PANDROL

FOCUS

OVER 50 YEARS OF EXPERTISE DEFINING A GENERATION OF RAIL

PIONEERING THE FUTURE OF

HEAVY HAUL

MONGOLIA

Future proofing Mongolias railway

ASK THE EXPERT

Alejandro Giner on sustainable heavy haul fastening technology

I+WELD

Revolutionising track welding

ISSUE 02

PANDROL

Keeping freight moving

With a full range of products for axle loads up to 40 Tonnes, **our products and technical expertise have shaped all of the major heavy haul railways in the world** with a track record covering more than five decades and extending across all continents.

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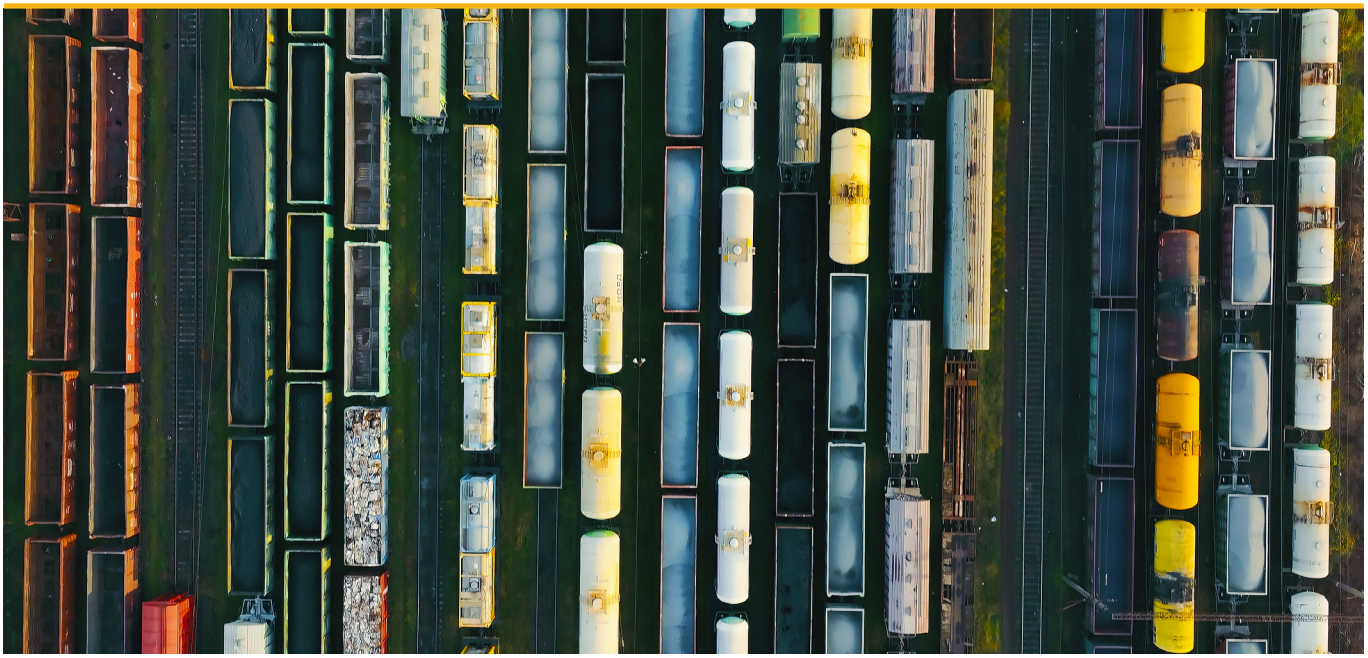
This edition of Focus is dedicated to heavy haul. Pandrol shares its stories, its experience and its solutions to drive availability, safety and lifetime value of freight operations.



EDITOR'S LETTER

ENGINEERED FOR THE WORLD'S MOST DEMANDING RAILWAYS

Pandrol delivers proven performance across the globe's most challenging heavy haul operations – from the arid deserts of North West Australia and the Middle East to the humid tropics of Africa and the extreme cold of Canada and Scandinavia. Operating reliably under axle loads up to 40 tonnes, our fastening systems combine advanced engineering with exceptional durability to minimise maintenance and maximise uptime.

THE CHOICE OF LEADING HEAVY HAUL OPERATORS

Pandrol are the proven choice across the world's major heavy haul networks. North American operators including Union Pacific, BNSF, Canadian National, Norfolk Southern, and CSX rely on our technology, as do VALE in Brazil and Transnet in South Africa.

DELIVERING SOLUTIONS IN CHALLENGING CONDITIONS

Within this brochure, we look at some of Pandrol's heavy haul projects across the globe and latest technologies.

As testament to Pandrol's technology was the integration of our rail fastenings and aluminothermic welding solutions for **one of the world's longest new heavy haul track installations in Mongolia**. The Pandrol team has delivered rail fasteners to around 800km of track so far and trained contractors in their installation and maintenance.

For the aluminothermic weld contract, Pandrol supplied rail weld solutions for the construction of the Tavantolgoi–Gashuunsukhait railway in Mongolia, enabling a critical 240 km railway that will increase Mongolia's coal export capacity by 30 million tonnes annually. In addition to the welding kits, Pandrol provided training on aluminothermic welding techniques and independent testing on quality.

This proved to be a huge success, as it meant that welds could be completed quickly and effectively, as the conditions in the Gobi desert are extreme, with temperatures ranging from -35°C to +35°C.

PANDROL'S COMPLETE SOLUTIONS FOR HEAVY HAUL CHALLENGES

Fastclip represents the evolution of fastening technology for high-capacity operations. Since 2010, it has proven its durability on Saudi Arabia's 2,000 km North-South Line, where automated installation and 'fit-and-forget' reliability support 16,000-tonne trains while dramatically reducing labour requirements and lifecycle costs.

SD (Safe Driven) demonstrates that sustainability and performance work together. Pandrol's compact screwed fastening system delivers robust heavy haul performance with efficient installation and low carbon footprint. Its configuration prevents dust ingress and ballast interference, ensuring sleeper protection and long-term performance. This is helping operators to meet net zero targets without compromising safety or reliability.

> **Proven performance across the globe's most challenging heavy haul operations**

Pandrol's i+weld transforms track welding through semi-automation. By combining seven integrated technologies – from automatic alignment to accelerated cooling – i+weld cuts installation time by 40% while improving weld quality and consistency. For heavy haul networks managing skills shortages and expanding maintenance programmes, it delivers both performance and cost effectiveness.

VERSE precision measurement addresses one of heavy haul's highest safety risks: thermal stress in rail. Here, Pandrol's non-destructive system provides accurate stress-free temperature data, enabling operators to target maintenance resources where buckle and fracture risks are highest – essential for networks carrying extreme axle loads through volatile temperature ranges.

From fastening innovation to welding automation and stress management, Pandrol provides integrated solutions that help heavy haul operators improve safety, reduce costs and meet the performance demands of tomorrow's railways.

i+weld

by PANDROL

Track welding has been waiting for a breakthrough. i+weld delivers.

We've developed a solution that addresses customers' challenges head-on. Complete more welds in less time with semi-automated processes that reduce the physical strain on welders and streamline training.

TECHNICAL EXPERT

i+weld

Revolutionising track welding through automation and data

Authored by Nicolas Demond, Thibaut Descamps, Pandrol

"Heavy haul networks face growing pressure to maintain expanding routes with fewer skilled welders and tighter budgets. Traditional aluminothermic welding (ATW) is flexible and low cost but relies heavily on expert operators. Flash butt welding (FBW) delivers speed but demands high capital investment suited only to large programmes.

Established rail markets in Western countries need investment in aging assets to handle increased traffic efficiently. Meanwhile, emerging economies, especially in Asia, are seeing growth in new rail projects, particularly in metro and light rail. Both face a common challenge: a shortage of skilled maintenance personnel.

Automation has become essential rather than optional. However, operators must balance reducing lifecycle costs with track availability and investment in automated welding technologies.

To address these challenges, Pandrol has developed technologies to automate key ATW processes, maintaining lower capital costs than FBW while improving efficiency and productivity and offering higher performance. Workers can be trained quickly with Pandrol's new ATW offering as the objective is to help networks meet operational targets, whilst working within budget constraints.

THE NEED FOR AUTOMATION IN RAILWAY MAINTENANCE

Pandrol i+weld bridges the skills gap, combining the versatility and low setup cost of ATW with semi-automation that improves productivity, consistency and safety.

THE i+weld INTEGRATED SYSTEM

i+weld transforms ATW through seven integrated technologies that automate key welding stages:

01 i+align – Automatic rail alignment

Automated alignment via tablet control eliminates manual wedge adjustments, improving accuracy and traceability while reducing setup time.

02 i+seal – Self-sealing technology

Luting-free moulds with expanding strips create leak-free seals without applying paste or sand. Compatible with vignole and groove rails, i+seal speeds up welding and reduces waste.

03 i+heat – Automatic preheating

Preheating errors account for around 20% of weld rejections in the UK. i+heat removes this risk through automatic pressure control and monitoring, achieving 100% acceptance in field trials.

04 i+ignite – Simplified ignition

Handheld trigger ignition streamlines setup and improves consistency.

05 i+cool – Accelerated cooling

A compact water-cooling unit brings weld temperature down to 50°C in around 20 minutes, cutting cooling time from up to two hours and reducing traffic disruption.

06 i+detect – Ultrasonic defect detection

The SonicVizio-WS-S system quickly identifies internal defects with 3D visualisation, supporting both novice and expert users.

07 i+connect – Cloud-based weld management

Live process data – batch numbers, pressure, duration, GPS location, timestamps – is captured via mobile app for full traceability and remote oversight.

MEASURABLE PERFORMANCE IMPROVEMENTS

Productivity: Traditional ATW requires around **45 minutes** active labour per weld.. i+weld can reduce this by up to 15 minutes, allowing for more welds per shift

Quality: Automation removes common human error sources. Field trials show **100% weld acceptance** with automatic alignment and preheating.

Safety: Reduced time kneeling in ballast, lowering strain and reducing hands-on-rail risks. Fewer personnel in-track further improves safety.

COST EFFICIENCY FOR HEAVY HAUL OPERATIONS

Semi-automated ATW remains more economical than FBW for projects up to 25 welds per shift – covering most heavy haul maintenance tasks. Automation allows track workers to be trained in just three days to carry out setup, alignment, and preheating under qualified supervision. This flexible workforce model addresses skills shortages and supports rapid deployment across wide geographic networks.

Unlike FBW, which requires 2,500–3,000 welds annually to justify costs, i+weld delivers efficiency for:

- Emergency repairs (1–2 welds)
- Standard maintenance with plug rails (4 welds)
- Turnout installation (4 welds)
- Re-railing (8 welds)
- Weekend possessions (15 welds)

CONCLUSION

The debate over optimal on-site welding systems continues, driven by the fact that welding is a critical process in rail maintenance.

Railway network operators and contractors continually seek solutions to maintain high quality standards while controlling life cycle costs and addressing worker shortages.

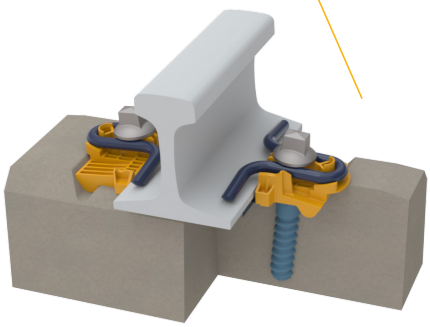
However, the introduction of semi-automated ATW, with its low capital expenditure, simple operation that allows for employment of a non-specialised workforce, increasing productivity during busy periods and quality performance, provides a compelling choice."

PANDROL SD SYSTEM

Sustainable heavy haul fastening technology

Railways worldwide are facing dual pressures: achieving “net zero” by 2050 while maintaining performance and safety in heavy haul operations.

Here, Pandrol’s Alejandro Giner, explains how the SD fastening system meets these demands, by delivering exceptional technical performance with significantly reduced environmental impact.



The design of Pandrol’s SD (Safe Driven) fastening system prioritised significant environmental impact reduction, resulting in a more streamlined, lighter and cost-effective solution compared to alternative systems. The SD system comes pre-assembled on the sleeper or slab component, offering guided clip movement from parked to operational position whilst enabling swift mechanical installation. The system utilises a screw and insert mechanism for tensioning the SD clip, generating sufficient axial force to compress the clip and ensure proper rail foot clamping.

SD: A VERSATILE SYSTEM FOR ALL APPLICATIONS

The SD system’s versatility enables its use across various railway types, from heavy freight operations to urban transit systems. Notable implementations include Mexico’s Heavy Haul lines and France’s Grand Paris Express driverless metro system, whilst also serving as a modern replacement for traditional screwed fastening systems across multiple different projects. The SD system presents a myriad of benefits over conventional screwed mechanisms.

ENGINEERED FOR HEAVY HAUL PERFORMANCE

The SD fastenings offer significant advantages over traditional fastening systems, combining enhanced protection and robustness with efficient installation and low carbon footprint. Its configuration prevents dust ingress and ballast interference, ensuring sleeper protection and long-term performance, while the guided clip geometry and compatibility with mechanised installation deliver exceptional productivity during installation.

RAIL FASTENER DURABILITY

The system's reduced weight does not compromise its robustness or durability. The SD range is engineered to withstand high-frequency vibrations typical of railway operations, minimising fastening system deterioration and ensuring track safety.

The SD clip's innovative design with its unique guidance enables a swift transition from parked to operational position through a simple screw adjustment. When combined with pre-assembly and mechanised installation options, this feature facilitates rapid track construction and maintenance operations. The result is considerable reduction in labour expenses, alongside decreased distribution and handling costs throughout the system's operational life.

TECHNICAL ADVANTAGES OVER GENERIC SCREWED SYSTEMS

01 **No ballast entrapment –** removing a frequent cause of maintenance

02 **Efficient installation provided by the clip guidance and automation**

03 **Increased robustness thanks to the higher natural frequency of the clip**

04 **Proven global deployment –** replacing legacy systems with decades of service

PROVEN HEAVY HAUL APPLICATIONS

Pandrol's SD systems are deployed across global heavy haul environments, demonstrating reliability across varying axle loads, climates, and operating speeds. They successfully replace traditional screwed fastenings while improving performance and sustainability outcomes.

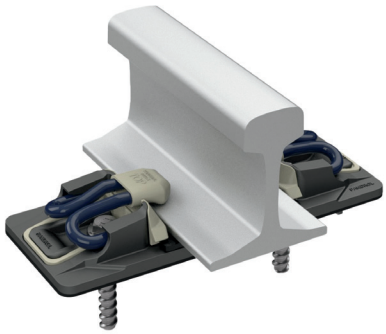
As networks pursue net zero targets, every component decision matters. SD demonstrates that sustainability and performance can work together – combining engineered resilience with reduced manufacturing, transport, installation and maintenance impact. For heavy haul operators, it offers a proven route to meet environmental and operational targets simultaneously."

TECHNICAL EXPERT

PANDROL FASTCLIP

Ensuring heavy haul installation and maintenance with automation that delivers speed, safety and savings

By J. P. Porrill and J. Spencer



INDUSTRY CHALLENGE

“Railway operators face mounting pressure to expand capacity while controlling costs and managing workforce challenges. Pandrol Fastclip addresses these demands head-on through revolutionary automation that transforms both track installation and lifecycle maintenance.

Traditional fastening systems rely on significant manual labour – this means teams assembling loose components in-track, positioning fasteners and repeatedly torquing screws across the asset’s life. This labour-heavy process is not only time-consuming but increasingly unsustainable as skills shortages and safety expectations grow.

THE FASTCLIP SOLUTION

Fastclip provides factory pre-assembled sleepers ready for immediate installation. Its ‘switch-on, switch-off’ function enables automated installation at speeds up to **40 sleepers per minute**, with a single operator. Rail is threaded into place and automated paddles move fasteners from parked to full installation in one motion – like closing an industrial zipper.

For maintenance, clips switch back to parked position without component loss, while Pandrol VSR rollers enable low-friction rail movement during destressing.

PROVEN PERFORMANCE ADVANTAGES

There are many performance benefits:

Installation efficiency:

Automation significantly reduces installation time and labour compared to systems requiring manual assembly and torquing. The captive design prevents component loss.

Fit-and-forget reliability:

As a self-tensioning system, Fastclip removes the need for torque checks required by screwed fastenings, which loosen over time. Components are matched to rail life for long-term performance.

Flexible performance tuning:

A standard anchoring system adapts to different operational demands. For heavy haul, the **FC1600** series delivers **1,250 kgf** clamping force per clip. Standard track uses **FC1500** at **1,050 kgf**. **LLR** and **ZLR** options are available via specialised toe insulators and low-friction pads, preventing rail foot fretting and potential fracture.

Superior electrical isolation:

Cast-iron shoulders isolated by pads and insulators deliver over **12 kΩ** resistance – more than double the **5 kΩ** European standard – ensuring reliable signalling performance.

SAFETY AND PRODUCTIVITY

Reducing the number of personnel working on the track enhances safety and addresses workforce limitations. Automation maximises the use of limited maintenance windows – essential on high-speed routes where access is restricted to a few night-time hours.

SUSTAINABILITY

Fastclip carries an Environmental Product Declaration of **15.2 kg CO_2e per rail seat assembly**. Pandrol’s circular economy programme has demonstrated that **recycled PA66 insulators** can match – and in some cases exceed – the performance of virgin material, while cutting emissions by **up to 50%**. These recycled blends are now **approved by Network Rail UK** for general use. Additional initiatives are underway to recover and repurpose rubber pads, and the system’s **extended maintenance intervals** further reduce carbon impact across the asset lifecycle.

PROVEN TRACK RECORD

Since 2010, Fastclip has proven its durability on Saudi Arabia’s North-South Line, where **16,000-tonne** trains run across **2,000 km** of track, demonstrating system reliability under extreme heavy haul conditions.”

UNDER SLEEPER PADS

Enhancing track longevity under extreme loads with Under Sleeper Pads

The adoption of Pandrol's Under Sleeper Pads (USPs) has accelerated across heavy haul networks in recent years, driven by their proven ability to enhance track resilience under demanding load conditions.

BUT WHAT MAKES USP PARTICULARLY EFFECTIVE IN HIGH-AXLE-LOAD ENVIRONMENTS?

The primary function of USPs in heavy haul applications is to protect and extend the life of the track superstructure. This is achieved through two fundamental mechanisms: **Increasing the sleeper-ballast contact area and optimising load distribution.**

In conventional track systems without USPs, sleepers typically engage with only 5 to 8% of their underside surface, resulting in elevated contact pressures and concentrated stress zones within the ballast. The introduction of USPs increases this contact area to approximately 30%, significantly reducing interface pressure and mitigating stress concentrations.

In addition, the resilient nature of USPs increases the elastic length of the track, enabling longitudinal load sharing across a greater number of sleepers. This redistribution of force reduces peak stresses and contributes to a more uniform load path.

Over time, these improvements translate into reduced maintenance requirements and extended asset life. Rail corrugation (particularly on curves) is reduced and the frequency of levelling, lining and tamping (LLT) operations can be reduced by a factor of two or more. Furthermore, the use of recycled materials in Pandrol's USPs contributes to a lower carbon footprint in track construction.

PERFORMANCE IN HARSH ENVIRONMENTS AND TRANSITION ZONES

Heavy haul infrastructure is often located in remote, environmentally challenging regions such as deserts, where windblown sand and other contaminants can infiltrate the ballast. These contaminants stiffen the ballast matrix, impairing its ability to distribute loads effectively. USPs help to restore track resilience by mitigating the stiffening effects of such contamination, preserving load transfer efficiency.

USPs are also highly effective in managing **transition zones**, such as bridge approaches, expansion joints and interfaces between differing track construction types. In these areas, USPs can be strategically deployed to control differential stiffness and settlement, improving both ride quality and component durability.

Critically, USPs enhance **lateral track stability**, a key consideration in heavy haul operations where the risk of rail buckling is elevated due to high compressive forces and thermal stresses.

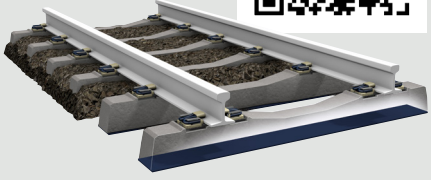
The durability of Pandrol's recycled rubber USPs has been validated through the EN 16730 Vibrogir fatigue test, the most rigorous standard for USP performance, demonstrating their suitability for long-term implementation in demanding conditions.

Ease of installation is also a key advantage. Pandrol's proprietary Micro-Filament Fastening (MFF®) bonding layer enables secure attachment during sleeper production, while post-production installation is also possible using adhesive bonding techniques.

GLOBAL DEPLOYMENT AND PROVEN RESULTS

Heavy haul operators worldwide are reporting measurable benefits from USP installation. A good example of this is **Roy Hill**, a major iron ore producer in Western Australia. Operating on a network with axle loads reaching 420 kN, Roy Hill faced persistent ballast degradation at bridge locations, necessitating frequent maintenance interventions. The implementation of Pandrol USPs successfully improved load distribution and reduced these maintenance demands.

Other adopters include **CSX** in North America, **Rio Tinto** in Australia, and **Trafikverket** in Sweden, all of which have integrated USPs into their heavy haul strategies. The growing global footprint of Pandrol USPs emphasises their value in enhancing track performance, durability, and sustainability in the most demanding rail environments.



PANDROL VERSE

Precision rail stress measurement for heavy haul safety

By Craig Mulvay

Continuously welded rail (CWR) improves ride quality and reduces maintenance, but introduces a critical risk: thermal stress. As temperatures fluctuate, unmanaged stress can cause fractures or track buckles. Network Rail UK cites rail stress management as one of the highest safety risks – which is especially relevant for heavy haul operations carrying extreme axle loads.

UNDERSTANDING STRESS FREE TEMPERATURE (SFT)

Stress Free Temperature (SFT), or neutral temperature, is the point at which rail carries zero thermal stress:

- Rail temperature above SFT = compressive stress and buckle risk
- Rail temperature below SFT = tensile stress and fracture risk

Setting the correct SFT requires balancing seasonal extremes with system limits. With climate-driven temperature volatility, active SFT monitoring has become essential, enabling networks to target maintenance resources where risk is highest.

THE VERSE SOLUTION: NON-DESTRUCTIVE PRECISION

Pandrol's VERSE (Vertical Rail Stiffness Equipment) provides accurate, non-destructive SFT measurement. By inducing a controlled vertical deflection and measuring force and displacement, VERSE directly correlates data to rail tension. Combined with rail temperature, it calculates true SFT on site.

VERSE APPLICATIONS ACROSS THE LIFECYCLE

VERSE supports railway operations throughout the track lifecycle. Routine surveys identify high-risk sections before they become critical, while spot checks target curves, gradients, and known stress zones where thermal effects are most pronounced.

During construction, VERSE provides quality control for new track and stressing operations, then follows through with post-maintenance verification to confirm work effectiveness.

WHY VERSE LEADS THE INDUSTRY

VERSE delivers accurate, absolute SFT measurement without needing residual stress data, which makes it suitable for both ballasted and slab track, including heavy haul configurations. The system provides instant digital results for integration into asset management systems while automatically compensating for rail wear, curvature, and section differences. Its reliability has been independently validated by RDSO (India), AEA (UK), TTCI (USA), and RRI (Czech Republic), and the equipment is designed for harsh field conditions with long-term reliability.

CHANGES OVER TIME

SFT continually evolves due to maintenance, rail welding, geometry changes, cyclic loading, and seasonal expansion/contraction. As installation records age quickly, regular VERSE monitoring allows operators to act on real conditions rather than outdated assumptions.

COMPLEMENTARY TECHNOLOGY: VSR STRESSING ROLLERS

When VERSE reveals stress anomalies, Pandrol's VSR rollers step in to correct the problem. By lifting the rail clear of sleeper friction, the rollers enable precise stress adjustment across the entire section.

This controlled approach prevents dangerous over-tensioning during welding operations while eliminating the hazards of manual jacking. The safety and consistency benefits have led many rail authorities to mandate roller-assisted stressing as standard practice.

MANAGING RAIL STRESS FOR ZERO-ACCIDENT OPERATIONS

A zero-accident vision for railways requires precision in monitoring and controlling fundamental risk factors. Rail stress management addresses one of the most critical contributors to accidents as a result of track buckling or rail fractures.

Pandrol's VERSE provides the data foundation for proactive, risk-based maintenance, enabling operators to maintain safe stress thresholds and eliminate buckles and fractures before they occur.

Key enablers include:

Routine non-destructive SFT measurement (e.g. VERSE). Integration of data outputs into asset management databases for predictive maintenance.

Effective SFT maintenance which includes even stress redistribution using friction management (e.g. VSR rollers).

Rail fastening system design which limit longitudinal creep of the rail.

Sleepers of the appropriate design and spacing.

Correctly filled and consolidated ballast beds with heaped shoulders.

Sound and stable formations.

VERSE – MAKING RAILWAYS SAFER

As precise control of SFT can ensure rail stress management, then VERSE becomes a vital part of any rail safety strategy.

VERSE offers an accurate, validated and globally adopted method for non-destructive SFT measurement, while VSR technology ensures correct stress redistribution during stressing. Together, these tools provide track maintenance teams with the capability to proactively manage one of the highest risks in rail operations.

As railway networks expand and modernise, embedding robust RSM practices into asset management frameworks is essential. Only through consistent, validated and technology-driven stress management can railways progress towards the ultimate goal: a zero-accident future.

PANDROL DELIVERS "HEAVY HAUL" SOLUTION FOR MONGOLIA RAILWAY

Building a future ready, Heavy Haul railway line that stretches across the Gobi desert, eastwards through Mongolia to eventually link up with the Russian network leading to Vladivostok, totally around 6,000 km, sounds both an exciting challenge and an opportunity.

Back in 2011, Pandrol's technical team completed a successful PIU/UBTZ pilot project in Mongolia of the Fastclip FE rail fastening solution for future projects involving Mongolia Railway (now MTZ). This trial involved several sections of Pandrol Fastclip FE1504, on UBTZ tracks. This pilot project used the panel build track construction method involving many different types of track, tight curves & gradients.

FASTCLIP FE

The Pandrol Fastclip FE1504 was specified as the fastening system for this project as it provides higher longitudinal restraint, therefore preventing railway creep. It also ensures higher clamping force, which is required in this very demanding track, where temperatures can fall well below 40°C in winter & well above 50°C in summer.

Specially designed for heavy haul applications, this resilient, threadless rail fastening system contains the unique Pandrol "switch on – switch off" function that enables fast, efficient track installation and reduced maintenance costs. The benefit is that sleepers can arrive on site with all components held captive and the clips set at the parked position, making the whole process of track construction that much quicker and more efficient. In single sleeper laying, once the sleepers are placed and the rail has been threaded, clips are simply pushed from the parked to the installed position for rapid installation.

CHALLENGES

As with the initial trials & under normal circumstances, a member of Pandrol's specialist training team would always travel to the work site to carry out in-person training on the installation of the fasteners with the sleepers. However, border closures and travel restrictions associated with COVID-19 made this impossible, with the first big installation, so Pandrol adapted its training to an online format. The training covered how to install a fastener to a sleeper, how to build a track, plus how to inspect and maintain the track once installed. Pandrol's team also advised on suitable equipment for installation. The Rosenqvist Clip Driver CD200 IQ was selected for installation of the track.

The second stage of the project, which started in 2019 was to connect the Sainshand-Baruun-Urt-Khuut railway with the Tavantolgoi-Zunbayan, Khuut-Bichigt, and Khuut-Choibalsan rail lines.

The total length of the track in this phase was over 400 km and it was constructed using pre-assembled sleeper panels with integrated rail fasteners, with the second half of the track being built using loose sleeper laying techniques by MTL the local private contracting & engineering company.

The Sainshand-Baruun-Urt-Khuot railway line will transport up to 12 million tons of coal annually once the extensions & connections have been completed.

A further phase of this huge project is the Zuunbayan – Hangi Mandal line where Fastclip FE fasteners for the 180km stretch of track has been completed by MTL using Rosenqvist Clip Drivers CD200 IQ.

A significant challenge on this project was dealing with the extreme conditions in the Gobi desert, which is known for its extreme climate and rapid temperature changes throughout the year, the conditions are exacerbated by the incessant wind & sand storms caused by the Siberian anticyclone.

It was therefore extremely important that work on site could be completed quickly and efficiently with installation of the sleepers being a prime constituent, the use of mechanical help from the Rosenqvist machines made a significant difference in speeding up the installation of the track.

PANDROL'S COLLABORATION WITH MONGOLIA RAILWAY

Pandrol has hosted delegates from Mongolia, including officials, railway executives and industry leaders at the factory in Worksop, UK on a number of occasions. Delegates have undertaken Pandrol site visits, laboratory tours and factory walk-throughs to give them a first-hand experience of the manufacturing processes and technological capabilities, which created a better understanding of the company's expertise and commitment to quality assurance. The visit served as a critical platform for knowledge exchange and the exploration of potential future collaborations.

This and subsequent visits by the Mongolian delegation to Pandrol's factory created a strong partnership, with a shared commitment to advancing rail technology and infrastructure development. The collaboration between Pandrol, Mongolia Railway and local track contractors represents a significant step forward in the development of modern, efficient and sustainable rail infrastructure in Mongolia.

The success of these projects was reinforced by the close working relationship between Pandrol's technical teams and the Mongolian team on the ground. Pandrol's training and technical support for contractors and employees served not only to improve the quality of rail infrastructure but also created a transfer of knowledge and skills.

So far, rail fasteners have been supplied to create over 800km of the track for Mongolia Railways, which, when completed, will become one of the longest, potentially, heavy haul railway lines in the world.

Tavantolgoi–Gashuun Sukhait railway, Mongolia:

PANDROL'S ALUMINOTHERMIC WELDING SOLUTION

CUSTOMER:
Bodi Group/INCON

DATE:
2021

HEAVY HAUL TRACK LENGTH:
240 km

The second Pandrol project in Mongolia was to supply aluminothermic solutions for the 240 km Tavantolgoi–Gashuunsukhait railway.

This line features two stations and five passing loops and was set to significantly boost Mongolia's economy. This new railway would allow Mongolia to increase its export capacity by 30 million tons of coking and thermal coal annually. As a result, the country's mining companies would be able to compete in the global market, supporting both coal exports and China's ports.

As the building of the Tavantolgoi–Gashuunsukhait railway was set to have a huge impact on Mongolia's economy, Bodi Group (one of the largest business groups in Mongolia) and its subcontractor InCon were looking for an effective, time-saving and reliable welding solution.

IMPROVING SLEEPER STABILITY IN HEAVY HAUL TRACK WITH RESILIENT TPE RAIL PADS

PHENOMENON SLEEPER SKEWING

The phenomenon of sleeper skewing can be identified, to differing degrees, on many railway tracks around the world. A sleeper is considered as being skewed when it has moved from its original position in the ballast, and is no longer at right angles to the rail.

A novel design of rail pad manufactured primarily from a thermoplastic polyester elastomer (TPE) compound has been optimised to accommodate the extreme axle loads and conditions experienced in the Pilbara heavy haul railways.

This insight article explores behind the scenes of the innovative track trials, lab tests and modelling conducted in relation to the mechanism of operation and effectiveness of these rail pads in the quest to prevent sleeper skewing. In heavy haul rail networks some areas of track, with particular geometry traits and where vehicle dynamic contributions from braking or acceleration are present, have demonstrated a predilection over time towards longitudinal sleeper movement and sleeper lateral rotation ('skewing'). This sleeper movement can lead to track geometry defects and ballast attrition that result in the need for vehicle speed restrictions and require maintenance operations at increased frequency.

UNDERSTANDING PLASTIC MOVEMENT

There are two events that precede a skewed sleeper; i) the sleeper must have moved within the ballast in a non-elastic manner and ii) one end of the sleeper must have moved more than the other. However, the key to prevention of sleeper skewing lies in understanding why any plastic movement occurs in the first place.

The main determinants of sleeper skewing behaviour are the longitudinal forces the rail is subjected to, which are distributed and dispersed by the fasteners, sleepers and ballast. The level of force, the distribution of forces, and the resistance to plastic movement in the fastening and of the sleeper in the ballast determine how much, if any, plastic movement and skewing takes place. The forces may arise from a number of different input conditions, and may include differential forces and stresses acting on the two rails as a result of track geometry (e.g. tight curve radii), the existing stressed state of the rails, and forces arising from the high tractive effort related to acceleration or braking of locomotives. Skewing can occur on tangent and curved track, and on gradients and level track. Because of the high traction forces that apply on heavy haul networks, these railways may be more prone to problems of sleeper skewing.

IDENTIFYING SKEWING BEHAVIOUR

Previous work by Rhodes et.al. (2005) identified a factor that may be important in determining sleeper skewing behaviour, particularly in heavy haul railway track. This is that longitudinal loads are distributed further along the track than are vertical loads, and that the vertical load modifies the longitudinal behaviour. The rail clips provide some vertical loading of the rail / sleeper interface in advance of a train's arrival, even before the train loading has any effect on this interface or the interface between the sleeper and ballast.

Rhodes also identified differences in sleeper skewing performance between two types of rail pads used in South African heavy haul track. A larger scale study was then conducted in Australia, comparing the performance with respect to skewing of two different types of pads on heavy haul track:

- Type A: a standard High-Density Polyethylene (HDPE) type widely used on heavy haul track in Australia
- Type B: a variant developed for use in the extreme heavy haul conditions (40 tonne axle load and above) found in the Pilbara region of Western Australia, manufactured primarily from a thermoplastic polyester elastomer (TPE).

FIELD TRIALS

After an appropriate section of track incorporating steep grades and curves had been identified for the trial on a suitable heavy haul network, approximately 10,000 Type B pads were installed over a distance of approximately 3,000 m during re-railing of the area in August 2016. This area was then monitored closely for a period of 12 months using creep markers to quantify the effectiveness of the pads. After the initial 12 months, monitoring was scaled back to less frequent visual monitoring as part of scheduled track runs by the area track inspectors.

The trial section has shown minimal movement relative to the installed creep monitoring stations since the installation of the Type B pads in August 2016.

Approximately 800 million gross tonnes have travelled over the site during that time (33 months). The sleepers in the trial area have remained in place with only minor visible movement. In contrast, on the same section prior to the trial when standard Type A pads were installed, extensive movement occurred after only 12 months of service.

On reviewing the number of hours of track occupation that were required to rectify skewed sleepers during the trial period, an adjacent section with Type A pads installed required 19 hours of maintenance time to rectify defects associated with skewed sleepers, in comparison with the trial section of type B pads requiring only three hours over the same period.

The field trial work shows a clear difference between the performance of pad types A and B. But it does not provide a means of explaining exactly why that difference occurs. In order to explore this question further, some laboratory testing and modelling work has been carried out.

INSTRUMENTAL BEND

At the Pandrol research laboratory in the United Kingdom, the first obvious difference identified in the tests was in the vertical stiffness of the pads.

Type A pads are a rigid design made from a stiff material with a relatively high modulus of elasticity. Type B pads are also made from a relatively high modulus material, but are designed to have a low vertical stiffness, while still being able to withstand heavy haul axle loads.

The Type B pad is characterised by a central membrane that has vertical studs on either side of it, but which are offset from each other. This means that when the pad is loaded vertically (either by the clamping force of the fastenings alone, or in combination with vehicle loading) the membrane bends, and this provides a level of resilience. As expected, a significant difference was found when these pads were tested.

In short, pad Type B is resilient in the longitudinal direction as well as the vertical direction. This was seen clearly in the test results.

FIELD TEST FINDINGS

A non-linear mathematical model was then developed to identify which of the above performance factors determine the difference in resistance to sleeper skewing, or if more than one factor is involved. This model also helps to identify where exactly slip is most likely to occur relative to the position of the train. The model led to the simple conclusion that there is a significant improvement in resistance to sleeper skewing predicted for pad Type B compared to Type A. In fact, all the pad performance indicators had some effect on the predicted resistance. In all cases, the effect was in favour of the characteristic measured for pad Type B.

RESILIENT PADS DELIVER

The implementation of a trial has proved that it is possible to successfully reduce sleeper skewing to a significant extent in extreme heavy haul track through the application of vertically and longitudinally resilient pads that are effective at mitigating the effects of forces applied to the track. Laboratory testing and numerical modelling explain a mechanism whereby the resilient pad can reduce sleeper skewing.

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