The type 'e' Rail Clip - the latest product of Pandrol International's continuing search for the perfect solution to the problems of track technology.
The description “Heavy Haul” became widely used after the First Heavy Haul Conference held in Perth, Western Australia in 1978. This was intended to provide a forum to discuss the problems, and possible solutions, which arise in the operation of unit trains, generally hauling minerals, with 30 tonne axles, train weights of 15,000 tonnes plus and dedicated routes. Since then the term has been extended to cover any particularly heavy Unit Train operation.

The first Conference on the subject highlighted the particular problems facing such railways. The majority of the Papers presented concentrated on rail composition and performance, track structure design and performance, and economics of operation. Other subjects covered were vehicle and track interaction, rolling stock design, and train handling techniques.

Four years later at the Second Heavy Haul Conference at Colorado Springs in 1982, rail composition and performance was still the major area of concern, followed by the track structure, operating economics and rolling stock design.

Railways (or railways with particular routes) which fall into the Heavy Haul category are found throughout the world in areas of concentrated mineral deposits, and some background details are given in the Table on page 7.

These railways travel through some of the world’s most difficult terrain, with many of the large iron ore, coal and other deposits, the easiest route for the Heavy Haul railways existence, being found in relatively recently explored and inaccessible territory. Furthermore they operate in some of the most severe climatic conditions with temperature ‘highs’ of 70°C and ‘lows’ of −40°C.

It has been a feature of many of the dedicated Heavy Haul railways that initial track construction was tailored to suit severely limited budgets — this applying particularly to the P Way materials, with rails of inadequate section and composition, sleepers not suited to the environment or loading and fastening systems which often proved inadequate in respect of gauge holding, rail creep or ability to change rail easily.

Whilst the pressures to minimise material costs were quite understandable at this time when the operations had no positive cash flow, the policy has often resulted in the need to spend considerable sums on subsequent up-grading.

Many of the Heavy Haul mineral railways have also had to cope with considerable increases in tonnage carried as compared to that originally envisaged. An example is the Hamersley Iron Railway designed originally for 10 million tonnes of ore per annum, which carried up to 64 megatonnes before the current recession in the steel industry reduced the demand for iron ore.

The problems with rail wear which formed major themes at the 1978 and 1982 Heavy Haul Conferences, have led to the extensive use of head hardened and alloy steel rail in sharp curves, with wear resisting carbon steel grades used for tangent track and flat curves.

In addition to the rails, however, Heavy Haul operations have proved a very severe testing ground for all track components — not least the fastenings.

In a Technical Paper on “16,000 tonne ore trains in Australia” by Col. W. P. Curlewis to the Institution of Mechanical Engineers in 1974, he described the steps taken to cope with the problems of Heavy Haul operation, in particular the short rail life and rapid deterioration of track geometry due to heavy unit trains. He also confirmed the benefit to be expected from a change to Pandrol rail fastenings in respect of easier changing of rails.

Dr I. H. S. Oliveira discussed the requirement for “Special Rail on Heavy Haul Railways” in a Paper to the Heavy Haul Railways Conference at Perth in 1978, based on the problems experienced by the Linha do Centro LCC the 1.6 m gauge line extending over 645 km linking Belo Horizonte City to Rio de Janeiro City. The largest portion of the transportation flow is carried by unit trains, consisting of 4 locomotives and 84 iron ore carrying wagons, each wagon of 120 tons gross weight, 30 tons of load per axle and 36,000 pounds, causing high contact pressure between wheel and rail. With the increasing transportation demand causing deterioration of the track structure, Dr Oliveira pointed to some of the problems and the steps taken to deal with them as follows:

- Difficulties in keeping the geometrical conditions of the track.
- Excessive rail wear and numerous cases of fracture being registered.
- Overturning of low rails in curves caused by excessive super-elevation and inadequate fastening.

To face problems of such nature a rehabilitation plan was produced consisting of:

- Replacement of all carbon type 115 RE rails by standard 115 RE rails.
- Replacement of all 115 RE rails by special steel alloy or head hardened 115 RE rails.
- Replacement of all AREM Standard rigid type fastening using sleeper screws instead of rail spikes, by Pandrol type elastic fastening, either by adoption of existing baseplates or purchasing of complete sets, i.e. baseplates and clips.
The original rail fastening used on the Lanco railroad was a combination of European spring splices to hold down the rail and American 1.406 plates fastened to the tie by cut splices in the tangent track and lockspikes in curves. The pressure of the spring splice on the railhead is based on a certain degree of deflection of the spikehead and when correctly driven amounts to 750 lb per spike or 1000 kg per fastening. This pressure depends mainly on the diameter of the New Zealand head and the actual deflection of the spikehead and we know that irregularities were made during construction with regard to boring and spike driving.

With this type of fastening basically no rail anchors should be necessary. However after having been in the track for only a few years it became quite obvious that this type of spike was not particularly suitable under heavy traffic conditions since it worked itself up leaving a track structure basically comparable to the standard American track structure but without rail anchors. With long welded track, heavy grades and heavy loads this was completely unacceptable.

Apart from a small number of plate fractures (which led to strengthened plate designs) there have been very few problems with baseplates in heavy haul track and experience is confirming a significant reduction in baseplate/sleeper indentation (tieplate cutting) where resilient fastenings have replaced cut spikes.

Both lockspikes and screwspikes are used for the plate to sleeper connection, with lockspikes predominating in the specific mineral carrying heavy haul operations. Concrete sleepers are being used increasingly by heavy haul operations as alternatives to wood, although their use is not yet widespread if considered as a proportion of total heavy haul track miles. There is also some interest in steel sleepers.

Mr. Newman Mining, after experiments with concrete sleepers, decided to use steel sleepers to replace their older wood sleepers, whereas Hammersley Iron, after their experiments, decided to use concrete sleepers in completely replacing all the wood sleeper track from Dampier to Mt Tom Price. Many other heavy haul railways have experimental lengths of concrete sleepers, for example CVRD, RFFSA, the Chezi, Canadian Pacific and the Quebec North Shore & Labrador. Examples of major operators who are making extensive use of concrete sleepers are Canadian National, using concrete sleepers for all curves of 2 degrees and over which carry more than 20 mt/annum, and South African Transport Services, who have some indigenous timber for use as sleepers.

As far as is known, all heavy haul operations are using monoblock concrete sleepers and no general problems of structural strength have been found with current designs. With the maximum speed of heavy haul train operation generally in the 50-50 mph (50-80 km/hr) range, heavy haul track is not normally subject to the very damaging high speed impact forces which can be detrimental to concrete sleepers. In addition, standards of vehicle maintenance -- particularly wheels -- are generally high on most heavy haul railways, thus minimizing the generation of impacts. This has meant that it has been possible to use the very durable rail pad materials such as High Density Polyethylene (HDPE) and Ethyl Vinyl Acetate (EVA). These have low impact attenuation capability as compared to, for example, natural rubbers, but they do give good results -- particularly in curves -- in resistance to abrasion and cutting.

HDPE does become brittle at low temperatures, say below -10°C, and EVA is preferred in such cases. On the other hand EVA can begin to soften at temperatures in the region of 70-75°C and HDPE is more satisfactory.

The most arduously loaded component in any of the concrete sleeper fastening designs which have been used in heavy haul conditions is the separate sacrificial insulator. This has often had an unacceptably short life and the more severe curves -- generally 6 degrees (100 metres) and over -- and much effort has been put into finding an improvement.

There is little information on the forces acting on insulators in such conditions (because of the difficulties of measurement in the limited space available), but we have found that a dynamic load range having a combination of 18 tons vertical load and 11 tons lateral on a fastener will produce insulator deformation similar to that found in service, in a relatively small number of laboratory loading cycles.
Test installations without insulators (installation provided by a coating on the embedded parts of the shoulder) have shown that in the case where the rail foot will cut into the gauge face of the shoulder with consequent reduction in sleeper life.

Clips on the rail head do not seem to be a critical factor in other than the most severe curvature, gradient and temperature combinations — where it would seem desirable that the average value on installation should not be less than 505.
1. INTRODUCTION

When a track is being constructed, there is an opportunity which does not normally recur to minimise future maintenance problems. There are two types of track which merit consideration; one is concrete-based track — which has been described in an earlier paper "Slab track and non-ballasted structures" — and the second is a ballasted track which will be dealt with in this paper. Research in recent years has shown that ballasted track could offer a very high quality track indeed, requiring only a small amount of maintenance if it is made correctly and with good quality materials. The cost of such a track need not be much greater than one which is made in a carefree fashion.

The purpose of this paper is to outline some of the more important features of track construction. The formation will not be discussed in detail because this has been covered elsewhere. However, the aim of the formation must be to provide a uniform stiffness, a smooth profile, and good drainage. This paper will concentrate on the ballast and track components.

2. BALLAST

It has been shown that to obtain a smooth compacted ballast profile it is necessary to start with a smooth uncompacted profile. Fig. 1 shows the relationship of ballast profiles before and after compaction.

Although a compacted ballast surface may look smooth to the eye it may nevertheless be unsuitable for the purpose of carrying a high-speed railway. It is particularly important to rectify irregularities in the ballast profile at wavelengths between 5 and 50 metres. This can only be done with special equipment.

The most suitable equipment developed in recent years is the V Laser (see Fig. 2). This system looks at the ballast surface 50 metres ahead and can be used to guide a plough to smooth out long wavelength irregularities in the uncompacted ballast surface. After compaction, the ballast surface should still be satisfactory at the important wavelengths.

The type of stone used for the ballast and the grading of the stone are very important. The most suitable stone is granite since this has a high resistance to attrition. However, whatever type of stone is preferred it is wise to preclean to establish periodic checks of its wet and dry attrition characteristics since the quality of stone supplied from a quarry can vary.

3. SLEEPERS & FASTENINGS

When the sleepers are laid on the ballast care must be taken to provide a uniform spacing. If groups of sleepers are close together or if the sleeper spaces are wide this will provide a source of uneven settlement under traffic. The uniformity of spacing is just as important as the nominal spacing.

As has been explained in a previous paper, the ideal rail is one which has resistance to reduce impact loads on the rail and sleeper but which also has a long life in track. The ideal fastening does not require maintenance but if it is not quite maintenance free then the maintenance should be easy and inexpensive. In the future there will be a progressive move towards fastening systems which can be installed and maintained by machines.

4. RAILS

The straightness and radius of rails is vital, there is little virtue in using a heavier rail section if the rails are not straight.

The transfer function between waves in the rail and waves in the track profile is shown in Fig. 3.

There can be no doubt that continuous welded rail is much superior to jointed track in its straightness. Nevertheless, in the past, there has been insufficient control over the straightness of rails and welds. This has occurred because important irregularities in rail shape are not obvious. If the rail is resting on a stiff support such as a concrete base, the long wave irregularities are suppressed by the stiff weight of the rail. When the rail rests on ballast, however, over a period of service the ballast compacts and allows the rail to move nearer to its natural shape. Sometimes referred to as its gravity-free shape since this means the shape it would assume if it was absolutely free. It is difficult to measure the free shape of a rail. Techniques have been developed in recent years to do this, however, and Fig. 4 shows the profiles of a long welded rail string. It is noticeable that the irregularities in shape are not only at weld positions.

In the future improved manufacturing techniques must be developed to ensure that the rails as supplied are straight and that the welding procedures are carefully controlled; current specifications and techniques are inadequate. Far too often flash welds are straightened in a press before they are cold; this must introduce variations in the angle of dip or bump at the weld as they cool. It is also common practice to use a 1 metre straight edge to judge the correctness of the weld profile. This is probably satisfactory if the rail is straight but if the rail end is inadequately straightened a 1 metre straight edge is insufficient to judge overall straightness. Having produced straightened rails and welds the long strings must be handled very carefully and on no account must they suffer plastic deformation before being installed and carrying traffic.

The next essentials for rails are cleanliness i.e. freedom from oxide inclusions and mild hydrogen levels. Shelling defects and tache oxides should not occur if rails are made properly with modern steel making practice.

The choice of rail steel is a difficult one since the decision rests on both economic and safety considerations. It would be possible to use a tough rail steel and thereby ensure that there are virtually no rail failures but such a steel would cost twice as much as normal quality rail steel. Current economic considerations seem to rule this out so the selection must be made amongst the available grades of pearlitic steel: Normal Quality, wear resisting grades A and B, and the 1 Cr 13 Chromium Steel. The British Steel Corporation have recently proposed a fan cooled version of the 1% Chromium steel which is of great interest. In this steel the cooling rate is controlled to give a high strength with a restricted degree of alloying. The cooling rate in manufacture is chosen to match the cooling rate during flash welding thereby achieving uniform hardness profiles across flash welds. This is important in order to avoid uneven wear properties across welds in service. This steel is of necessity more expensive than normal quality rail steel and may therefore only be selected for severe wear situations. In the future, however, its usage could become more widespread, especially if very straight rails can be produced since a harder grade of rail steel will be more resistant to permanent deformation and should help to ensure good track geometry.

One of the most interesting developments recently has been the straightening of rails by stretching. This produces a rail which is free of residual stresses and may offer straighter rails. Thus the future could see a move to straighten rails in high yield strength steel and lower rail section. Such a rail would tend to control the track profile and even out local unevenness in ballast conditions.
5. SWITCH AND CROSSING WORK

The impact forces on switches and crossings create a more severe stress problem for point rail and have required extra high strength steels. Of these, austenitic manganese steel (AMS) in the form of castings has proved the most durable. It does, however, have disadvantages, the most important being the difficulty of welding this steel to normal quality rail steel. Other problems stem from casting defects which are difficult to avoid in large castings, and from its very high thermal expansion coefficient which causes high stress due to temperature changes. In practice it is necessary to connect cast AMS crossings to the adjacent rails by tight bolted joints. Differential wear across the joint and mis-match in rail heights cause impact forces and it is common for these joints to become dapped and need maintenance. The advantage of a cast crossing lies in avoiding the need for a bolted assembly, why not therefore make the casting from pearlitic rail steel which can be welded? This has been done on a small scale in the very brittle nature of those steels and the possibility of casting defects. Now, however, there is a new possibility since they have been developed which offer all the required properties, namely toughness in cast form, weldability, high strength and reasonable costs. For the first time it is possible to have a tough high strength cast crossing which can be welded directly to normal quality rails. This should produce a substantial saving in maintenance. The first of these castings to be introduced on British Rail was installed at Easington Street in the Scottish region in 1983 (Fig. 5). These appear to perform well. Bainitic steel could also be used in the future for switch blades since it is also attractive in the form of wrought rails.

6. TRACK DESIGN

Some of the important variables to be decided in track design are: the rail head geometry, the ballast shoulder dimensions and the ballast depth. It is necessary to provide resilience in the track structure to avoid excessive impact loads. The track should not be too soft, however, since this will increase stresses in the rails and fastenings and increase rolling resistance. A typical track with concrete sleepers on BR has a stiffness of about 200 MN/m i.e. a 20 tonne axleload causes a vertical track deflection of 1.5 mm.

The addition of a layer of ballast on top of a formation will tend to give an overall increase in stiffness on a soft formation and a reduction in stiffness on a very hard formation e.g. rock. Design methods to give a specified track stiffness and minimum ballast construction under traffic are not yet fully developed and are the subject of current investigations. It is possible, however, to determine the minimum depth of ballast needed to protect a soft subgrade from being overstressed and often this is the determining factor.

The ballast shoulder width is usually increased when track is converted to long welded rail because of the increased lateral resistance it provides. However, the increased width reduces rapidly as the width increases and it is unlikely that dimensions beyond those used by BR are necessary for this reason. There is, however, another factor to be considered. On the FAST test track in the USA it has been found that a wide ballast shoulder also reduced vertical settlement.

This may at first sight seem surprising but, in fact, the shoulder provides dead weight. This makes it easier for the ballast beneath the sleeper to support high traffic stresses since it is more effectively confined radially. Thus the ballast shoulder should be both highly proportioned and uniform along the track since variations in width will cause variations in settlement.

When considering sleeper spacing, the main considerations are track settlement and the stability of long welded rail in hot conditions. Thus, the track settlement and the possibility of track buckling will both increase as the sleeper spacing increases. It is possible to calculate both these effects, but in many cases track designs will simply copy an existing design as a basis from which to work. For track settlement the critical quality is the sleeper softness, pressure, for track buckling the situation is more complex.

In general, the temperature range for a rail in much greater than the ambient temperature range. The lowest rail temperature can be 5°C below ambient and the highest 8°C above ambient due to thermal radiation effects.

The axial force in two rails P is given by the formula

\[ P = AE \Delta T \alpha \]  

Where \( A \) is the area of cross section of two rails, \( E \) is Young’s modulus of the steel, \( \alpha \) is the temperature rise above stress free and \( \alpha \) is the coefficient of expansion.

An approximate formula to predict track buckling is that it will occur when:

\[ P = k x 2 \]  

Where \( k \) is the torsional stiffness of the rail fastenings (it is the resistance to lateral track shifting (k & 7/ are per unit length of track i.e. inversely proportional to sleeper spacing).

\( \alpha \) is the lateral bending stiffness of two rails side by side and \( y \) is the amplitude of a lateral track irregularity or realignment.

The formula indicates the relative importance of the different track features and can be used to determine the desirable stress free temperature (for a specified maximum rail temperature) when moving from one track design to another. For BR track, the contribution of the rail fastenings towards resisting track buckling is equivalent to about 8°C increase in rail temperature. Thus the bulk of the resistance comes from the second term involving the lateral resistance of the ballast. A more thorough analysis of track buckling based on a computer program has been developed in recent years.

8. REFERENCES


Modern resilient rail fasteners are to be found in a great many surprising locations around the world, but perhaps none more surprising than in the laser optics laboratory of a major scientific research organization.

The National Physical Laboratory at Teddington, near London, has been using some of the latest techniques of double-exposure holography and computer image analysis to tackle what seems at first to be such a simple problem—to measure the distortion of a rail clip as the rail moves vertically on its pad. Purely theoretical methods cannot cope, because it is so difficult to represent the friction and movement of the contacting surfaces as mathematical equations. Conventional measurement techniques are inadequate because it is impracticable to measure strains in all directions at more than a few locations on the clip.

The technique employed at NPL involves the use of three-dimensional photographic images—holograms. To record a hologram, the object of interest is illuminated with laser light, and an image is formed on a special photographic plate without using a lens. At a later date, the plate may be illuminated again with the same type of laser and the image may be viewed, or photographed. Looking at a hologram gives much the same impression as looking at an object in a mirror; as you move from side to side, you can see quite clearly that the object is three-dimensional, even though the mirror itself is flat.

Holograms have existed as scientific curiosities for more than twenty years, but it is only recently that their use in fine measurement techniques has been developed. If the object is moved, or distorted, by a small amount after the hologram is recorded, and the plate is then exposed for a second time, the two images 'interfere' with each other and a pattern of light and dark bands appears where the images are imperfectly matched. These 'interference fringes' are also three-dimensional, and may be photographed from different directions.

Fig. 1 shows a short length of rail attached to a section of concrete sleeper with 'Pandrol' type D 2000 series clips, cast-in shoulders and nylon insulators. Part of the rail pad has been replaced by a plastic tube which is folded back and forth under the rail and connected to a pneumatic pump. Varying the air pressure in the tube causes small vertical movements of the rail, similar to those which occur when a vertical load on the rail compresses the pad. Fig. 2 shows a photograph of the resulting double-exposed hologram. The light and dark interference fringes are clearly visible.

For detailed analysis, nine such pictures were taken from slightly different angles, using a video camera.

The video recording was then played back into an 'image analyser' connected to a mini-computer. The computer was programmed to identify and measure the fringes and to calculate the movement in three dimensions at each of the 23 points on the clip surface. Fig. 3 shows some typical results. The line U represents longitudinal movement (i.e. parallel to the rail), V lateral movement (i.e. parallel to the sleeper) and W vertical movement of the clip. Similar plots can be obtained for torsion of the clip. From these curves it is possible to estimate the performance of the clip and thus to obtain vital information about its strength and its expected life under track conditions.

PANDROL ASKS WHY?

Today's Railway Engineer is being asked to provide track over which trains can operate at ever increasing speeds or with heavier axle loads, and in some cases with a combination of both. This is usually called for within the existing railway system and invariably with a reduction in maintenance cost. Historically railway track design has been an evolutionary process with the inadequacies of the present track being corrected, often piecemeal, in successive designs. Tomorrow's needs, with much more emphasis being placed upon the value of the engineering, require a more structured design approach. Unfortunately there is a dearth of basic data on the performance of railway track. Much of the work which has been done has been directed towards the solution of specific problems rather than investigating the basic cause.

In particular there is a limited understanding of the dynamic behaviour of track which is of specific importance in designing for higher speeds. In 1981 Pandrol Limited embarked upon a programme of research and development to correct this deficiency. A new dynamics laboratory was built as an extension to the existing laboratory on the Workshop site and equipped with a loading frame and servo-hydraulic computer controlled actuators of up to 100 kN capacity. One frame straddles a 9 m long ballast tank. The laboratory is also provided with equipment for dynamic excitation and frequency spectrum analysis, multi-channel FM tape recorders, UV oscillograph and galvanometer recorders, and a range of electronic tests. A Development Department was created to prepare and manage the programme. Today's railways are using increasing numbers of concrete sleepers and fewer timber sleepers. The larger mass of the concrete sleeper is advantageous in continuously welded track and it is substantially cheaper than timber in many parts of the world. The quality of the sleepers is much more controllable and they should have a substantially longer life. But concrete does not behave dynamically in the same way as timber and much of the current thrust of the Development Department's work is directed towards gaining an understanding of this behaviour.

One particular approach is an extension of the work originated by engineers at the Battelle Institute in Columbus, Ohio, in their investigations into sleeper problems on the North East Corridor lines of Amtrak in the U.S.A. The forces generated in the rail seat area of a sleeper from discontinuities in the rolling surfaces of the rail or the wheel can be very large. Transducers to measure them are much too large to accommodate within the rail seat area and Battelle solved the problem by measuring the effect of the forces on the sleeper. The sleeper was statically calibrated to enable a relationship to be determined between the forces and the sleeper strain. Pandrol has developed and refined the Battelle test. This is of particular value in comparing the dynamic performance of rail pads. A predetermined energy is imparted to a rail assembled in a full size concrete sleeper via a free falling mass. The sleeper is instrumented with strain gauges and the induced bending strains are recorded. Similarly instrumented sleepers have been installed in a main line on British Rail and soon it will be possible to compare in-track results with those found in the laboratory and to further refine the laboratory procedure. Concurrently the dynamic behaviour of all the components of the track are being studied and particular emphasis is being given to the development of a reliable system to measure their dynamic displacements. This is a particularly difficult problem in an environment of large and changing electrical and magnetic fields.

All this data will assist in the development of laboratory tests which will simulate in-track service conditions. Currently our laboratory tests do not reflect actual conditions closely enough and the wear patterns developed do not represent accurately those found in service. The practical work is being supported with an analytical study of railway track and the development of a mathematical model. Much work has already been undertaken in this field and this is being drawn together and extended to produce a programme capable of being run on a desk-top computer. The influences of sleeper support and lateral forces are the particular subject of current work.

The early railway engineers were very pragmatic and resourceful men. They developed a system which has seen very little fundamental change over a century and a half. Their successors have refined and modified designs as the need arose. The reduction in manpower as a result of mechanisation has now greatly changed the requirements of the track. No longer can the quirks and foibles of particular areas be left to the care and skills of the local permanent way gang—they no longer exist. A much more engineered track with consistency and predictability of behaviour is needed. To reach this standard there are still a number of very fundamental questions to be answered. When the current Pandrol research programme has been completed we hope to have some of these answers.
In August 1983 the new factory at Blacktown in New South Wales was officially opened by the Minister of Transport for Australia, the Hon. P. F. Cox M.P. This expansion of facilities by Pandrol Australia has been necessary to cope with the increased demand for Pandrol Track Fastenings in Australia and New Zealand, and also South East Asia.

As one of the major subsidiaries of Pandrol International and also the first to be established outside the U.K., the company has produced over 200 million fastenings since 1956. The new facility is capable of producing some 23 million rail clips, spikes and ancillary items annually and replaces the plant at Seven Hills, Sydney which could not be expanded to meet current requirements due to lack of space. The company also has a production facility at Maddington which supplies Western Australia.

The Australian market calls for a variety of track fastenings to meet the different needs of the railways and Pandrol Australia has responded to this challenge. Pandrol Track Fastenings are in use on the conventional passenger and freight lines, sophisticated mass transit railways and a wide range of specialised heavy haul freight lines in different countries. The sugar railways in Queensland; on the other hand, utilise simple elastic spikes on timber sleepers.

In Western Australia, some of the heaviest unit train systems in the world are run under extreme climatic conditions of wide temperature variations and torrential rainfall.

A strong home market has enabled Pandrol Australia to compete effectively in South East Asia, earning valuable foreign exchange for Australia during the last decade.

Although the majority of Group research and production is based at Pandrol's headquarters in the United Kingdom, there are considerable advantages in having regional subsidiaries in close proximity to local conditions. Pandrol Australia has been the source of several new product developments, including re-pressed baseplate and Clipunder clip conversion of the A.S. baseplate. The re-pressing of plates provides a cheap conversion for existing designs of baseplates including the flexibility to recycle them. In the case of the Clipunder conversion, this is carried out in situ in the track. A hole is drilled horizontally into the sleeper under the baseplate to form the centre leg housing for each clip, and a bead of weld applied to the edge of the plate to assist in positioning a specially developed e-series clip. Pandriller and Panwelder machines have been developed in Australia to carry out the drilling and welding operations automatically.