300 million reasons to choose Pandrol

Foreword

This is the first edition of Track Report—a magazine which we hope will be of genuine interest to everyone involved with the track.

With Pandrol fastening systems now being manufactured in 12 countries and with plans for further plants at advanced stages, it is becoming more difficult to keep members of our Group and their customers up-to-date with all our various developments worldwide.

Track Report is therefore being utilised to help bridge the gap in communication.

Pandrol will cover significant developments in the Group's activities throughout the world as well as providing in-depth coverage of customer applications of Pandrol Systems.

We shall value any comments on the contents and will consider any suggestions for inclusion in the future.

Despite the many technological advances in our daily lives, the rail vehicle is still the most viable and cost-effective solution to the problem of moving bulk freight, minerals, people, or large masses quickly safely and at relatively low cost.

Every day in cities throughout the world, millions of people are carried on rapid mass transit systems above and below the ground.

Local, national and international high speed rail networks linking cities, ports and manufacturing centres, carry people, raw materials and finished goods essential to our way of life.

But to succeed against the competing forces of road, air and waterborne traffic, a railway system has to overcome one built-in weak spot—the life of the permanent way.

Higher vehicle speeds, now over 300 kilometres an hour for passenger trains, increased axle weights, increased passenger densities, sharp curves and steep gradients, all take their toll of rail and sleepers, despite considerable recent improvements in vehicle suspension design.

To overcome the forces of wear and punishing shock, rails need to be fastened flexibly with a system that allows the track to accommodate the forces of a loaded wheel without losing gauge or toppling under sideways pressure.

If the fastening system is also cheap, simple, easy to install and maintain, and allows rail replacement with minimum cost and downtime, so much the better.

Pandrol is such a system and with more than 300 million Pandrol rail clips now sold, the company is celebrating 45 years of track fastening technology.

Designed by Pandrol International, manufactured by Pandrol plants all over the globe, in 98 countries the Pandrol system meets the requirements of the most severe service, in extremes of climate, in a manner second to none.

Made from high quality spring steel alloy the unique Pandrol rail clip works through a combination of bending and tension to provide strong vertical clamping forces to the foot of the rail, while still allowing progressive lifting of the rail in response to forces generated by a loaded wheel as it approaches the sleeper.

Opposing clips, driven in from each side of the rail, provide strong frictional forces to prevent longitudinal rail creep under traffic.
and in extremes of temperature, while the design of the clip housing prevents the clip from being dislodged.

In addition, the system is universal—capable of working with all weights and profile of rail and all types of sleeper: hard or softwood, pre-stressed or post tensioned monobloc or twin block concrete steel sleepers, concrete waybeams, or continuous concrete slab.

The system is also adaptable, capable of being fitted to existing steel baseplates by means of a simple welded-on shoulder—or to steel sleepers by welding on a specially designed 'Pandrol' baseplate.

On concrete, no baseplates are used. Instead cast-in or resin-bonded shoulders hold the clips. With a resilient pad beneath the rail to absorb shock and vibration—plastic insulators are inserted between the rail and the shoulder to locate the rail precisely with varying thicknesses allowing widening of gauge in curves.

These plastic or nylon insulators extend over the rail foot, preventing metal to metal contact between the rail and the clip and, combined with the rail pad, ensure total insulation, essential for track power supply to electric vehicles and for modern track signalling systems.

But apart from its technical excellence, the strength of the Pandrol track fastening system lies in its ease of maintenance and long trouble free life. Installation and removal of the clips needs nothing more complicated than a trackman's hammer although for efficiency a range of specialist hand tools have been devised. The Parpuller for easy insertion and removal, particularly in confined spaces such as points and crossings. And the Pansetter devised for accurate centralising of the rail between Pandrol shoulders during the insertion of Pandrol insulators.

In situations where security is of prime concern a modified anti-vandal clip and housing is available preventing unauthorised removal without the appropriate tool.

For high speed mechanical maintenance a range of mobile on-track Pandriver vehicles have been designed. The fastest of these are capable of installing or extracting Pandrol clips at the rate of 790 sleepers an hour driving four clips simultaneously at each sleeper, with a rail lifting device for de-stressing operations, or pad inspection.

With over 30 variants on the basic system, including the new 'e' clip, designed to apply even greater holding power but with considerably less metal, the Pandrol track fastening system is capable of holding any rail, at any gauge, for either welded or jointed track under the harshest of operating conditions anywhere in the world.

Pandrol's ability to cope with severe conditions can be seen on the Hamersley Iron Railway Running through North West Australia, the single track line carries trains of 26,000 tonnes total load with axle weights of 30 tonnes, round the clock 365 days a year, with rail temperatures ranging from 70°C at noon to below zero at night, with rainfall of up to 100 millimetres in an hour.

Pandrol's ability to cope with rail forces and wear in curves and gradients has been effectively demonstrated in Canada where in 1972 CN Rail began replacing timber sleepers with concrete to handle traffic in excess of 30 million tonnes a year in their curves of 2 degrees or more. Pandrol clips and insulators contributed to a significant increase in track life, with reduced day to day maintenance and extended resurfacing cycles.

One of the greatest advantages of the Pandrol system is its ability to modify existing track fastenings at low cost to provide an immediate high technology answer to a complex problem. In Brazil, the Petrobras Federal S.A. upgraded its vital system carrying iron ore from the mines in Minas Gerais State to the steel production area around Volta Redonda, and from there, the basic steel products to manufacturing areas, including Sao Paulo and Rio de Janeiro.

Simple weld-on shoulder conversions for existing AREA baseplates on timber sleepers, plus Pandrol rolled steel base plate assemblies supplied an effective low cost answer, with elimination of creep and rail roll-over problems that had plagued the line for years.

Wherever there are rails Pandrol's track fastening system can provide a positive answer backed by on-going research and development, and technical support throughout the world.
The 'e' Clip
-Bringing economy and technology together

Two years ago, in a triumph for technology, America's Voyager 1 spacecraft sent back the first-ever detailed photographs of the planet Saturn and its moons. At the same time Pandrol in a more modest and down-to-earth achievement, completed the development of a significant advance in track fastening technology—the 'e' clip.

The criteria behind the 'e' Clip development programme were those of operational economics. To take a system already acknowledged to be probably the simplest and most effective and make it better still is sometimes possible. But to make it better and less costly is extremely difficult.

The 'e' Clip, however did just that. By bringing together the experience gained in 43 years of track fastening manufacture and the results of new research in materials design techniques and manufacturing processes, Pandrol made the best a little better.

Evolved from the PR series clip, the 'e' series has been designed to generate higher damping forces than PR clips of the same bar size, thus allowing considerable economies in materials without sacrificing any of the PR clips operational qualities.

For example, a PR400 clip, made from 306 mm round bar, has a mass of 0.984 kg and produces a nominal toe load of 700 kgf. An e1800 clip, made from 18 mm round bar, produces a toe load of 900 kgf, but has a mass of only 0.589 kg. So for 55 km of track this represents a saving of about 1.200 tonnes of steel with a gain in rail restraining force of almost one tonne per metre of track.

The 'e' series clip has another important economic advantage in that its low profile design allows much greater scope for mechanical handling with Pandrol's new MX VI automated installation vehicle.

With installation speeds of 750 sleepers per hour, and automatically fed clip magazines, track can be fastened much more cost effectively using fewer personnel, thereby releasing man hours for other tasks.

For example, a working team of four men using manual tools will install 150 metres of track in an hour. Using the fully automated MX VI Pandriver, two men can install 750 metres of track in the same period.

Proving the 'e' Clip

Having finalised the design profile of the 'e' clip (so named because it resembles the letter 'e') a batch of development clips were manufactured and subjected to an extremely rigorous and exhaustive test programme, part of which included the following test carried out for the Swedish State Railway.

Six e1800 clips, selected at random from a batch, were weighed, checked for dimensional accuracy and surface hardness, and then driven into a concrete sleeper of the same type currently used by the Swedish State Railways for their $350 kgf rail. The generated toe load of each clip was then measured.

The clips were positioned in a test rig and an average toe load/toe deflection characteristic was obtained with the heel seat 7 mm below the top of the clips centre leg settings. The generated toe loads were again recorded to measure the incremental increase in the clips' toe deflection.

Each clip was then subjected to five million operational cycles (a cycle being representative of rail movement upon and after the approach of a loaded wheel) under the following conditions:

a) Heel seat of clip 7 mm below top of centre leg.
b) Static deflection 12.7 mm.
c) Dynamic deflection 0.25 mm.

In order to establish the expected life of the 'e' series clip, a further fatigue test programme subjected a number of e2001 clips at varying deflections, to a minimum of 20 million cycles. At amplitudes of between 0.030 and 0.040 inches, the clips withstand the test without failing.

The above chart shows the range of toe loads obtained at various intervals throughout the tests. As can be seen, the mean toe loads had relaxed by only 16 after 20 million cycles, still well within the minimum operational requirement.

Experience under Traffic

Some of the first 'e' clips to be installed went into a line operated by Mt. Newman Mining in Australia in August 1978. The clips were installed on steel sleepers. By the end of last year eight other operators in Australia had brought the total of 'e' clips installed in Australia to 1.47 million, the majority of these being in Westrail track.

New Zealand Government Railways has also installed 'e' clips and between the two countries, 'e' clips are now operating under conditions which involve typically 60 million gross tons per annum, gradients of 1/44 and curves of 400 metres radius.

A further eight countries have installed 13.5 million 'e' clips, bringing the total to 15 million. By the end of 1982, a further 10 countries will have installed evaluation lengths of 'e' clip track.

The 'e' clip is proving to be the right solution at the right time and is now very much the rail fastening of the future in use today.

| Comparison of typical Pandrol PR series and 'e' clips |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Clip            | PR400           | PR600           | e1800           | e2000           |
| Bar Diameter    | 206 mm          | 222 mm          | 18 mm           | 18 mm           |
| Nominal Toe Load| 700 kgf         | 900 kgf         | 118 kgf         | 118 kgf         |
| Working Deflection| 14 mm          | 13.5 mm         | 12.7 mm         | 13 mm           |
| Nominal Rail Seat| 14 mm          | 18 mm           | 18 mm           | 25 mm           |
| Clamping Force  | 14 kN           | 18 kN           | 18 kN           | 25 kN           |
| Surface area in contact with Insulator or rail | 315 sq mm | 343 sq mm | 370 sq mm | 525 sq mm |
| Pressure on Insulator | 2.1 kN/m² | 2.1 kN/m² | 2.4 kN/m² | 2.4 kN/m² |
| Creep Resistance for Concrete Sleepers with: | 2.2 mm | 2.2 mm | 2.2 mm | 2.2 mm |
| a) rubber pad   | 13 kN           | 16 kN           | 16 kN           | 21 kN           |
| b) EVA pad      | 11 kN           | 12 kN           | 16 kN           | 18 kN           |

The results of the test were very favourable. With an average generated toe load of 953 kgf on completion of the test, against the indicated toe load of 900 kgf for the design nominal deflection of 12.7 mm, all of the clips tested were unaffected by the five million fatigue cycles and no difficulty was encountered in removing the clips from the $350 sleeper assembly.

This test, like the others in the development programme, including accelerated corrosion and fatigue tests, showed that the 'e' series clip would meet all its design requirements when subjected to active track conditions.
Hamersley Iron successfully build the first Australian turnout made with concrete sleepers

The problems were finally overcome by Austak, a subsidiary of a Swedish company using a Swedish patented design and process through the Perth company, Delta Concrete. Austak are the representative company for the Swedish Rail System (SRS) Group in Australia. The Swedish group has installed 100 concrete turnouts since developing the process some seven years ago.

The sleepers in the Swan 27 turnout are, however, believed to be the heaviest concrete sleepers yet manufactured. Life expectancy is expected to be more than 20 years and anywhere up to 40 years.

Hamersley's Bob Vanselev (Civil Engineer Technical Dept) explains the project's benefits.

The design of the turnout is based on the following features:
- Planes are used absolutely necessary which reduces stock holding costs.
- Cast-in Pandrol shoulders are used wherever they will fit.
- Standard shoulder-shape dimensions, for mainline concrete sleepers are used wherever possible. This enables standard Pandrol clips, pads and insulators to be used to the maximum.
- Cast-in nylon ferrules and Pandrol shoulders are placed as close to the sleepers' centre-line as possible. This makes the maximum section area available for pre-stressing tendons.
- Ease of tamping, with the depth and base width of the sleepers is the same as for our mainline concrete sleepers, i.e. depth is 207 mm and base width is 264 mm. Side slopes are 1:12. Insulating pads 6 mm thick were used in this turnout, but future turnouts will use the latest mainline standard pads of 9 mm thickness. Plafting in the switch and frog areas adds a further 23-30 mm to the effective depth for tamping machines. Lengths are in 3m and 100mm steps.
- Design moments of resistance for the sleepers were chosen by considering the maximum amount of pre-stress permitted by Code, given the derived overall cross-section

Positive (rail seat) moments were then chosen to be 4% higher than those of the mainline concrete sleepers, which is the same as the British Rail which left us with sufficient negative moment to generate a positive (rail seat) moment of 1.2, about mid-way between the British Rail ratio of 1.03 and the Swedish Rail System ratio of 1.47.

The designs are compatible with possible future loco axle loads up to 35 tonnes at current operating speeds of 60km/h.

Pre-stressing of the sleepers was achieved by 207wire strands of 79mm diameter, jacked to a total of 115 kN.

The concrete had a compressive strength of 53 MPa at transfer and 45 MPa at 28 days. Two mild steel deformed 3mm bar stirrups were provided at both ends of each sleeper to protect against end splitting.

The turnout is fully insulated for signalling, with glued insulating joints (staggered) on the two turnout rails. Plates are insulated with specially cut high density polyethylene (HDPE) pads beneath them, and the cast-in nylon ferrules which accommodate the screw spines. The number of different types of specially cut pads is kept to a minimum by using 'loose' dimensions so permitting the use of each type in a number of positions. The frog casting has HDPE pads beneath its base (if swing nose) or beneath the frog plates (if open throat) but no insulators as such. This enables use of standard Pandrol shoulders (if swing nose) and standard frog plates (if open throat) but does cause an electrical problem as the stock rails are insulated.

At the staggered insulated joints the conduit for the wire bond will in future be set into a rebate provided in the top corner of a sleeper.

Sleeper spacing varies between 495mm (standard mainline timber sleeper spacing) and 125mm (mainline concrete spacing), with a bias towards the larger spacing wherever possible. Switch blades are inserted and reinforced, and the positions of operating and detection rods, vertical heelblocks, heelblocks and fish plates at the blade heels are all kept standard—so sleepers are spaced to suit. In the frog area sleepers were spaced to suit a swing nose frog. The seven plated sleepers in the frog guard rail area will eventually be replaced with unplated sleepers to take the non-guarded swing nose frog and switch motor. Future turnouts will have eight plated sleepers under open throat frogs, reverting to seven unplated sleepers under a swing nose frog.

The Featherock mechanism previously required on our swing nose frogs will be replaced by a simple lost-motion bar when the turnout is converted to 'swing nose' in November 1981.

All the switches, slide plates are made interchangeable so that the amount/position of braiding may be varied if necessary.

Insulated gauge plates, normally required across the top of timber sleepers in the Point of Switch area and at the swing nose 'Featherock' mechanism, are not provided.

Switch mortises and operating mechanism are mounted on lengths of rolled steel channel section inverted over the top of the concrete sleepers. The motor's hold down bolts are stud welded to the channel.

In the confined regions behind the heels and on either side of the frog, tapered wedge washers (bent down by screw spines) are used. These are machined from mild steel and are slotted to ensure a tight fit between the rail flanges. Beyond these, single Pandrol shoulders alternate from rail to rail until there is sufficient spread to permit back-to-back shay frog operation.

The sleepers were originally designed with 50% of the fastenings cast in place (i.e. all the chain related to the mainline rails) and long pockets provided to epoxy glue the others in later but, after several tenders, decided to opt for a fully cast in place system offered by Austak/SRS.

With the help of an expert from Sweden, Austak supervised the manufacture of the sleepers at Delta Concrete plants in Heme Hill in the outer suburb of Perth.

With respect to the ease of installation, and their performance to date, we are extremely pleased with the sleepers. Gauge is very accurate, and general condition and surface finish are excellent. Although we preferred to fabricate our first concrete turnout as a unit, we are confident that these sleepers could be installed singly if required.
through holes drilled in the sole plate, whereas with bolt-on baseplates the fastening secures both the baseplate and the sole plate together.

**Steel Sleeper Systems**

Where there are no problems with groundwater or serious floor heave and traffic is restricted to low speed and relatively low axle loads, steel channel sleepers offer a system that combines strength with economy and gives excellent gauge retention.

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**Glue-In Shoulders**

Excessive performance has shown that simple glue-in shoulder housing are a highly effective, low cost solution for converting wooden sleepers to accept ‘Pandrol’ fastenings.

Formed from mild steel plate, the ‘Pandrol’ shoulder is bonded into place in a pre-drilled hole in the sleeper using a two component polyester resin. Normally a rail pad is placed beneath the rail foot to absorb working stresses. Pull out strength is between 2 and 2½ tons, depending on the timber used.

**Pressed Steel Baseplates**

‘Pandrol’ pressed steel baseplates offer the most comprehensive system for narrow gauge railways, with particular application on high speed man-carrying tracks. The baseplates are secured to the sleeper by either Pandrol® Lockspikes or coachscrews. Lockspikes are driven into pre-drilled holes and when in position the spring pressure prevents any lateral movement between the spike and the baseplate. The compression of the lockspikes in the baseplate hole causes the spike ends to open, resulting in increased grip. The Lockspikes can be extracted and re-driven in the same hole without plugging.

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**Installation and Maintenance**

One of the outstanding advantages of the ‘Pandrol’ system is the ease with which ‘Pandrol’ clips can be installed and removed from their housings, making rail replacement, track maintenance, or track laying an extremely simple and simple operation.

Insertion and removal of clips may be achieved successfully and safely even in confined spaces, using the ‘Pandrol’ simple hand tool operating on the lever principle that completely eliminates any risk of sparking which could be caused by hammering or any other form of impact driving.

‘Pandrol’ systems are supported by a continuous programme of research and development covering new designs, new materials and improved production methods and, as necessary designs can be tailored to meet a specific customer need.

If safety of men, materials, time and costs are your concern, PANDROL has the comprehensive answer.
The Dynamics of Railway Track

Dr. S.L. Grassie

The curious, and indeed the sensible, engineer will ask on reading this title: 'What is track dynamics?' and 'Why should we be interested in it?'? In the following article I shall attempt to answer the first of these two questions in a way which I hope will enable the critical reader to answer the second question for himself or herself more fully than I attempt to do here.

Dynamics is the study of how systems of mechanical components behave when they are excited by forces which vary with time. The frequency of these forces may be only a few cycles per second, or Hertz (Hz), or perhaps a thousand or even a million Hertz. In the context of the dynamics of railway track, the former may be regarded as low frequencies and the latter as high frequencies. Vibration at a few cycles per second is visible to the naked eye, for example, the buoy of a ship rocking, while vibration at the order of a few hundred cycles per second is more easily perceived as noise.

As a particular example of a dynamic system let us look at a typical section of modern railway track, with continuously welded rail, concrete sleepers, railpads between rail and sleeper, and ballast beneath the sleepers. If we watch what happens when a train passes over it will be clear that the force on the piece of rail varies as each wheel of the train passes over it. The track moves in and out of phase with respect to one another; that is, their motion is out of phase.

By studying the dynamics of railway track we are attempting to explain and understand how much the different components move at different frequencies, how they move with respect to another, and why they are excited. The last question is the most difficult, because the forces that cause the motion are not always obvious. For example, the roughness of the wheel and rail tends to force the track up and down. If the track is perfect, then the force is simply the weight of the train, and the vibration is negligible. However, in reality, the track is never perfect, and the forces are always present.

More illuminating is the study of how the track moves when a train passes over it. The forces on the track vary with time in such a way that the track moves in and out of phase with respect to one another. This movement is called 'track dynamics'.

In the impulse response technique the track is excited by a force which lasts for a very short time and is of known magnitude and duration. This force is applied at the centre of the track, and the resulting displacement of the track is recorded. The response of the track is then analysed to determine the frequency response of the track.

In the harmonic response technique the track is excited by a steady oscillating force of constant magnitude and frequency. The response of the track is then measured at the point of excitation.

Our study may be either experimental or theoretical. In this case, both are used. The former involves the use of the harmonic response technique.

At low frequencies we see that the model response is constant and that the rail moves in and out of phase with the force. At higher frequencies, the rail moves in the same direction as the force.

In Fig. 1 is shown schematically a mathematical model of track whose behaviour is similar to that of the real track. This model is made up of an infinite number of springs, each of which is connected to the track at a point where there is a force on the track. The behaviour of the track is then determined by the forces acting on it.

The mathematical model can be used to study the behaviour of the track in a number of ways. The forces acting on the track can be determined, and the motion of the track can be predicted. The model can also be used to study the effect of different track configurations on the behaviour of the track.

The model is not perfect, and there are limitations to its use. For example, the model does not take into account the effect of the ballast, which is an important factor in the behaviour of the track.

The model is useful, however, and it can be used to study the behaviour of the track in a number of ways. It can be used to study the effect of different track configurations on the behaviour of the track, and it can be used to predict the motion of the track.

In conclusion, the dynamics of railway track is a complex subject, but it is one that is important to study. The model is not perfect, but it is useful, and it can be used to study the behaviour of the track in a number of ways.
Conversion systems for baseplates

simple, safe and sound

It is a popular railway myth that in order to upgrade your track to Pandrol, you first have to throw away all your existing baseplates. Like the majority of myths, this one has no foundation either. Most baseplates designed for use with cut spikes (dog spikes) or with bolted types of rail fastenings, can be modified to accept Pandrol fastenings. The conversions involve a number of methods, the most widely used being:

**Weld-on Shoulders**

This system is almost universally applicable, and is suitable for most types of rolled steel baseplates. A pair of pressed mild steel 'Pandrol' shoulders are jig welded onto the baseplate, normally using a semi-automatic MIG welding system. With the gas composition arranged to suit the baseplate material. Since the 'Pandrol' shoulders often cover holes positioned for the original baseplate securing devices (screws, spikes, lockspikes, etc.), new holes should be formed either by punching or drilling.

**Hook-in Shoulders**

This system is suitable for rolled steel baseplates designed for use with cut spikes and is particularly suited to AREA type baseplates. Two specially designed spring steel 'Pandrol' shoulders locate through existing square cut spikes holes in the base plate and lock under it. The shoulders can then be driven into position with a sledgehammer. The conversion is carried out without disturbing the rail or baseplate, unlike weld-on shoulder conversion which can only be undertaken after the baseplate has been removed from the sleeper.

**Weld-on Shoulder**

This system is only suitable for double shouldered rolled steel baseplates. A special clip is used where the centre leg locates underneath the baseplate. To accommodate the centre leg a hole is drilled into the edge of the sleeper to a depth of about 3 inches. A short length of weld bead is deposited on the top face of the baseplate to act as a guide for the heel of the clip. This conversion can be effected with the baseplates in position on the sleeper, and on-track equipment has been developed to drill the sleepers and place the weld bead automatically.

Other systems have been developed for specific applications, such as conversion of rolled steel 'K' and 'Heyback' baseplates, and Pandrol's design engineers will examine any specific conversion requirements.