Contents

PANDROL FASTCLIP Introduction .................................................. page 3
Metro North Adopts PANDROL FASTCLIP
by Dave Ordel, Director of Force Account Management, and John Wagner, Assistant Chief Engineer Maintenance, Metro North Commuter Railroad .......................... pages 4 & 5

The Gardermoen Airport Rail Link
by Arne Svenstad, Senior Project Engineer Track, NSB Gardermoenen AS ........................................... pages 6 & 7

Track System for the Danish Landworks of Øresund
by Johnny B Sørensen, Project Director, A/S Øresund ...................... page 8

PANDROL FASTCLIP Shoulder Locations within a Sleeper Mould .... page 9

Partek Østspenn and PANDROL FASTCLIP
by Bjørn Thoresen, B.Sc., Ch. Eng., Senior Engineer, Partek Østspenn ... pages 10 & 11

Racine Application Machine ........................................................ page 11

Pandrol Concrete Sleeper Installation
by Cal Ooy, Vice President North American Sales, Fairmont Tamper, Harsco Corporation ........................................... pages 12 & 13

PANDROL FASTCLIP Handtools .................................................... page 14

Pandrol Fastening System on Concrete Tie Turnouts
by J. J. Cunningham, Assistant Chief Engineer Track, Amtrak ........ page 15

Track Design and Track Component Testing
for the Korean High Speed Rail Project
by Dr. K D Kang, Director Track Bureau of Korean High Speed Railway Construction Authority .......................... pages 16, 17, 18

The PANDROL e-PLUS Rail Fastening
Resilient Rail Pads used in South Africa
by J. S. Maroo, M. Eng., Senior Engineer (Test) Testing Centre, Spomed ... pages 20 & 21

The EUROBALT Project ............................................................... page 22

Use of VORTOK Coils by the Portuguese Railways CP
by Engº António Sequeira da Cruz, CP, Chefe de Divisão de Via Da Conservação ........................................ page 23

PANDROL GAUGE-LOCK makes In-Roads into Argentina ............ pages 26 & 27

Installation of PANDROL FASTCLIP Concrete Sleepers
by a P911 SP-FC tracklaying machine
Metro North Adopts Pandrol Fastclip

by Dave Ortas, Director of Force Account Management, and John Wagner, Assistant Chief Engineer Maintenance, Metro North Commuter Railroad.

MTA’s Metro North Railroad operates from Grand Central Terminal (GCT) in midtown Manhattan. Created in 1983 to assume responsibility for Conrail’s commuter operations in New York and Connecticut, the railroad provides over 220,000 customer trips per weekday over its three main lines: the Hudson Line (GCT to Poughkeepsie, N.Y.), the Harlem Line, which branches off the Hudson Line five miles north of GCT and continues to Dover Plains, N.Y., and the New Haven Line, which branches off the Harlem Line twelve miles north of GCT and continues to New Haven, CT. These branch lines fed the New Haven Main Line and serve New Canaan, CT, Danbury, CT, and Waterbury, CT.

Since its inception, Metro North has looked to investments which would provide long-term service improvements for its customers. Goals included providing reliable service, improved on-time performance, and investments in infrastructure which would minimize future maintenance. Wood tie replacement was an area where these goals could be met. Metro North’s wood tie replacement policy was based on a six-year tie cycle program. Track was removed from service during off-peak periods every six years for cycle replacement.

Tie replacement in double track territory necessitated single-tracking, which had a negative impact upon on-time performance. Since on-time performance is a key to not only maintaining Metro North’s customer bases, but increasing ridership, the Engineering Department was mandated to investigate the alternative of installing concrete ties.

Researchers reviewed existing installations in development of a concrete tie suitable for Metro North, one that could support both third rail and train loads. Washington Metro and Boston’s MTA utilized concrete in third rail territory, but their systems operated light weight transit equipment. The Amtrak concrete tie, designed for higher speeds and heavier equipment, utilized a sloped design that would not support third rail. With the assistance of other railroads and concrete tie manufacturers, a tie design which met the criteria established by Metro North was finalized in late 1983 and test installations commenced in 1985 using PANOROL e-clips.

In 1993, Pandrol introduced a new fastening system, PANOROL FASTCLIP, which eliminated the need to handle clips, past, and insulators required by the PANOROL e-clip system. A Metro North representative visited a CSX installation of 1,000 PANOROL FASTCLIP-equipped ties in September of 1994 and was favorably impressed by the fact that all components of the system were pre-mounted at the KSA concrete tie plant and were shipped to the site captive on the tie.

Metro North reviewed the PANOROL FASTCLIP system. At the time, there were only two or three test installations in the United States and, while Metro North considers itself a progressive company, it usually feels more comfortable investing in a proven technology. PANOROL e-clips. In addition, the savings to be realized in elimination of material handling of PANOROL FASTCLIP was also weighed against the fact that its installation equipment was still prototype and modifications would have to be made by CANAC, the selectedconstructor of its Track Laying Machinery (TLM).

After careful consideration it was decided to make a change in the original tie order to KSA to include 25,000 PANOROL FASTCLIP for the 1995 season. The United States’ first double-track PANOROL FASTCLIP installation with third rail therefore took place on the Harlem Line; it drew the attention of Amtrak, Conrail, and the Long Island Rail Road.

The program has been increased to 37,000 PANOROL FASTCLIP concrete ties for 1996 making Metro North a leader in the installation of concrete ties for commuter systems.

The future of concrete tie and other capital programs is dependent on funding. New York State is reviewing all funding requests for improvements for the MTA Capital Program. The Connecticut Department of Transportation funds all capital improvements on the New Haven Line in the State of Connecticut; plans to initiate a concrete tie program are included in the next five-year plan.
The Gardermoen Airport Rail Link

by Arne Sveney, Senior Project Engineer Track, NSB Gardermobanen A/S

The Project
In October 1992, the Norwegian Parliament decided to construct the new Oslo International Airport at Gardermoen, 45km north of the city centre. At the same time it was decided that a new high-speed rail link should be constructed to connect Oslo to the airport. The line will be extended to link up with the existing Hovedbanen at Eidetroir, 67km from Oslo. In this way the new rail link will be closely interconnected with the existing NSB network and timetables will reflect the new opportunities for better train services not only from central Oslo and the western suburbs which will be served by the special Airport Express Train, but also interCity and regional traffic which will benefit from the new infrastructure after completion in October 1998.

The construction of this new link is the responsibility of a newly formed company, NSB Gardermobanen A/S, a fully owned subsidiary of the Norwegian State Railway (NSB).

From Oslo Central Station to Lillestrom, the only intermediate station, the line goes through a rock tunnel which together with the adjacent concrete culverts is 14.9km long. Between Gardermoen and Eidetroir there is a further 17.9km long rock tunnel and a number of small structures to allow game to cross the line safely.

The entire line is of double track construction except a short section of single track near Eidetroir where construction costs for double track would have been prohibitively high considering the envisaged traffic volumes.

Construction of such a line gave Norwegian Railway Engineers an opportunity to introduce new developments in railway technology on a large scale. This is reflected in the overhead line and signalling systems as well as track and rolling stock technology.

NSB made the decision to adopt PANDROL FASTCLIP on its new design of UIC 60 concrete sleepers in 1994, following a 2 years of observation of a trial FASTCLIP installation at Lillestrom, where its performance was excellent. The Gardermoen track superstructure is state of the art ballasted track with UIC 60 rails and monoblock concrete sleepers of the new design which included the first large scale use of PANDROL FASTCLIP rail fastenings worldwide. This development in rail fastening is being used for both tangent tracks and through turnsouts.

The Turnouts
NSB has recently modernised its turnout philosophy by introducing centred rails and manganese crossings which were featured in a turnout in 1991: 8.5km long 1220m metres which has successfully been evaluated under NSB mainline conditions. Discussions have taken place between NSB and NSB Gardermobanen A/S regarding the design of the turnouts required for the Airport Link project with the result that both 1:18.5 and 1:26.5 designs will be used, featuring the most developed stage concerning all relevant aspects, like geometry and rail fastenings. The main reason for incorporating the latest available technology was that such developments would be considered for the next generation of railway track standards in Norway.

Normally such bold steps bring uncertainty by introducing prototypes directly into construction without prior testing. However, in this case the new developments consist of elements which are separately well proven and only the combination is new. Further the cooperating partners are familiar with the technical matters and have long experience in working closely together, hence there is great confidence that the result will be successful.

Turnout Geometry
The two designs of turnouts permitting speeds in deviating track 150km/h had originally been designed as 1:18.5.

R=1200m (V=100km/h) and 1:26.5.

R=2000m (V=160km/h). To optimise passenger comfort and minimise maintenance, it was decided to introduce centred curves in the deviating track. The basic curve radii would be maintained, but the overall design parameter changed to 1:18.4 and 1:26.1 respectively with corresponding lengths 88.5m and 94.5m.

The revised geometry would permit passing on the deviating track on the 1:26.1 turnout at V=140km/h.

The Gardermoen rail link will have forty one 1:18.4 and ten of the 1:26.1 turnouts.
Track System for the Danish Landworks of Øresund

by Johnny B Sørensen, Project Director, A/S Øresund

On October 24, 1996, A/S Øresund received tenders from six pre-qualified bidders subject to the tracklaying contract as part of the Øresund fixed link.

Banverket of Sweden tendered the most competitive bid which also constituted the financially most advantageous bid for A/S Øresund.

The contract covers 13 km dual track railway line for the Danish landworks of the Øresund Fixed Link, including the main track from Copenhagen Central Station to the new Copenhagen Airport Station and onwards to the immersed tunnel under Oresund, with a new freight line from Vigerslev to Kalvehave channel and the reversing loop on the artificial peninsula at Kastrup.

A 45% reduction in the number of welds on the rails was one of the technical reasons why A/S Øresund selected Banverket to lay the 13 km dual track on the Danish landworks. Fewer welds mean higher quality as well as cheaper and easier maintenance.

As all track materials were specified on the basis of functional requirements, the bidders were in a good position to offer a matching package.

Due to the fact that the client, prior to the bidding, favoured the PANDROL FASTCLIP as the choice for the elastic fastening of the prestressed concrete sleepers, the bidders were asked for an optional price for FASTCLIP.

The tracklaying begins in November 1996 and the track is expected to be commissioned in August 1998. A smaller section of the work, including the artificial peninsula, will, however, be carried out in the period September 1996 to March 2000.

Pandrol Fastclip Shoulder Locations within a Sleeper Mould

The creation of the PANDROL FASTCLIP system required development of a new method of securing the new design of shoulder in the sleeper mould.

Shoulder moulds which had been used to standard PANDROL shoulders for over 30 years were faced with a FASTCLIP shoulder which was not only quite different, but did not have the "centre leg hole" into which most sleeper makers drove a pin of some type.

In order to assist sleeper manufacturers in making the changeover, Pandrol developed a method which uses the same principles of location as those used for PANDROL "e" clip shoulders where the key working parts of the shoulder are the holding points.

A pocket, set in the mould carcass, contains a fixed heel register to set the height of the rear of the casting whilst two connected sliding mandrels move into the pocket to fix the position of the other working features of the casting. This sliding unit is also designed to push the gauge face hard up against the mould pocket, thereby ensuring rail seat width is controlled within tolerances.

Moulds using this principle to manufacture PANDROL FASTCLIP sleepers are currently in use at both Tarmac and RMC in the United Kingdom.
Sleeper Preparation

Partek Østspenn and Pandrol Fastclip

by Bjørn Thoresen, B.Sc., Civ. Eng., Senior Engineer, Partek Østspenn

When we were asked by Norwegian State Railways in 1984 to prepare ourselves for converting our sleeper plant from PANDROL "n" clip sleeper production to PANDROL FASTCLIP there was no previous experience in the world of full scale FASTCLIP sleeper production. Our own experience related to production of 500 test sleepers in 1992, but we had not developed a satisfactory mechanism to hold the shoulders firmly in the mould during the concrete pouring and vibration process. Looking to other sleeper makers around the world who had produced test sleepers, we could not find a solution which suited us.

We wanted a mechanism as simple as possible, preferably non-powered, which led us to a spring-loaded latch fitting into a recess in the FASTCLIP shoulder, pushing the shoulder against the gauge-face and at the same time holding the shoulder down with its four pegs resting on the bottom of the sleeper mould. The tolerances were now guided by the tolerances in the mould and the shoulder, not by the holding mechanism. For the moulding, the moulds are pushed downwards, and the latch springs back and automatically releases the shoulder. During one year of full production with the system (512 sleepers per day) our expectations have been fully met. There is no evidence of the latches releasing the shoulders prematurely and no significant wear on the tip of the latches has occurred although these are made of mild steel.

The operation of the new system is also simpler than the old one. In fact we can see manpower savings. At the other end of the plant we planned to assemble the rail fastening with all parts ready to go into track on the sleeper. Again there were no machines or previous experience of mechanical assembly available. The saw-cutting of the reinforcement wires determines the rate of fastening assembly at 2 sleepers a minute at most. The conveyor from the saw to the assembling point has a small buffer capacity.

The FASTCLIP components are placed onto the sleepers manually and the clips are pushed into the rail threading position by means of a simple hydraulically powered device operating on all four clips simultaneously.

Hydraulically powered device for pushing clips into shoulders, showing assembled position of clips

All the FASTCLIP components are supplied by Pandrol UK and each Thursday a new container with one weeks requirement arrives on site to be exchanged with the empty one from the previous week.

In conclusion, we feel that the new FASTCLIP sleeper production line works to our, Pandrol's and NSB’s satisfaction.

Racine Application Machine

Originally designed by Pandrol Rail Fastenings, Racine modified the PANDROL FASTCLIP applicator for North American applications. It will apply clips at a rate of 12 ties/minute, and retract clips for rail distressing/maintenance at a rate of 6 ties/minute. Racine Railroad Products of Racine, Wisconsin, is currently producing a new machine that will increase these rates to 20 ties/minute, and 12 ties/minute respectively. Delivery of the new machines for Amtrak's 150,000 FASTCLIP sleeper programme is scheduled for June 1995.
Pandrol Concrete Sleeper Installation

by Cal Coy, Vice President North American Sales, Fairmont Tamper, Nasco Corporation

As manufacturers and railroads have worked as partners to improve quality, extend useful life, and reduce costs of concrete sleepers and fasteners so has the contracting industry worked together with railroads in reducing concrete sleeper installation costs.

A classic example of this is the evolution of Fairmont Tamper’s concrete sleeper installation machine used for installing concrete sleepers in existing track.

First introduced in North America as a P811, then improved to the P811S, then to the P811SP, and most recently to the P811SP-FC, these machines have installed wall over 10 million concrete sleepers in North America within the last 15 years.

Working with railroads, fastening suppliers and concrete sleeper manufacturers, as well as conducting in-house Research and Development, has enabled Fairmont Tamper to improve and refine the concrete sleeper installation process significantly.

Here are some of the noteworthy developments:

P811: Intended to North America in the late 1970’s, the basic concept of the P811 is still in use today.

Many North American railroads still use the cut, spike for rail retention on wooden sleepers and since the rehabilitation work in North America usually involves replacing wooden sleepers with concrete sleepers, the first development on the P811 for North American application was automatic spike pullers that operated independently underneath the basic P811 machine structure.

P811S: The P811S is a shorter version of the P811. This version allowed the working of sharper curves, up to 12 degrees, and due to its 'floating bogie' configuration reduces bending and potential rail stress particularly when the same rail is threaded out of the track and then back in to the track on the new sleepers.

Since old spikes have a value, a spike retrieval system was developed that recovers the old spikes for use elsewhere.

Traditionally rail anchors are removed by hand ahead of the concrete sleeper installation.

An anchor remover has been developed that removes rail anchors from the rail as it is being threaded out of the track. The anchors removed from the rail are captured and distributed along the track for later reclamation.

P811SP: New technology, called the Pony System, was developed in the area of old sleeper pick-up, ballast excavation and new sleeper installation. These enhancements increased productivity, reduced manpower, and provided greater reliability of the system. This enabled the customer to take maximum advantage of available track windows for accomplishing the work.

P811SP-FC: The greatest single technological breakthrough for concrete sleeper systems was the introduction of the PANDROL FASTCLIP. This system involves the pre-assembly of the rail seat pad, insulators and clips onto the sleeper at the sleeper manufacturing facility. When the sleeper arrives at the installation site it is ready to be installed in track with all of the hardware remaining captive.

This prompted Fairmont Tamper, working in conjunction with a major US railway, to expand further the sleeper installation system to include rail heating and PANDROL FASTCLIP application. These enhancements allow the rail to be heated to required, stress-free temperature just prior to locating it in the rail seat of the sleeper.

Immediately thereafter an automatic device operating within and under the rear of the P811SP-FC engages and drives the PANDROL FASTCLIP into its working position on the rail base. Thus the clip application operation is fully integrated within the track renewal machine and completely mechanized. Ploughing devices on the rear end of the machine move ballast from the shoulders to the ends of the sleepers to prevent movement of the sleepers and rail as rail temperature changes.

This system allows rail to be laid at optimum and uniform temperatures at the outset and in most cases completely eliminates the requirement of a separate rail distressing operation.

So now in a few short years the industry has moved from a P811 machine, that basically removes and replaces sleepers to a P811SP-FC machine, that removes and replaces sleepers and in addition pulls spikes, recants spikes, removes rail anchors, heats rail, and automatically applies the PANDROL FASTCLIP elastic rail fastenings.

These innovative enhancements developed through joint efforts of the railroads, sleeper manufacturers, fastener manufacturers and equipment manufacturers have lowered overall sleeper installation costs 20%-25% and has made concrete sleepers with PANDROL FASTCLIP hardware very competitive.
Installation

Pandrol Fastclip Handtools

Although PANDROL FASTCLIP was designed to be switched on and off the rail by a machine, the fastening system must also be capable of operation by handtools. This is necessary for those customers who choose FASTCLIP for its significant advantages of captive components and increased longevity performance but whose track installation techniques are manual or only partially mechanised. In addition, spot maintenance on a small number of sleepers must be able to be carried out with handtools since moving a machine to some remote locations for a small scope of work would not be cost effective.

Consequently features have been designed into the FASTCLIP system where handtools can be located to drive the clips on and off the rail. Photograph 1 shows the Installation Tool located onto the protruding features on the front of the shoulder ready to drive the clip onto the rail. The Installation Tool can also be easily adjusted to pre-install the clip into the shoulder prior to the switching on process. This would normally be carried out in the first instance at the sleeper factory, and a specific factory installation tool can be supplied.

Photograph 2 shows the Extraction Tool, located on a recessed feature on the shoulder, having driven the clip off the rail. This tool also incorporates a mechanism to control the position of the clip to enable, for example, re-raising, sidepost insulator replacement, or complete clip removal.

Pandrol Fastening System on Concrete Tie Turnouts

by J. J. Cunningham, Assistant Chief Engineer Track, Amtrak

Amtrak has taken a bold approach to fixation of special trackwork on new concrete tie turnouts. Beginning in 1992 with the first high speed #32-3/4 turnouts, a fixation system was used that allines threaded fasteners to hold down plate work associated with the moveable point frogs. In this system, the centre of the tie plate ends are machined to emulate the profile of a rail base. The corners of the plate are left unmachined and the resulting ears act as stops to prevent the tie from shifting under the frog. A PANDROL HD-10 insulator bears against the end of the plate just as it would a rail. There are currently 20 turnouts in track with this system and an additional 25 turnouts on order.

On the #32-3/4 turnouts the frog plates are attached permanently to the frog by means of a rail brace. Because the plates are set perpendicularly to the bosector of the frog it is possible to use the same frog on either a right hand or left hand turnout. This has helped reduce inventory. Amtrak estimates changeout time to be less than half of a comparable frog using threaded fasteners.

Also, with the PANDROL system there is no danger of overtightening the threaded fasteners which can result in permanent damage to both the threaded insert and the tie.

With the success of the resilient fastening system on the frog, attention was turned to the switch and switch heel areas.

The #32-3/4, #40 and #45 turnouts all use 2x1-60 asymmetric switch points with cast slide plates and both the Schwiag and PVT fastening systems.

A system that was used in South Africa was adopted for use on both the slide and the switch heel plates. A cast shoulder known as the 7250 is cast in the tie immediately adjacent to the rail base. The 7250 shoulder resembles an inverted "U". The toe of the PANDROL clip bears on the railbase while the heel bears against a raised surface on the tie plate. This sandwiches the plate and the 9mm tie pad between the rail and the tie. Since the PANDROL clip bears directly on the railbase there is no associated moment arm. Plate lengths have been reduced by as much as 8" and tie pad creep has been minimized.

The use of the 7250 shoulder has been expanded to include the frog on #15 turnouts and both the frog and guardrails on the #10 turnouts.

The 7250 shoulder has been standardized for use on all future #10, 15, 20 and 32-3/4 concrete tie turnouts throughout the switch as well as railbound, springfrog and moveable point frog locations.

Resiliently mounted plate for turnouts, Kingston, Rhode Island, USA

1. Installation Tool

2. Extraction Tool

3. Sleeper Lifting Tool

Inspections of various worldwide FASTCLIP installations indicate that, because of its increased durability, the use of the latter two conditions is likely to be very infrequent. It is acknowledged that a good level ballast bed cannot always be achieved and consequently a Sleeper Lifting Tool has been designed. This is depicted in Photograph 3. This tool also locates on to the same features as the Installation Tool and is able to lift sleepers by as much as 100mm.

During hand installations of a length of FASTCLIP sleepers a team of five persons working in sequence can quickly and efficiently lift sleepers and drive clips at a rate of 6 sleepers per minute even with unfavourable ballast conditions. This was achieved recently in an installation in Scrondinville.

#32-3/4 Moveable Point Frog, Kingston, Rhode Island, USA
Track Design and Track Component Testing for the Korean High Speed Rail Project

by Dr. K D Kang, Director Track Bureau of Korean High Speed Railway Construction Authority

1. Project Background
The Korean government assigned the Korean High Speed Rail Construction Authority (KHSCA) the task of designing and constructing the new 430km long Korean High Speed Rail Line between Seoul in the north and Pusan in the south, as shown in Figure 1. This new High Speed Rail Line is urgently needed to relieve the existing traffic congestion in the Seoul-Pusan corridor on both the existing freeway and the double track conventional railway that is operating at maximum capacity with 134 train movements per day in each direction. The new High Speed Rail Line will be exclusively used for passenger traffic. Extensive track component testing in France and Korea confirmed that the prestressed concrete (PC) sleepers and rail fastenings fully meet their intended design functions. The contract for the rolling stock, catenary and automatic train control has been awarded to the French consortium in June 1984. The prototype train is shown in Figure 2.

2. International Track Advisory Committee
KHSCA, in an effort to obtain the best possible technical advice, invited international track experts from Austria, France, Germany, Holland and Japan to participate in an advisory committee that reviews and comments on track related criteria and design as well as track construction issues. This International Track Advisory Committee provided an in-depth review and comments on the following track related issues:

- Technical specification for track laying equipment such as tamping machines, ballast regulators, track compactors, rail welding and grinding and track inspection cars
- Track installation methods

3. Track
The 430km long new High Speed Rail Line between Seoul and Pusan is shown in Figure 1 and consists of:
- Design Speed: 350 km/h
- Maximum Speed: 300 km/h
- Maximum Super-elevation: 180 mm
- Twin-track at grade: 134 km
- Twin-track on bridges: 133 km
- Twin-track in tunnels: 163 km

- Tunnel cross section: 100 m<sup>2</sup>
- Track gauge: 1435 mm
- Minimum radius, main line: 7000 m
- Maximum grade: 2.5%
- Rail: UIC60 Continuous Welded Rail (CWR)
- Track on at grade sections
- Ballasted track with monoblock concrete sleepers
- Track on bridges
- Ballasted track with monoblock concrete sleepers and ballast mat
- Track in tunnels
- Ballasted track with monoblock concrete sleepers and/or slab track
- Turnouts
- Moveable nose and flexible switch
- Tangential design
- Typical track spacing: 5.00 m

4. Testing of PC Sleepers
The following PC sleeper tests were performed by SYSTRA (formerly Soofrail) in France:
- Bending tests to assess the sleeper bending stress in the region of the rail support and at the mid point of the sleeper. All sleepers exceeded the minimum bending strength requirements.
- Abrasion resistance tests that evaluate the abrasion resistance of the sleeper at the sleeper-ballast interface. After 202 hours of testing the sleeper experienced a weight reduction of 0.86%, i.e. 0.20%. This weight reduction is well below the acceptable weight loss of 3%.
- Porosity tests to determine the porosity of the sleeper concrete. The porosity was determined from a 50mm diameter sample without any cracks. The calculated porosity was in the range of 7 to 8 percent of total volume.

5. Testing of rail fasteners
The following tests were performed on Pandrol Rail Fasteners (PANDROL Type 'E' 1977 clip with studded natural rubber pad) by SYSTRA in France:
- The static rail pad stiffness within the typical working range is about 750 N/mm.
- Torsional resistance for rail fasteners was evaluated to determine the spring stiffness of the rail fastening in the longitudinal rail axis. The minimum required spring stiffness of 724 N/mm was exceeded in all cases.
- Longitudinal resistance to rail creep was determined by three tests. The average creep resistance before and after the three fatigue tests was 12 kN and 11 kN respectively.
- Resistance to combined horizontal and vertical load was tested for three million load cycles ranging from 5 to 70 kN with a sinusoidal loading application and a frequency of 5 Hz. The test setup is shown in Fig 3.
- Resistance to corrosion and accelerated ageing was evaluated in a controlled atmosphere with 25 accelerated ageing cycles in 90% relative humidity and temperature changes from -25°C to 70°C. Both the rail and rail fasteners showed no indication of corrosion or ageing.

6. Test Track Chonan-Taejon
The 63.0 km long test track between Chonan and Taejon as shown in Figure 1 is being constructed first and will be part of the 430 km Seoul-Pusan High Speed Rail Line.
7. Slab Track

The underlying technical reason for using slab track is to obtain a "maintenance-free" or "extended-term maintenance track". The slab track will be used in most of the long tunnels (i.e. those more than 7 km long). The proposed slab track design is based on the Japanese slab track type which is extensively used in tunnels and on segments at grade on the new Shinkansen lines in Japan. The slab track consists of a prestressed concrete panel with embedded base plates. The panels are 5.60 m long and 2.34 m wide and the spacing of the base plates are 625 mm. The base plate has serrated features in order that lateral adjustment can be made by the use of serrated connector wedges. The prestressed concrete track slab panel is temporarily supported and the approximate 50 mm wide gap between the foundation concrete and the underside of the track slab is then filled with a cement-asphalt mixture poured through holes in the track slab.

8. Conclusion

The PC sleeper and rail fastening test results confirm that they meet the Technical Specifications and all Technical Requirements for use on the High Speed Rail Project. The track for the new Korean High Speed Rail Line between Seoul and Pusan is quite similar to that used on the TGV lines in France or the ICE lines in Germany. The mono-block PC sleepers are somewhat larger and have more prestress force than those used in France and Germany and are expected to provide superior performance during operation. The track is designed for 350 km/h and provides the necessary capacity to accommodate trains with a higher speed than those of our first generation rolling stock that will operate at a maximum speed of 300 km/h. The use of slab track in tunnels is expected to reduce greatly required track maintenance and contribute to the safe, reliable and economical performance of the track.
The Pandrol e-Plus Rail Fastening

The PANDROL FASTCLIP system was developed as the world’s first fully captive, pre-tensioned rail fastening. It benefitted from being designed by a team with long experience of rail fastening systems, but that team quite deliberately “started with a clean sheet of paper”. As experience with FASTCLIP was accumulated, it has become clear that some of the new features in its design could be incorporated into some of Pandrol’s earlier fastening designs giving some of the advantages of FASTCLIP whilst retaining a degree of interchangeability with older track designs.

The main feature to be engineered back into the older designs is the two-part insulator. In the FASTCLIP system, one part of the insulator is attached to the toe of the clip, and the other part is fitted around the shoulder. This was necessary in order to make the “switch on/off” action move the toe part of the insulator along with the clip, cler in rail threading and so ensure the absence of metal to metal contact to the rail, which is so important when using resilient pads. Laboratory and field tests showed that this also had the effect of extending insulator life significantly, especially where large lateral loads are applied to the rail.

In order to add such a feature to the traditional PANDROL e-clip system, a method had to be found whereby part of the insulator is attached to the clip. Early attempts at adding such a feature date back to the mid-1980s, when clips with toe insulators glued on were installed on Narita Iron Railroad in North West Australia. The concept worked, but the process of bonding the insulator to the toe proved uneconomical and unreliable.

When the problem was re-addressed in 1994, with the benefit of FASTCLIP development experience, a toe insulator made of high viscosity nylon was designed to snap-fit over a specially forged shape on the toe of the clip. When the insulator was allowed to rotate on the clip toe, another advantage was found: as the clip was less tightly constrained in the assembly, dynamic stresses in the clip, generated by lateral movement of the rail in curves, were found to be reduced substantially. Thus the new system – which was named the PANDROL e-PLUS rail fastening – offered three advantages compared to the PANDROL e-clip:

- Extended insulator life
- Reduced stresses in the rail clip
- Reduced number of loose components on site (the pad and side post insulator can be pre-assembled on the sleeper, and the clip delivered complete with the toe insulator).

The first trial of the e-PLUS system in track took place in June 1995 on a 300 metre radius curve on the East Japan Railways line leading into the New Tokyo International Airport at Narita. The clips, pads and insulators were changed from e-clip to e-PLUS components at twenty rail seats across a transition from ballasted to non-ballasted track. Clip strain levels and rail displacements were measured before and after the components were changed.

The measurements were repeated in November 1995, and the clips and toe insulators then replaced by components more representative of the proposed production e-PLUS system. The diagram shows how the clip strain levels in the front arch of the clip compare with those in a conventional PANDROL e-clip.

The track test results showed that the strains in parts of the clip sensitive to lateral movements of the rail could be reduced to less than half of the level expected in a conventional e-clip. Laboratory tests were also run, to standards laid down by the Railway Technical Research Institute (RTRI) in Japan. These tests are particularly demanding in terms of lateral forces, but the e-PLUS clips passed the complete suite of tests with considerable spare capacity. This test confirmed the track test result in terms of clips strains, and also demonstrated the remarkable durability of the insulators in the PANDROL e-PLUS system.

Subsequently further trials of e-PLUS rail fastenings have been installed in Heavy Haul tracks in North America. The test installations in North America and Japan will be monitored during 1996, to identify any areas in which further development may be needed before the system is offered for widespread use.
Resilient Rail Pads used in South Africa

by J S Maree, M.Eng., Senior Engineer (Track Testing Centre), Spoornet

In South Africa, skewing of concrete sleepers and powdering of ballast on the coal export line, from Broederstroom to Richards Bay (500km) were reported after the introduction of 26 ton axle loading. Consequently an investigation of the behaviour of more resilient rail pads on Spoornet was initiated (see “Dynamic Behaviour of Track with Resilient Rail Pads”, Maree, 1993).

The original planned capacity of the Coal Line could not accommodate the expected export demand. The line was therefore upgraded to accommodate 26 ton axle loads. The track structure, 1007mm gauge, was improved to a standard of 60kg/m SAA chrome manganese rails with Fat or PANDROL fastenings on 215kg concrete sleepers spaced at 650mm on 280mm ballast. With the upgrading, the ruling grade of 1:66 was changed to 1:160 for loaded trains by building deviations where required.

Following the introduction of 25 ton axle loads on the coal trucks and the 11E locomotives with 26 ton axle loading, skewing of concrete sleepers and powdering of ballast on some curves were reported.

The problems mainly developed on the uphill curves in the Paal Pietensberg area and was soon named the “Paal Pietensberg Syndrome” (PPS).

The PPS problem initially developed on the low leg of curves. It mainly occurred on the sharper curves (800m radius), steeper uphill grades for loaded trains and in cuttings the following sequence was observed.

1. Ballast on the low leg of curves was powdered and rounded, resulting in the development of blind stacks.
2. Fat clips (25KN clamping force) were deformed and HDPE pads moved onto the sleeper rail seats (see photo left).
3. Sleepers were skewed (every 8th to 12th sleeper) and pads moved out of the Fat sleeper rail seats.
4. Ballast rapidly deteriorated, resulting in a loss of resistance.
5. Longitudinal movement of rails occurred under trains.

The PPS is attributed to a combination of large vertical movement of the formation under loaded trains occupied with the high tractive forces generated by the locomotives.

Pandrol International and DuPont Engineering Polymer worked together in developing a resilient rail pad manufactured from Thermoplastic Elastomer marketed by DuPont as Hytrel.

The standard rail pads used on the coal line were 12mm thick High Density Polyethylene (HDPE) pads. Pandrol and Spoornet tested a variety of resilient rail pads.

The most successful combination was a 6.5mm Hytrel 6336 insert with the resilience obtained from bending of the centre web between offset studs on either side of the web (see photo below) placed on a Hytrel EPP baseplate.

In-track measurements showed a relative longitudinal displacement between rail and sleeper under the 11E locomotives on HDPE pads (see Fig 1) under maximum traction. Permanent displacement of 1mm after 16 seconds occurred under the 4x11E locomotives.

A vertical pre-load of 75KN was applied on one of the sleepers. With the Hytrel combination the friction coefficient improved by 44%. The sleeper reaction for a 11E locomotive is 75KN.

Dynamic stiffness and damping constants of the pads were determined in a test rig shown in Fig 3. These results are shown in Fig 4.

The resilient pads have also been tested in track with rail corrugations. Early indications are that the corrugation length is longer on track with resilient pads resulting in lower dynamic forces than track with HDPE pads. “White” ballast occurred on track with HDPE pads with corrugation depth of 0.25mm but not with the resilient pads.

Tests are also being conducted on the coal line to determine the effects of resilient rail pads on ballast screening cycles.

Fig 1. Relative movement between rail and sleeper with HDPE railpads under 4x11 E locomotives with maximum traction.

Fig 2. Relative longitudinal movement between rail and sleeper with EPP/6336 combination pads under 4x11 E locomotives with maximum traction.

Fig 3. High frequency test rig developed to determine effective stiffness and damping of railpads.

Fig 4. Dynamic Stiffness and Damping Constants of Rail Pads

Skewed sleepers on Richards Bay Coal Line before remedial treatment.

Age of Pad Dynamic Stiffness Mh/a Damping Constant Mh/a

New 111 22.7
100 MOT 113 20.0
225 MOT 114 15.1
315 MOT 130 18.3
The EUROBALT Project

The European Commission has a policy of encouraging industrial organisations and universities in EU member countries to collaborate in major pre-competitive Research and Development projects. One such project which has just been completed was "EUROBALT".

The EUROBALT project (European project for Optimisation of Ballasted Tracks) was set up with partners in France, the UK and Germany to investigate the behaviour of ballasted track, especially under high speed trains, to try to predict rates of deterioration of track components and track geometry, and to propose ways in which track design could be improved. About half of the cost of 4.6 million ECU (4 million US$) was funded by the European Commission, and the balance was funded by the industrial partners. There were nine partners, each concerned with different aspects of the problem:

- French National Railways – SNCF (project managers)
- German Railways – DB
- British Rail Research
- Pandrol International Limited, UK
- Allevard/Bedaf, France
- M.A.N. Technologie, Germany
- INRETS (National Research Institute for Transport and Transport Safety), France
- ENPC (National Civil Engineering School), France
- Technical University of Berlin, Germany

Work was carried out over a three year period from November 1992 to October 1995. Pandrol's main involvement in the project was to provide laboratory and track test equipment and expertise. As well as applying existing technology (including their unique Dichrotic Placement Monitoring System for measuring rail movement under traffic), Pandrol developed a new method of processing data from accelerometers to determine the exact amount of movement of sleepers in ballast, under traffic. In theory, this is easy to do, but in practice the output from accelerometers mounted on the railway track includes data, noise and drift that make the signal processing very difficult. Pandrol's approach was to use general knowledge of the way in which track recovers when it is unloaded, to provide a means of correcting the displacement data after the passage of each group of wheels. This method was tested on high speed passenger lines in the UK, France, Germany and Italy.

Another track test technique developed during the project was based on the use of piezo-foil force measuring transducers, which could be attached to the rail in the same way as strain gauges, or which could be built into track components such as the rail pad. Some tests were even carried out with piezo-foil transducer attached to a stone in the ballast. The method was developed by T.U. Berlin and M.A.N. Technologie and was evaluated and calibrated in the ballast pit at Pandrol's laboratory before it was used in track. Work was carried out at ENPC to study the fundamental behaviour of the ballast, and to investigate the way in which it settles under long term repeated loading. Results from this work were supplied to INRETS, who used the data as input to its mathematical models to predict rates of deterioration of track geometry on high speed ballasted tracks. British Rail Research investigated other aspects of track deterioration, including development of corrugations and fatigue cracks in rails. Two of the partners developed mathematical modelling techniques to help to predict track forces and, consequently, track degradation behaviour – T.U. Berlin concentrated on evaluation of high frequency dynamic effects, and INRETS concentrated on lower frequency behaviour. By this combination of activities, EUROBALT has provided a framework within which "tools" have been developed which can help the partners to improve the performance of ballasted railway tracks, and to plan appropriate inspection, maintenance and renewal programmes.

Use of Vortok Coils by the Portuguese Railways CP

by Eng. António Sequeira da Cruz, CP, Chefe de Divisão de Vía da Conservação

At the Portuguese National Railway CP (Caminhos de Ferro Portugueses), we have a network of about 3500 km length, the majority of which is on wood sleepered track.

We purchase up to 250,000 sleepers annually. The majority of these are manufactured from locally grown maritime pine (Pinus pinaster) which grows in the northern half of the country. A proportion of this locally grown pine is of relatively low density giving timber properties reduced by 10 to 25% when compared to other pine grown more slowly in other areas of Europe. Consequently lower mechanical performance in track and life expectancy are obtained.

Usually the first signs of mechanical failure of the weaker sleepers occurs at the fastening, especially on curves or at turnouts, where screws work loose, and gauge spread and plate-cutting follows.

Insertion of the "special" VORTOK Coil in new timber turnout bearings at the factory

The cost of purchase and replacement of turnout bearings is two or three times that of plain line sleepers, and the increased track stresses on turnouts shorten the average life of such bearings.

At CP we considered both the introduction of a strength grading system to eliminate weaker sleepers, and the alternative possibility of mechanically reinforcing all sleepers which were to be used in Points and Crossing work to increase their life in track.

Track trials over several years by CP and Vortok International have shown that screw loosening can be delayed significantly by the use of VORTOK coils as a repair measure. Having already established the in-situ plain track applications, where the effectiveness of VORTOK coils for restoring the holding powers of screws in worn holes was demonstrated, there was also a very strong case for inserting VORTOK coils in new bearers during the construction of turnouts at the factory.

Vortok International developed for us a special coil section for use in new bearers. Tests proved that this new coil gave improved pullout resistance and resistance to loosening by vibration, both characteristics being critical in a turnout situation (see figures). Their application has now become a regular practice and the first results appear to be very encouraging.
Pandrol Gauge-Lock makes In-Roads into Argentina

The Tren de la Costa (Train of the Coast) system is located in the northern suburbs of Buenos Aires, Argentina and serves a multifunctional complex of railway transportation and from the city for both the neighbourhood residents and the business areas. The total project investment was US$150 million and took 2 years to complete.

The railway was constructed on land where some 35 years ago the Retiro to Delta line of the Mitre Railway operated. The initial Tren de la Costa project consists of 15 kilometres (9.3 miles) of double track construction with overhead electrification at 1500V DC. The trains consist of double units with a total maximum loaded weight of 72 tonnes (ade load 12 tonnes) and operate a service at 12 minute intervals in both directions with a maximum speed of 80 km per hour with a possible acceleration of 1.0 metres/sec² from 0 to 38 k.p.h.

The track was constructed to 1435mm gauge using BS100R 60kg/m (50kg/m) rail, continuously welded and supported on Quexacho hardwood sleepers at an average spacing of 1655 per kilometre. The sleepers were laid on crushed granite ballast to a depth of 200mm (8 inches) with a full cleft.

Due to the extreme hardness of the Quexacho timber it is not necessary to include a metal baseplate between rail and sleeper. After consideration of the available spring clip fastenings that can be used without a baseplate, a decision was taken to use the PANDROL GAUGE-LOCK fastening system. This type of fastening provides both the gauge control and rail restraint that was considered desirable for the type of traffic to be operated.

The track was pre-assembled and transported to site in 11.3 metre (37.7 feet) panels. The two rail seats per sleeper being sided over a 265mm (10.4 inch) length to produce the necessary 1 in 40 rail inclination with the length of cut covering both the rail base width and the bearing of the two GAUGE-LOCK clips. Two 14mm (0.55 inch) diameter holes for the location of the front leg of the clip and two 23mm (0.90 inch) holes for the tensioning screws were drilled at each rail seat.

Having transported the panels to site, they were installed using a self propelled gantry. Finally the rails were welded into long lengths by the aluminothermic process.

The decision to feature continuous welded rail was taken after consultation with Pandrol Rail Fastenings Ltd, as previously all GAUGE-LOCK installations had been with jointed rails. Pandrol conducted laboratory tests to verify the performance of the GAUGE-LOCK fastening prior to the commencement of track construction.

The track was monitored over the Argentine summer period when it would be expected that movement of the rail would occur. Even on the hottest days the track standard was maintained – the GAUGE-LOCK fastening doing its job.

The latest work that has been undertaken has been to destress the track which was carried out without any problems. The screwspikes were removed which detained the clips. The clips were then rotated through ninety degrees to remove contact from the base of the rail whilst the front leg held the rail to gauge. After destressing, the clips were rotated back into the installed position and the screwspikes reinstalled to achieve the original clamping force.

The Tren de la Costa railway is now operating with good efficiency using local hardwood sleepers than can have an in-track life in excess of 40 years with a fastening system that can provide all the restraints for continuous welded rails without the need for an intermediate baseplate.

PANDROL GAUGE-LOCK on Tren de la Costa, Buenos Aires, Argentina