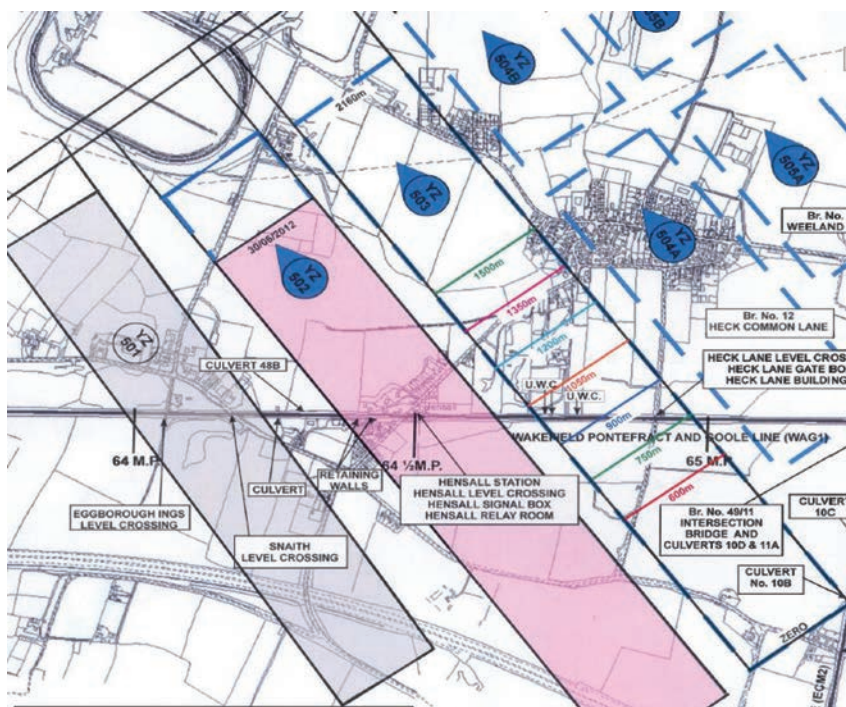
This is the challenge posed by the current mine workings from Kellingley Colliery in Yorkshire. The mine operator is extracting the coal in 'blocks' referred to as panels, from a seam almost 3m thick, at a depth of 800m below the surface. The method, known as 'longwall' retreat mining, mechanically extracts

the coal laterally across the 350m 'face' of the panel and the roof of the resulting void is deliberately allowed to collapse behind the extraction machinery. These panels of coal, which are around 2.4km long, are remote from the pit head, and at Kellingley Colliery the coal extraction starts about 11km away and retreats back towards the mine shaft via underground roadways.

Subsidence can occur relatively quickly, the rate of surface settlement has been known to exceed 200mm per week during rapid settlement. As the coal face passes beneath the railway at a relative angle of 50° the location of peak settlement moves along the track. The development of the subsidence basin can create differential settlement across the rails, and has resulted in isolated increases in cross level of up to 10mm, as well as laterally shifting the track by up to 75mm.

The large associated longitudinal ground movements which are generated have a significant and detrimental impact on the SFT across the length of the CWR affected. In order to keep the track open to traffic, it became necessary to measure the SFT in the rails daily and re-stress the track every weekend during the rapid settlement phase. The degree of compression and tension induced into the rails as the ground moves longitudinally is illustrated by the strain profile graph. The centre of the site is known as the compressive zone; here the ground may experience compression of up to 3mm/metre. At the extremities of the site the ground experiences up to 1.5mm/metre of tensile strain and is therefore referred to as the tensile zone. Under normal circumstances the tensile and compressive strains in the ground are transferred to the rails through the ballast and sleepers and thus the SFT is altered significantly as the mining progresses. If no





intervention occurs, the compressive force developing in the centre of the site could result in a reduction of SFT of 240°C (increase in compression of 580MPa). A significant loss of SFT could rapidly lead to a track buckle, even at winter weather temperatures. In the tensile zones an increase in SFT of 120°C (increase in tension of 290MPa) could be experienced, which could lead to rail fracturing or curved track displacing laterally especially during the winter.

The traditional methods of correcting these huge SFT variations during the British Rail era place an almost unmanageable demand on Network Rail's resources, with the associated high labour costs being passed onto the mine operator. The need for a less resource intensive and more cost effective track management technique led Network Rail to investigate best practice from other railways experiencing similar sub-surface mining issues.

Personal contact was made with Australian consultant railway engineers Allan Pidgeon and Graeme Robinson, working for Hyder Consulting in Sydney, and site visits to New South Wales (NSW) Australia were arranged. This facilitated discussion on similarity in operating conditions and current asset management practices in both countries. In NSW the mining industry needed to demonstrate to regulators that they were able to work coal from beneath the railway, without affecting the operability

of the Main Southern Railway, operated by Australian Rail Track Corporation (ARTC). A review of methods used on ARTC and Network Rail infrastructure identified similarities in practices and management approaches, however it became clear that the Australian engineers had developed a novel, effective, and low cost methodology based upon the concept of the Pandrol Zero Longitudinal Restraint (ZLR) or 'rail free' system.

The methodology introduced multiple sets of adjustment switches and ZLR fastenings into the affected CWR, intermediate short 'anchor' lengths of traditionally fastened rail prevent migration of the rail under traffic. This effectively splits the rails into multiple sections which span through the compressive and tensile zones. Adjustment switches are frequently used in the UK to protect jointed track, un-strengthened switches and crossings or novel track designs on bridge decks from the forces induced in adjoining CWR, however adjustment switches had not previously been used in this 'free rail' configuration.

The rails were held in position with the Pandrol ZLR assembly; this isolated the rail from the effects of the ground strain by allowing it to move independently of the sleepers. This effective decoupling of rail and sleeper allows movement due to ground strain and thermal expansion to be accommodated by the opening or

closing of adjustment switches, hence avoiding build up of excessive rail stress.

Kellingley Colliery's operations will be affecting Network Rail's assets both on the Wakefield to Goole line (WAG1) and East Coast Main Line (ECM2) during the next six to eight years. Up to 2 miles of track on each route will be affected, as several panels of coal are worked from two separate seams of coal. Therefore the development of the most effective method of managing the sites was an essential part of the asset management process.

For the most recent panel, YZ502 in the Beeston seam, Network Rail opted to install seven sets of adjustment switches in each of the two tracks on WAG1, covering both tensile and compressive zones. In addition to the use of Pandrol ZLR assemblies, short anchors consisting of standard Pandrol components were located centrally between adjustment switches in order to prevent the rail from migrating under traffic. Network Rail also worked with suppliers to develop rail strain and adjustment switch gap monitoring equipment. This resulted in 88 strain gauges with rail temperature sensors and 56 linear potentiometers being installed and monitored from seven trackside control stations. The data was remotely interrogated allowing engineers to assess system conditions on a daily basis. It was demonstrated that rail movement from both thermal forces and subsidence ground strain



migrated through the ZLR fastenings and was accommodated by the adjustment switches, which had to be periodically reset.

The system significantly reduced the impact of ground strain avoiding build up of excessive rail stress. Additionally the remote monitoring, with pre-set trigger levels, alerted engineers to the development of any abnormal conditions.

As predicted, it was observed that the gaps in the adjustment switches closed within the compressive zone and widened within the tensile zones. Using strain profiles and coal face position, it was possible to predict when remedial action may be required. The remedial work predominantly consisted of re-setting the adjustment switches. This was achieved by removing narrow slices of rail around adjustment switches in the compressive zone, or the insertion of wide gap aluminothermic welds, to close up the adjustment switches in the tensile zones.

The ZLR assembly design received Network Rail product approval for both the older F27 and the more recent F40 sleepers, with a solution based around the Pandrol e-Clip fastening. In addition there were a large number of G44 sleepers in one track on the site, employing the Pandrol Fastclip fastening, where an alternative design had to be derived. This required a

new ZLR Fastclip toe-insulator to be procured, which proved impractical prior to the onset of mining activity during 2011.

This required the two tracks to be managed slightly differently. Both the Up and Down lines had adjustment switches installed throughout, however the absence of ZLR fastenings on the G44 sleepers on the Down line resulted in the ground strain being transferred from the sleepers into the rail. Throughout this G44 length, rail stresses built up more significantly than in the adjacent F27 and F40 sleepers, thus proving the effectiveness of the ZLR assemblies. In order to manage this build up the Pandrol Fastclip's were unclipped regularly during active settlement allowing the stresses to equalise along the rail. Whilst this proved a valuable learning experience, Network Rail will be installing ZLR Fastclip toe-insulators in the G44 sleepers for future worksites.

At the limits of the site anchor resistance plates were established within the CWR, together with traditional rail anchors this provided added longitudinal resistance against migration of rail at the boundary between conventional track and the ZLR system.

The track asset, which has now undergone almost 1.5m of subsidence, has been managed without incident. The structures and buildings adjacent to the track have however suffered significantly

over the course of the settlement. The large deformations and structural failures help to demonstrate the magnitude of the forces that develop during subsidence, underlining the nature of the challenge.

The timing of coal production from Kellingley Colliery resulted in the next panel affecting the railway beginning Autumn 2012. This provided the track engineering team adequate time to prepare themselves and the operational railway for the next challenge presented by one of the largest operational deep mines in the UK. With international co-operation Network Rail learnt a lot during 2011 and 2012 and these systems will continue to be developed in the years to come.

*Nigel Keightley would like to thank Network Rail's maintenance and route asset management teams for delivering this phase of the work, as well as Allan Pidgeon and Graeme Robinson for their advice on the lead up to this project, and Ross Barber Team Manager, ATRC Moss Vale for facilitating the site visits.*

# Vortok AWS Magnets

For Network Rail, UK



In the UK, trains are prevented from passing through a red “stop” light by a system known as AWS (Automatic Warning System). A pair of magnets are placed in the track some 200m before a signal. A passing train detects the first magnet and the system is armed for automatic application of the brakes. Depending on the state of the second magnet, the brake signal is either cancelled or applied. The driver receives a visual and audible warning in the cab and must acknowledge the warning or the brakes are applied automatically. This system is active on the majority of lines in the UK and has successfully reduced incidents since its full introduction in the 1950s. There are currently no plans to replace the system.



## The Magnet Design

It was against this background in 2005, Vortok received a call from a senior engineer at Network Rail requesting that we look at developing a modern version that eliminated the problems with the existing magnets.

Vortok have been developing products for the railways for many years and have gained a reputation for innovation and success with many railway authorities, including Network Rail. It was as a result of our development of the temporary AWS magnets used for speed restrictions at worksites that lead to this enquiry.

The design of the AWS units is based on a combination of magnets and coils which enabled the signaller to control a magnetic flux field to be picked up by the passing train. The magnets are either a permanent magnet, an electromagnet or a suppressed magnet (a permanent magnet that can have its field turned off by an opposing coil). In the event of a trackside power outage the system failed safe and all trains stopped.

The 1950s' design of AWS magnets used ferrite magnets, rubber or cork insulation, pitch potting, cotton wound coils and shellac lacquers. A ferrite magnet cannot produce a strong magnetic field and so the magnets were large to compensate. Ferrite magnets also have a poor resistance to being demagnetised by external fields and so every time the suppressed magnet was turned on, the ferrites strength was diminished. Over a period of time the magnets performance fell outside the design specification and the magnet had to be replaced and serviced. This was particularly true of the extra strength ("green") version.

Due to the amount of ferrite required to produce the flux field, the magnets were large and contained a "sump" which displaced ballast between extra widely spaced sleepers. The weight of the units was significant and lifting equipment was essential to install and remove them from track.

Over time the seals gave way and water ingress was the main failure mode, exacerbated by fractured insulation on the coils and supply wires.

The coils were directly powered from the line side supply and with changes in temperature the resistance of the coils changed so the magnet field strength varied. If the cable run to the AWS unit were long then the variation of flux could be significant and missed signals were often reported by drivers.

Vortok listened to the main objections and the desires of the installers and maintenance teams and incorporated the feedback into the design of the current product range. The fundamental enabler for the new design was the use of modern rare earth magnets (Neodymium Iron Boron - NdFeB). This material has a high flux density for its mass and so powerful magnets can be made very much smaller than the ferrite equivalent. This permitted a much smaller format unit to be designed which removed the need for a "sump" on the unit, the weight could be reduced and a common form factor could be used for the entire range. Another significant advantage of the NdFeB magnets is that they are virtually impossible to demagnetise and so there is no gradual degradation in the field.

The modern control electronics uses a feedback system so that no matter what the temperature, the flux emanating from the top of the unit could be controlled accurately. The electronics used a Pulse Width Modulating (PWM) power supply to the coil which enabled full control of the current and power demand. This control also enabled the response times to be tailored to suit the needs of the signalling system, balancing current draw against response time.

The enclosure for the magnets was made very small and compact and achieved an IP67 rating - they can run underwater even if the trains cannot. As can be seen from the image on page 23, the AWS unit was submerged at 1m depth in the finest quality seawater that could be found in Plymouth - without a drop getting in!

With the size, weight, reliability and performance all addressed the focus turned to the installation issues.



Drilling the sleepers



Typical BMS installation for ERTMS



Typical single frame installation

## The installation made easy by Pandrol fastenings

The original method of installing the magnets was to move the sleepers apart to allow the sump on the magnets to be lowered into the ballast. It was then required to drill the sleepers and mount special bolts and mounting plates to enable the magnets to be fitted. The average time to install a magnet set was well in excess of three hours. With the downward pressure on possession time this was seen as a critical issue.

Vortok has had huge success with the mounting beams developed for the TPWS project with over 68 000 panels installed to date. This led onto the development of the balise mounting system (BMS) which is currently rolling out across Europe under the ERTMS projects. The fundamental advantage of the BMS is the speed of installation. The patented method of attaching the beams is a direct result of the Pandrol fastening system. Using the Pandrol e-clip or the Pandrol Fastclip to trap the beam ends against the sleeper has enabled a typical beam to be installed in under two minutes, often much faster. Much of this advantage would be lost if screwed fastenings were the only system in existence.

The development of an AWS magnet mounting system was just a logical progression of the BMS system. A concept of a mounting frame was developed using strengthened beams and two mounting rails. The resulting system can be installed very rapidly with the current installation record standing at nine minutes for a double unit set.

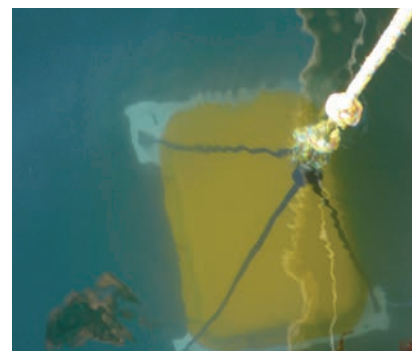
The railway industry tends to be conservative and to propose to mount a 300kg load on glass reinforced pultruded beams caused some eyebrows to be raised. Vortok have had

to undertake a significant amount of testing and analysis to prove that our frame is capable of withstanding the rigours of a typical track installation. A full dynamic model of the biggest and heaviest frame was subjected to both physical and FEA testing at an extreme level. It was highlighted by the test house that if these levels of shock and vibration were applied to real piece of track, our equipment would stay attached to the sleepers but the sleepers, ballast and rails would become airborne!

The range of frames that has now been developed cover Pandrol e-Clip, Pandrol Fastclip, timber and concrete with special versions for bearers and within S&C, an area that has been impossible until now. These frames can take one, two or three magnets and they are completely interchangeable. They are currently on trial and we expect full approval in Q1 2014.

The demand for this system has been significant and we now have over six projects being added to the trial certificates just to get the product in track. The speed of installation is exactly what the project set out to improve and there are many happy customers now able to plan much reduced possession times and associated cost downs.

The full range of magnets consists of; a suppressor, an electromagnet and a permanent magnet, powered by either 110V ac or 24V dc and are compliant with the extra strength or standard strength profiles. All the original issues have been eliminated and the maintenance teams can concentrate on keeping the railway running. We expect full approval from Network Rail in the first half of 2014.



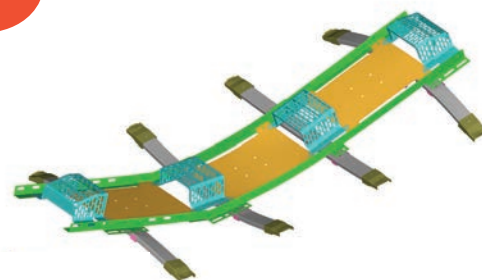
Immersion testing for IP67



Typical double magnet installation



Two man lifting frame in use



Finite Element Model showing extreme magnified deflection



# Pandrol Victor

For Norfolk Southern Railways, USA

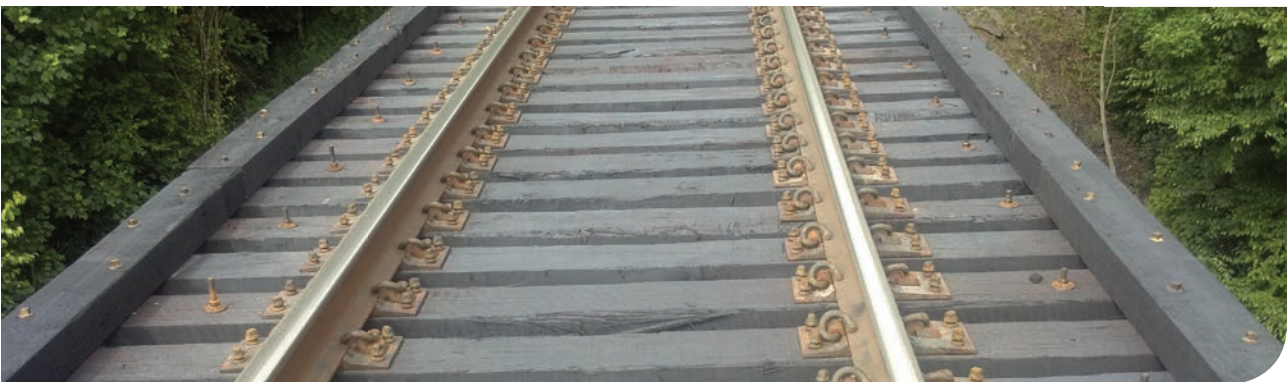
Author: Randy L. Bowman, Engineer Track & Material  
Norfolk Southern Railroad, USA

Norfolk Southern Railroad had been looking for a heavy duty 18" tie plate with an elastic fastening system for use on timber ties, but all of the tie plates on the market with elastic fasteners had a smaller footprint. In 2005 Pandrol answered the call and introduced the Pandrol Victor plate. It had the same footprint as a standard asymmetrical 18" AREMA tie plate and incorporated a cast swaged-in shoulder that utilized a standard Pandrol e-Clip to secure the rail to the plate.

The initial design utilized screw spikes to fasten the plate to the tie. Since Norfolk Southern is primarily a cut spike railroad, this design was not compatible with their line maintenance and production gang work. The added steps to drill holes and screw down the plate compared to simply driving cut spikes with our current equipment added more manpower and expense than we thought necessary. Therefore, NS urged Pandrol to modify the Pandrol Victor plate design to incorporate the use of cut spikes to secure the plate to the ties. And they responded.

Norfolk Southern installed the first Pandrol Victor plates with cut spikes in August 2007 in Maher, WV. The location was in a 6.0-degree curve (290m radius) on a 0.09-inch grade with 3.5" (90mm) of super elevation and carried mainly coal trains totalling around 40 MGT annually. These plates were monitored periodically and found to perform well with respect to reduced tie plate cutting and gauge widening, reducing maintenance required for this curve. The reduced track degradation was verified with subsequent runs of the Track Geometry Car.

With the success at Maher, additional installations of Pandrol Victor plates were made at strategic locations around our system, including open deck bridges. NS specifically targeted locations where reverse rail cant was an issue. The installation of Pandrol Victor plates in these curves provided the needed rail restraint to prevent rail rollover.



**In 2010, Norfolk Southern changed their Standard Procedure on tie plate usage to apply Pandrol Victor plates in conjunction with rail and gauging programs and bridge tie renewal as follows:**

1. On both the high and low rails of curves 6 degrees and greater where the Chief Engineer Line Maintenance determines they are necessary
2. On open deck bridges where rail anchoring is required
3. On open deck bridges with curvature of 2 degrees and greater where annual tonnage is greater than 10 MGT
4. Any other location as directed by the Chief Engineer Line Maintenance or the Chief Engineer Bridges

Beginning in 2012, Norfolk Southern began specifying the use of Pandrol Victor plates with screw spikes for bridge applications. To date, NS has installed over 1.2 million Pandrol Victor plates. These plates have proven to be beneficial in reducing plate cutting, reverse rail cant and gauge widening conditions as well as providing rail roll-over restraint on Norfolk Southern. Addressing these factors ultimately reduces maintenance cost and increases efficiency.



# Pandrol CDM Track



Pandrol CDM Track (PCT), formerly CDM Track, is a European company based in Belgium, specialising in the design, manufacture and implementation of noise and vibration isolation solutions.

With more than 60 years experience in the industry, PCT offers a complete range of cutting-edge solutions to guarantee elasticity at every level in ballasted tracks, slab tracks and embedded rail systems.

The company has its own in-house test facility, where a continuous programme of testing and development ensures it is able to comply with any technical specifications that the rail market may demand.

Pandrol CDM Track was acquired by Pandrol Track Systems in January 2014.

## Embedded Rail Solutions

If you need to design a tramway track, PCT has the solution to make it quiet, sustainable, cost effective and good looking.

For design without sleepers, the easy-to-install PCT-Q(quiet)track offers excellent lateral stability, high electrical resistivity and multiple choices for the finishing layer. You can choose between three levels of vibration mitigation and combine it with a floating slab to cope with any kind of urban environment. In rehabilitation projects, PCT offers the possibility of integrating QTRACK in precast concrete modules to minimise the installation time and local disruption to road traffic.



When embedded sleepers or direct fasteners are designed, PCT-F(lexi) track and PCT covers are custom-made to completely de-couple both the rail and fasteners from the concrete and provide the necessary protection for a high-quality track.

For special applications, such as level crossings or flood / fire gates, you can encapsulate your rails with the poured-in-situ PCT-P(oured) track.

## Ballasted Tracks

Track quality starts with the rail pads. Standard rail pads (PCT-SRP) and resilient rail pads (PCT-DRP) are produced in four different materials to cope with any technical specification.

Under sleeper pads (PCT-USP) are produced in different materials and designed for specific requirements. Soft USPs designed for light axle loads give high vibration attenuation while intermediate and stiff USPs are the solution for mixed traffic, transition zones, main lines and high-speed tracks.

It is also possible to have high vibration mitigation in ballasted track with under ballast mats (PCT-UBM). Made in resin-bounded rubber they are easy to install without joints, resistant to any climatic conditions, and deployable in various thicknesses.



### Slab Tracks

Floating slab mats (PCT-FSM) can be deployed in numerous thicknesses and stiffnesses to accommodate any technical criteria. PCT-FSM are easy and quick to install in any weather condition.

It is also possible to customise your floating slab to meet the exact isolation level you need. With floating slab pads (PCT-FSP) the company not only provides tailor-made bearings, but can also design them accurately using cutting-edge simulation software.

In areas where it is not possible to install a floating slab but vibration mitigation is still a requirement, the resilient direct fastener (PCT-DF-SP/HP/XP) may be used. When combined with a highly resilient under baseplate pad (PCT-UBP) up to 15dBv vibration mitigation can be achieved.



## Pandrol CDM-USP System



Under Sleeper Pads have been installed since the 1990s and are now a proven technology that can be used to manage track stiffness, increase track quality, and control vibration levels in track.

The Under Sleeper Pad (USP) provides a simple way of modifying the stiffness of ballasted track with an attractive cost-benefit ratio, by adding an elastic layer to the underside of the sleeper.

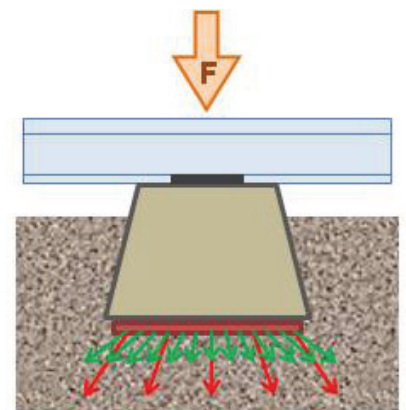
In the PCT-USP system a resilient material (usually Resin Bonded Rubber or Thermoplastic Elastomer) is fixed to the sleeper either by means of glue or using the unique CDM-MFF® technology as described below. The pad fully or partially covers the bottom surface of the sleeper. This improves the maintainability and the quality of the track, and can also provide vibration mitigation.

Right from their first installation, great benefits were identified by using USPs. These applied especially in transition zones, on turnouts, bridges, and in tunnels. Now, following years of experience, and also because of an increase in the volume of concrete sleepers being installed, use of USPs is becoming common practice on permanent way owners such as: DB (Germany), SNCF (France), ÖBB (Austria), ADIF (Spain), INFRADEL (Belgium), REFER (Portugal), SBB (Switzerland), etc.

The application of USPs can be divided in two broad areas: track quality improvement and noise and vibration control. However these are not mutually exclusive, so that, for example, even when a USP is designed to target track quality improvements, there will also be some degree of noise and vibration isolation.

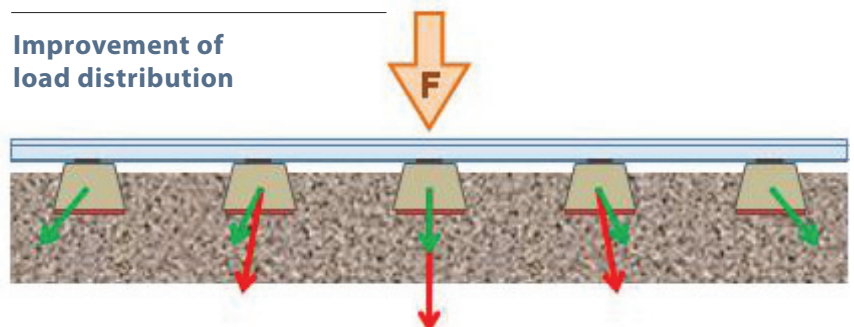
The same applies in reverse, too. The degree of each type of benefit depends primarily on the stiffness of the pads.

#### Increases ballast contact area



**Track Quality Improvements** may be achieved thanks to a better load distribution and a reduction in the pressure on the ballast and superstructure brought about by the insertion of the elastic material between ballast and sleeper.

#### Improvement of load distribution

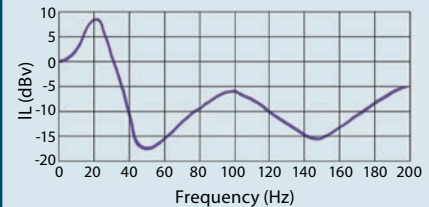


## Track Quality Improvement

- a. Ballast protection: as a result of the track quality improvement, the intervals required between levelling, lining and tamping can be approximately doubled
- b. Possibility of reduced ballast thickness: from 30 to 20cm due to the better load distribution
- c. Possibility of reduction of rail corrugations, especially in tight radius curves: grinding intervals may be more than doubled
- d. Mitigate the effects of local discontinuities: such as differences in track settlement, hanging sleepers, differences in stiffness of the soil, etc
- e. Ideal for use in transition zones: to mitigate differences in settlement or step changes stiffness. Can be used on the approach and running off area for bridges, transitions between track construction types, rail expansion joints, control short bridges responses, etc
- f. Better track quality in turnouts

## Noise and Vibration Control

Noise and vibration control is achieved thanks to the insertion of an elastic layer between the rigid concrete sleeper and the stiff ballast. The level of vibration reduction will depend on the stiffness of the material introduced.



## Noise and Vibration Control

- a. Alternative to Under Ballast Mats (UBM): soft USPs may be a good substitute for UBM if the requirement is to control vibrations in the frequency range above 40-50Hz
- b. Ground-borne noise control: it has been demonstrated that up to 15dBv reduction in vibrations within the frequency band of maximum energy can be achieved
- c. Air-borne noise control: although not the main objective, the possibility exists for reducing train passage noise in curves indirectly, due to the improvement in the quality of the track



The benefits of using USPs have been substantiated by in-situ measurements and numerous studies such as the UIC project 'Under Sleeper Pads in Track' in which 12 European countries and Japan conducted one of the biggest research programs ever carried out on the subject. The project included several laboratory and in-track tests which demonstrated the advantages of using USPs both for track improvement and for noise and vibration control.

It is important to note that all of the above mentioned benefits have a direct impact on track maintenance costs. USPs will reduce maintenance activities such as tamping, ballast cleaning, grinding, etc. In some cases, the time interval between maintenance interventions has almost doubled. A reduction of 32% in the life cycle cost has been estimated for tangent track fitted with USPs and subject to more than 70,000 gross tons per day.<sup>1</sup>

With over 40 years' experience in the field of noise and vibration control, and more than 20 years' experience designing, producing and supplying USPs, Pandrol CDM Track is able to provide high quality PCT-USP products based on its main core materials: Resin Bonded Rubber (RR) and Thermoplastics Elastomers (TPE). As a result of its wide materials portfolio, PCT-USP can provide a static stiffness range that goes from 0.068 up to 0.25 N/mm<sup>3</sup> for RR materials and from 0.216 up to 0.40 N/mm<sup>3</sup> for TPE materials.

These satisfy the high level of technical requirements on this type of product. PCT-USP has been tested at the Technical University of Munich according to the German standard DIN 45673-6. Both the standard and the homologation body are recognized worldwide.

Regardless of the material type and the stiffness, PCT-USP may be installed

once the sleeper has been produced by means of glue, or it can be fixed during sleeper production thanks to CDM-MFF® technology. CDM-MFF® is a Micro Fibre Fastener layer attached to the resilient layer, which facilitates a direct bond between concrete and the USP. This bonding has been proved to be very effective - reaching strength values of up to 1.0 MPa - which is well in excess of the 0.4 MPa required by DIN 45673-6. Bonding strength is an important factor since during track laying the sleeper is subjected to pull off forces as it is handled and installed into the track. CDM-MFF® ensures that the resilient pads will be bonded to the concrete sleeper at all times.

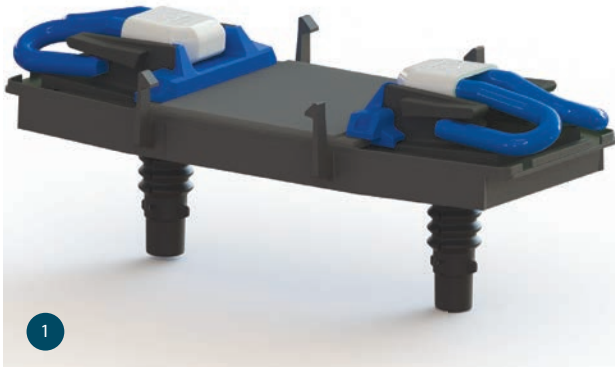
<sup>1</sup> Under Sleeper Pads in Track – The UIC Project. European Railway Review, Vol. 19, Issue 2, 2013. Auer, F., et.al.

# Pandrol Fastclip FCA

The Pandrol Fastclip FCA has been designed for use on slab tracks where vertical adjustment is required. The system is suitable for use with all forms of pre-cast elements (block, twin block or slab). These may in turn be either cast-in, or resiliently mounted. Alternative configurations with a plastic construction plate that allow for wet pour, top-down construction are also possible for some applications. Pandrol Fastclip FCA can be assembled at the sleeper factory and delivered to site captive on the pre-cast element.

## Installation

Installation by top down wet pour method with alternative plastic construction plate



1 The pre-assembled plastic construction plate ready for attaching to rail.



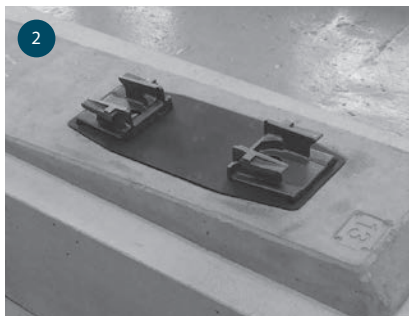
2 Assembly attached to the rail ready for concrete pour to underside of construction plate. Clips in the parked position.

## Installation

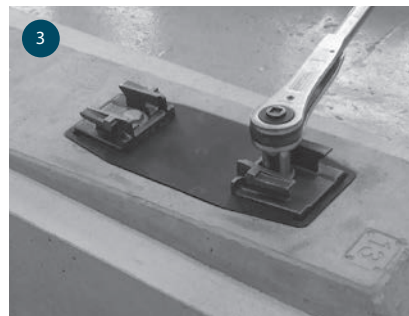
### Installation in pre-cast elements (block, twin block or slab)



1 Plastic sub-plate and anchor inserts cast into pre-cast element.



2 Cast shoulders locate on plastic sub-plate.



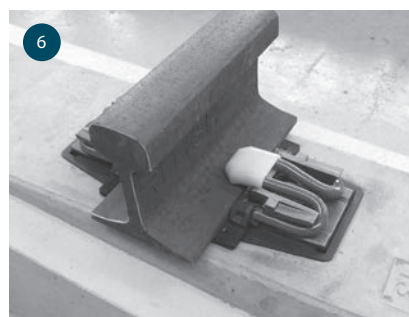
3 Anchor bolt torqued to secure cast shoulders.



4 Rail pad and post insulators installed in the rail seat.



5 Pandrol Fastclip fastenings are installed into the parked position. The finished concrete elements would normally be delivered to the construction site in this configuration.



6 Once the sleepers are placed and the rail has been threaded, clips are driven from the parked to the working position.

## Features of Assembly

### EXPERIENCE

Pandrol Fastclip FCA is an adjustable version of the widely used Pandrol Fastclip system. All component materials are based on long established Pandrol specifications.

### FULLY PRE-ASSEMBLED

The Pandrol Fastclip FCA system can be delivered to the track site fully pre-assembled/captive and attached to a pre-cast concrete element. Low clamping force and rail free variants are available to address track-structure interaction issues.

### ADJUSTABILITY

Lateral adjustment of +/- 5mm per rail seat is possible by exchanging side post insulators. Vertical adjustment of +20mm is possible by component change and shims. For special applications please consult Pandrol.

### TRACK STIFFNESS

Track stiffness typically >40 kN based on CEN track category B, C and D. Stiffness can be varied within limits through consultation with Pandrol.

### ELECTRICAL RESISTANCE

The Pandrol Fastclip FCA has two levels of electrical resistance.

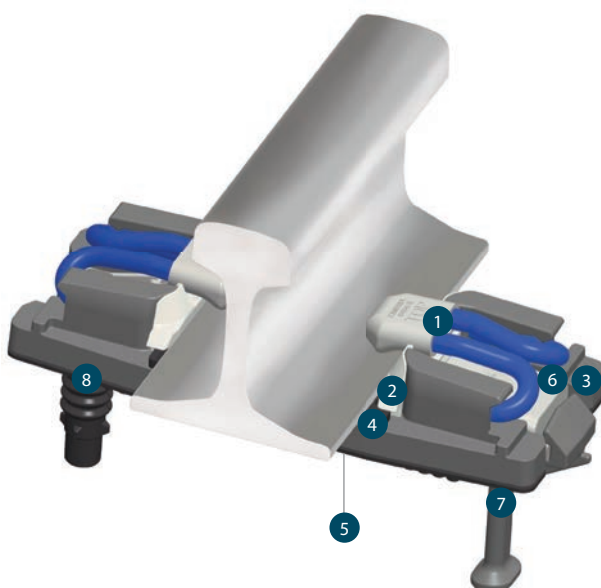
- The rail is isolated from the shoulder by rail pad, side post insulators and toe insulators.
- The shoulder is insulated from the concrete by a conforming shim and plastic dowels.

### VERSATILITY

Bespoke designs can be provided to suit customer operating requirements.

# Pandrol VIPA DFC

Pandrol VIPA DFC has been designed for use on slab tracks where a typical vertical system stiffness of 20-25 kN/mm is required, for applications on LRT, Metro, high speed and other non-ballasted tracks. The Pandrol Fastclip fastening allows for efficient stressing and rail maintenance. The assembly is optimised for top down construction with embedded pre-cast elements but is also suitable for installation on pre-cast slab systems. Pandrol VIPA DFC can be assembled at the sleeper factory and delivered to the site captive on the sleeper or block.



## Components:

### 1. Clip and Toe Insulator

- 1000 kgf nominal toe load, high deflection
- Integral toe insulator to reduce rail contact stresses and improve electrical resistance
- Zero toe load option (rail free) available

### 2. Side post insulators made from high viscosity nylon

### 3. Cast SGI Baseplate

### 4. Rail pad

### 5. Baseplate pad

### 6. Field side clamp

### 7. Cast-in SGI field side shoulder

### 8. Plastic dowel/bolted gauge side fixture

# Installation

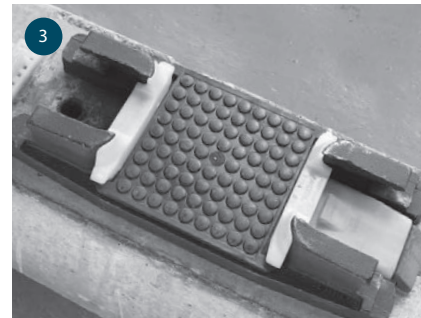
## Pre-Assembly Process



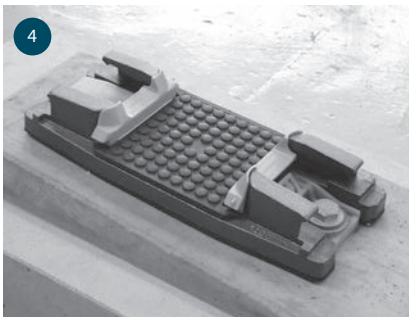
1 The sleeper is supplied with a cast-in SGI iron shoulder on the field side and a cast-in plastic insert on the gauge side of the rail seat.



2 A field side clamp is positioned on the field side SGI shoulder.



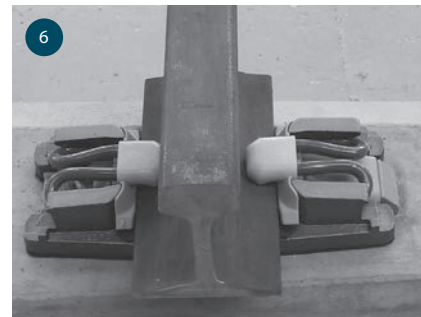
3 The baseplate (with sidepost insulators/ rail pad and baseplate pad already in position underneath it) is then slid into engagement with the field side clamp.



4 The gauge side clamp is then positioned and bolted down.



5 Pandrol Fastclip Fastenings are installed to the parked position. The fastenings would normally be delivered to the construction site in this configuration.



6 Once the sleepers are placed and the rail has been threaded, clips are driven from the parked to the working position.

## Features of Assembly

### EXPERIENCE

Pandrol VIPA DFC is based on proven Pandrol Fastclip materials and technology.

### FULLY PRE-ASSEMBLED

Pandrol VIPA DFC baseplates can be delivered to the track site fully pre-assembled/captive and attached to the sleeper. Track structure interaction low clamping force/rail free variants available.

### ADJUSTABILITY

A maximum lateral adjustment of +/-5mm per rail seat is possible by exchanging the side post insulators.

Vertical adjustment of +20mm in 1mm increments is possible by exchanging the field side clamp, and shimming under the baseplate, using simple flat shims. Higher levels of vertical adjustment may be possible depending on operating conditions.

### TRACK STIFFNESS

Typical track stiffness between 20-25 kN/mm (0-50kN). Stiffness can be reduced or increased through consultation with Pandrol.

### VERSATILITY

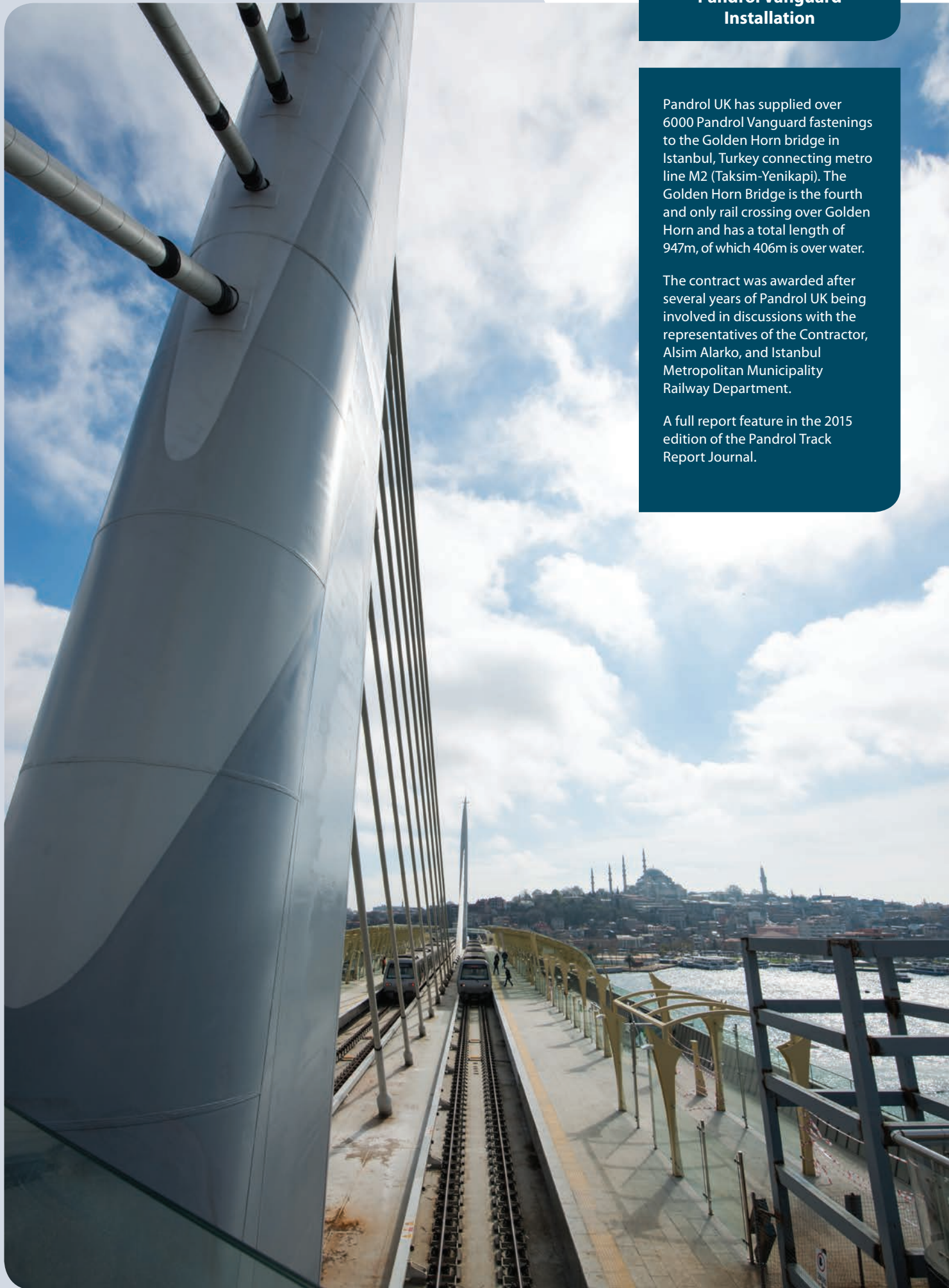
Bespoke designs can be provided to suit the customer operating requirements.

## Pandrol Vanguard Installation

Pandrol UK has supplied over 6000 Pandrol Vanguard fastenings to the Golden Horn bridge in Istanbul, Turkey connecting metro line M2 (Taksim-Yenikapi). The Golden Horn Bridge is the fourth and only rail crossing over Golden Horn and has a total length of 947m, of which 406m is over water.

The contract was awarded after several years of Pandrol UK being involved in discussions with the representatives of the Contractor, Alsim Alarko, and Istanbul Metropolitan Municipality Railway Department.

A full report feature in the 2015 edition of the Pandrol Track Report Journal.





PANDROL VANGUARD installed on the Golden Horn Bridge Istanbul, Turkey.

