Characterisation of self-tensioning elastic Rail Clips, ERC, of PANDROL Type

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Sculpture of the original Pandrol PR ERC Clip at Calgary, Alberta, Canada

INTRODUCTION:

By Jackson, Tanya: Obscure Objects of Transport Beauty: Pandrol Rail Clip; British Rail: The Nation's Railway; Stroud, Gloucestershire: The History Press; thebeautyoftransport.com>obscure.

"The Pandrol clip panted in 1957 was invented by Per Pande-Rolfsen, an employee of the Norwegian State Railway, and the man from whom the Pandrol clip draws its name. He had offered his employer the clip, but it had shown no interest, not least because the company's chief permanent way engineer had also designed a new rail clip. The elastic Spike Company, on the look-out for the next great rail-securing product,

considered the latter inferior to the former, and took Pande-Rolfson's clip to British Rail. Its research department undertook further testing and development, and in 1965, it became BR's standard rail clip just at a time when the company was beginning to focus on the development of its Inter-City product - frequent high speed express passenger trains. It was the right product at the right time, something that would stand up to the stresses of faster trains on the British rail network.

After that, the Pandrol rail clip was unleashed upon the world. It swiftly became a best-seller, and one can now see Pandrol clips practically everywhere. Though Pandrol Track Systems has become part of the French Delachaux Group, its head office remains in the UK, in Addlestone, Surrey.

Pandrol PR Clips in Coledale, New South Wales, NSW, Australia., replacing Dog Spike Fastening on Wooden Sleepers. *Photo by Wikipedia: User: Samwilson (own work) [CC BY-SA 2.5], via Wikimedia Commons*

The Pandrol rail clip's design is absolute genius. It is easy to install, simply being slid into place in a tunnel on a baseplate attached to the sleeper. With the one end (leg) in the tunnel, one of the curves (heel) of the clip rests on the rail itself, and when the clip is put under stress by the passage of a train, its design means that it grips the rail even harder. Compared to earlier track fastening systems, it also significantly *reduces rail 'creep', the tendency of rails to move longitudinally over time. It has played a fundamental part in the safe operation of high speed trains ever since.*

Pandrol Track Systems has continued to refine the product over time, and one can now see Pandrol clips with coatings rather than being finished in bare metal, and insulating materials between the clip and the rail. The original PR clip has been later superseded by the e-shaped clip, which is bended in the opposite direction. On the e-clip, the non-socket (leg) end of the clip called "toe" grips the rail, rather than one of the curves (heel) as in the PR clip. Nowadays there's the Fast-Clip, a clip which is pre-assembled on the sleeper and driven into position once the rails are laid. The Fast-Clip has a completely different shape, and has a butterfly-like symmetrical form. It is nowadays slowly superseding the e- and PR clips.

Fast-Clips in Southern California. *Photo by Downtowngal (own work) [CC0], via Wikimedia Commons*

But it was the PR clip, which started it all. *Like many pieces of pure engineering, the underlying physics and mathematics result in something, which attains beauty through the expression of its fundamental properties? The Pandrol clip is a work of art just as much as (and indeed because of the fact) it is a work of pure engineering. It might be replicated in its millions around the world, but that doesn't make it any less of a sculptural wonder. Look at it for a while and you'll begin to think of art like this, Henry Moore's "Sheep Piece"*

If only the Pandrol clip was the size of one of these sculptures, perhaps the world would more easily recognise its artistic, as well as its engineering, qualities. Thanks to the splendid efforts of Calagary, *Canada, there is an actual giant Pandrol PR clip on display as a piece of public art, where it appears as dramatic and distinctive as any other abstract modern sculpture.*

Pandrol Clip Sculpture in Calgary, Alberta, Canada. *Photo by Alex Peterson (own work) [CC BY-SA 3.0], via Wikimedia Commons*

The Pandrol clip is the physical expression of the forces generated on railway tracks by the movement of trains. Its exquisite form can also be appreciated in special highly polished versions of the clip (see one here) which I assume were created for promotion purposes.

But surely the greatest tribute to the Pandrol clip is the countless miles of them, stretching off into the distance on railway networks around the world, keeping the rails exactly where they should be; passengers in trains cheerfully unaware that underneath them, there are some little clips doing a really big job."

GEOMETRY, DESIGNATION AND APPLICATION OF SEF-TENSIONING PANDROL-TYPE ELASTIC RAIL CLIPS, ERC:

The self-tensioning or self-stressing elastic Pandrol-type rail clips are manufactured by giving a spatial bend to Silicon-Manganese alloy spring-steel rods. Their advantage is the simple installation parallel to the rail. The ERCs are pushed with their leg from right to left parallel to the rail into the tunnel/housing of the shoulder plate/insert with the help of a standard hammer or a puller device.

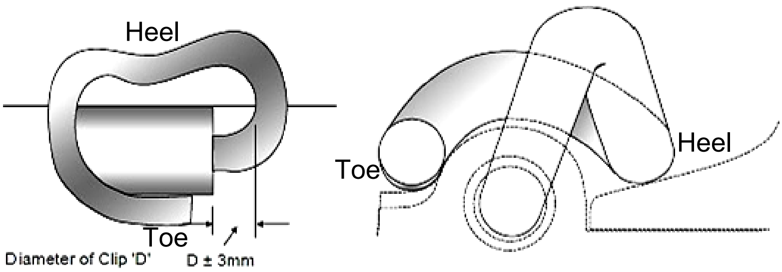
Worldwide there are two types of self-tensioning Pandrol Clips in use:

1. The original PR Clip with an anti-clock-wise bended geometry, shaped as the letter “e” and

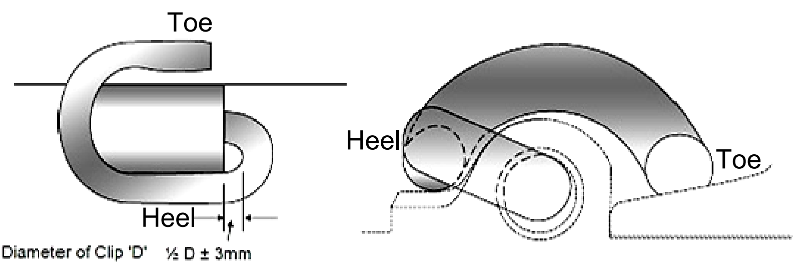
2. The e-Series Clip with a clock-wise bended geometry, shaped as the letter “G”.

In 1. the rod takes behind the **“LEG”** (inserted in the **“TUNNEL”**) an anti-clock wise bend to the **“FRONT ARCH”** and a further dip to the **“HEEL”**, which clamps the Rail-Foot. Next comes the **“REAR ARCH”**, and the rod ends at its **“TOE”**, which counter-balances the clamping force on the **“SCHOULDER PLATE”.**

In 2. the rod takes behind the **“LEG”** (inserted in the **“TUNNEL”**) a clock wise bend to the **“FRONT ARCH”** and a further dip to the **“HEEL”**, which counter-balances the clamping force on the **“SHOULDER PLATE”**. Next comes the **“REAR ARCH”,** and the rod ends at its **“TOE”**, which clamps the Rail-Foot**; Fig. 1:**



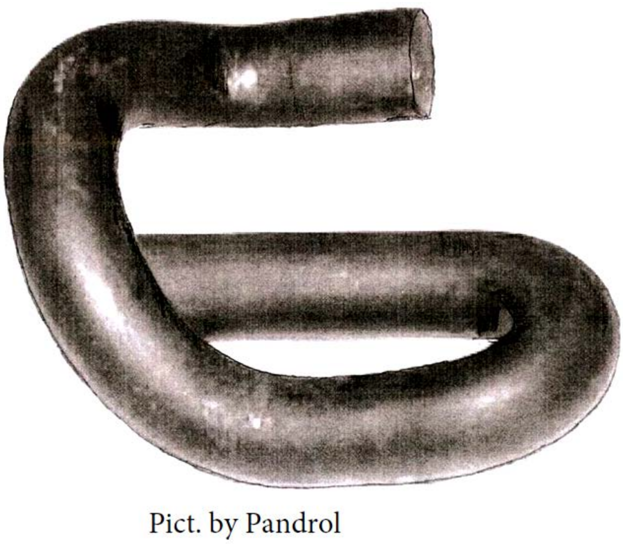
Installation of PR Type Pandrol ERC Clip



Installation of “e” Series Type Pandrol ERC Clip

Fig.1: Installation Scheme of Pandrol PR- and “e”- Brand (Series) ERCs; source: ***ENGINEERING MANUAL TMC 221, SLEEPERS & FASTENINGS,*** August 2011, Version 4.4. NSW Transport Rail Corp., Australia

Fig. 2: Anti-Clockwise bended Pandrol PR 401A Clip



Pict. by Pandrol

Fig. 3: Clock-wise bended Pandrol “e” 2003 Clip

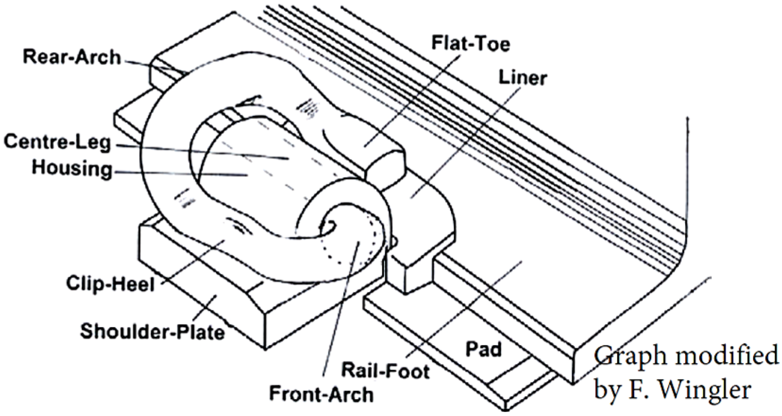


Fig. 4: Scheme for Assembly of Clock-wise bended ERC of Pandrol "e"-Series Type

When installed under deflection of about 14 mm the Pandrol Clips develop a clamping force (formerly called "Toe-Load"*) of about 12.5 kN. **Fig. 5** delineates the Clamping-Force* (Toe-Load*) versus Deflection Diagram for the main type Pandrol Brand "e"-Clip 1800/2000 Series and PR 400 Series.

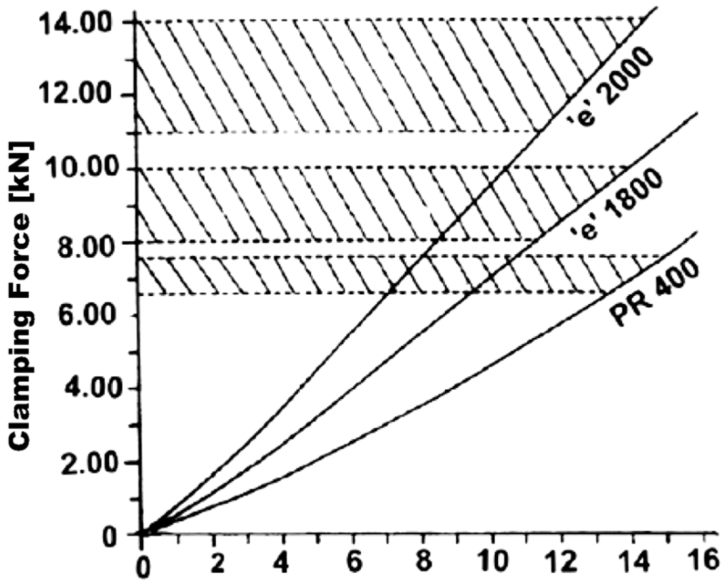


Fig. 5: Diagram of Clamping Force* versus Deflection of Pandrol Brand "e"- and PR-Clips; Graph modified by F.A. Wingler

<u>*** Note:**</u> The term "Toe-Load" is a traditional term, although it represents actually a Clamping-Force measured in the unit of [kN]. The mass of 1 metric ton generates by its earth gravity on its support a force of 9.81 kN, say: 10 kN.

The Diagram shows, that in order to generate an appropriate clamping-force, a deflection of 11 to 14 mm is needed. Without deflection the clip generates no tension, and hence there will be no clamping force. The characteristic of self-tensioning clips is that with less deflection less tension is generated, and the clamping force gets diminished. This can happen due to corrosion, wear of liners, missing liners and worn pads in the contact areas of the rail-foot. There is no mechanism to adjust a drop of tension or clamping-force.

Fig. 6: Assembly of anti-Clock-wise bended Pandrol PR Brand Type ERC

Fig. 7: Assembly of Clock-wise bended Pandrol "e"-Brand (Series) Type ERC

The Pandrol "e"-Brand (Series) Type ERCs one can find in India as rail fastening on the ballast-less tracks of the Chennai Metro:

Fig. 8: Ballast-less Track of Chennai Metro with Pandrol "e" Brand (Series) Clock-wise bended ERC

The Indian ERCs, designed by RDSO, evolved from the Pandrol PR 401-Series ERC with an anti-clock-wise bend of the Silicon Manganese Steel Rod. When assembled they develop a clamping force of about 9 kN.

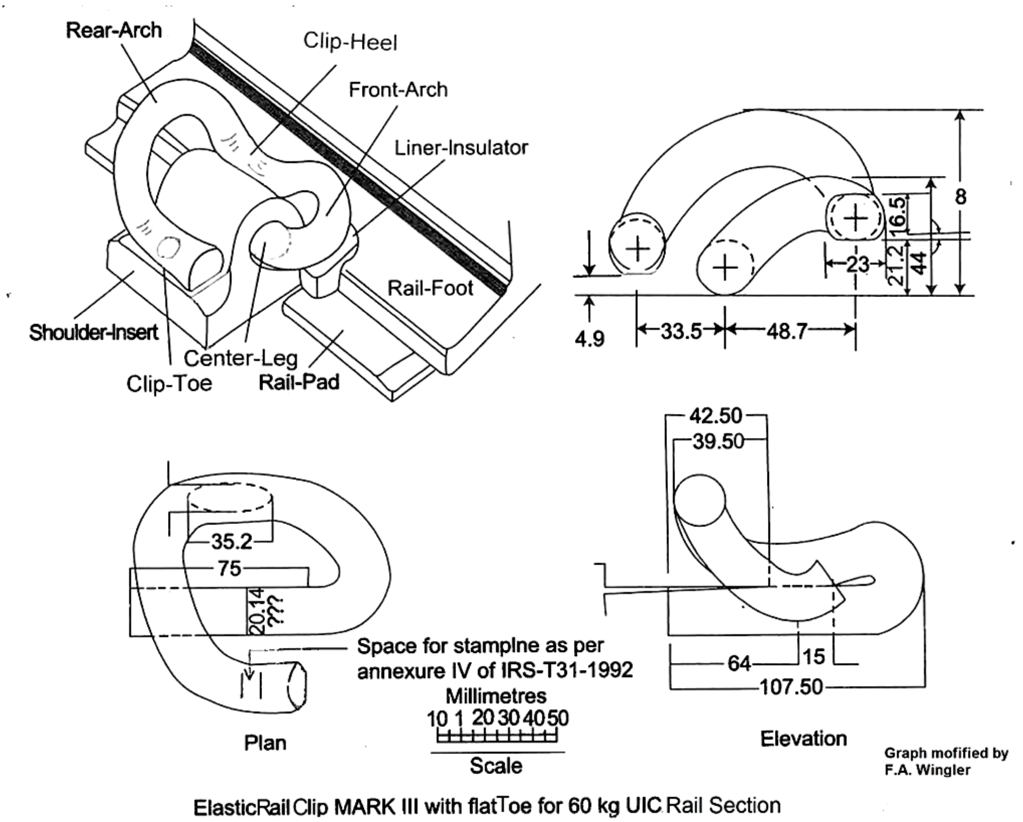


Fig. 9: Assembly and Dimensions of RDSO MARK III ERC

The Mark III ERC has at Heel and Toe each a flat areas below to be gentle to the liner at the rail-foot and to the shoulder-plate:

Fig. 10: Indian MARK III ERC

Fig. 11: View on MARK III ERC with flat Heel and Toe from below

Fig. 12: MARK III Assembly

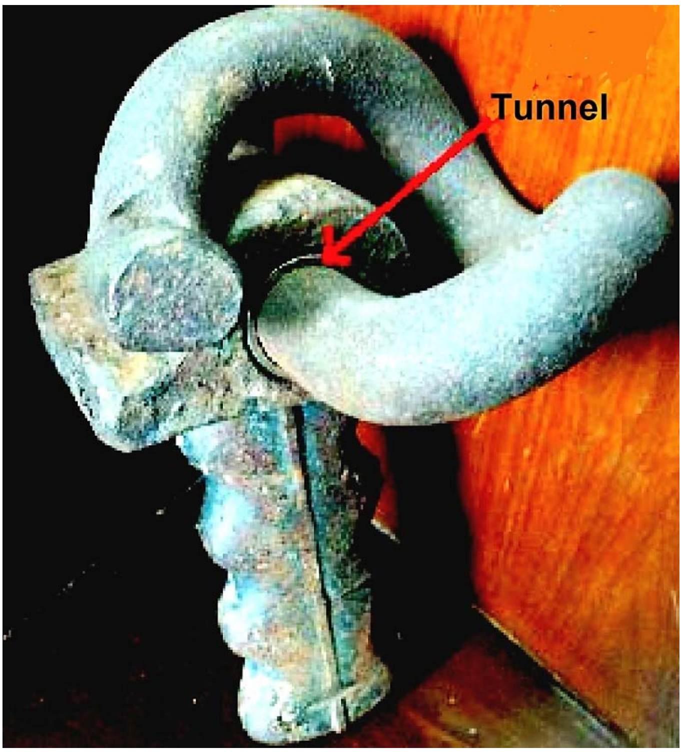


Fig. 13: Shoulder/Tunnel Insert with MARK III ERC

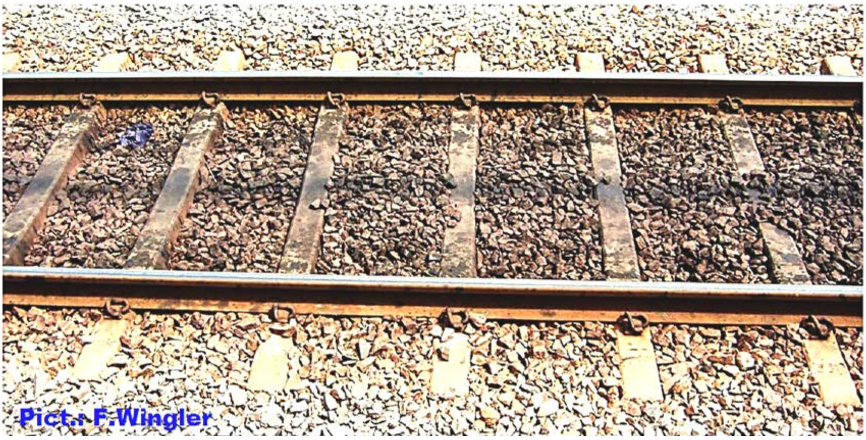


Fig. 14: INR Rail-Track with MARK III Rail Fastening

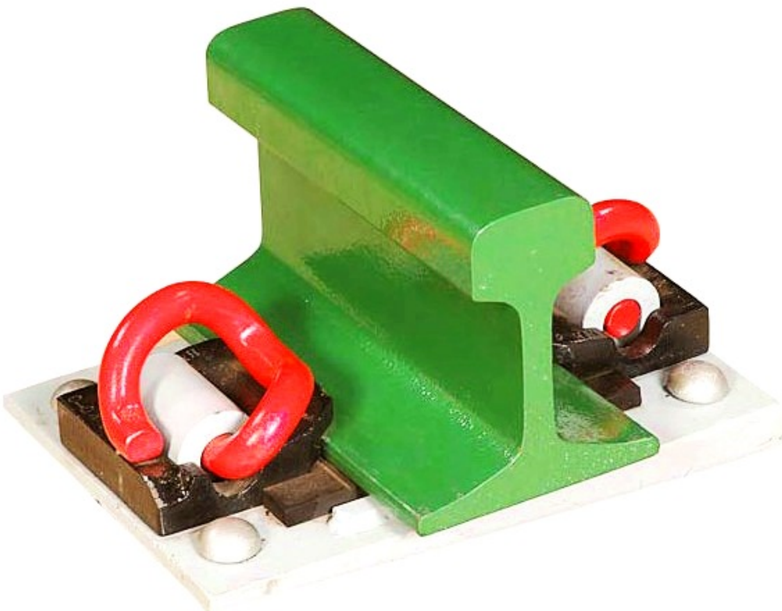


Fig. 15: MARK III Assembly for Girder Steel Bridges; Rahee Industries

ABSURD DESIGNATIONS OF CLIP STRUCTURAL ELEMENTS:

The designations for ERCs with **LEG, FRONT ARCH, HEEL, REAR ARCH** and **TOE** follow the anatomy and structural elements of a self tensioning clip. For one-and-the-same structural clip element (rod-end and rod-middle part) always the one-and-the same term should be designated independent from the application and the spatial bend of the rod, anti-clock-wise or clock-wise.

But since the Indian Track Men are used to call the force, which clamps the liner/rail-foot, ***"Toe Load"***, they name by their tradition the middle part of the anti clock-wise bended Pandrol PR type clip, which clamps the rail-foot, a ***"TOE"*** and not, as with the clock-wise bended Pandrol e-Brand clips, ***"HEEL"***. According this tradition, what clamps the rail-foot is called **"*TOE*"** regardless if it is the middle- or end-part of the ERC. By this traditional practise the ERC-designation is determined by the application and not by the geometry or structural elements. This can lead to **ABSURD SITUATIONS**:

Sometimes Indian track men push the Mark III ERC in the other (wrong) direction with the leg into the housing/tunnel from left to right instead from right to left. In such a case the clip parts, that have been called before ***"TOE"*** and ***"HEEL"*** (when correctly inserted from right to left) mutate now to ***"HEEL"*** and ***"TOE"*** according the Indian traditional application based terminology.

Fig. 16: When a Mark III ERC is wrongly pushed from left to right with its Leg into the Tunnel, the *"TOE"* mutates to a *"HEEL"* and the *"HEEL"* to a *"TOE"* under traditional Indian Terminology

Fig: 17: Inserting the Leg of a Mark III ERC correctly from right to left into the Tunnel/Housing of the Shoulder Insert

Fig. 18: The Incorrect and correct Assembly of the Leg of an Indian Mark III ERC in the Housing/Tunnel of an Indian Sleeper with Indian CMS lead according traditional Application based Terminology to a Mutation of a *"TOE"* to a *"HEEL"* and of a *"HEEL"* to a *"TOE"* for one-and-the-same structural Element of one-and-the-same ERC Type

According the traditional Indian application based terminology for ERCs the middle part of a Pandrol “e”-series ERC will be called ***“HEEL”*** and the end-part ***“TOE”*** and the middle part of a Pandrol PR type ERC (Mark III) will be called ***“TOE”*** and the end- part ***“HEEL”***, although those parts are the same structural element of an ERC.

Fig. 19: Clock-wise bended ERC made in China with *“TOE”* clamping the Liner / Rail Foot, replacing a lost anti-Clock-wise bend MARK III ERC; pict.by F.A. Wingler

Until now, this absurdity has not become so much obvious in India, since INR uses only the anti-clock-wise bended MARK III ERC and not the clock-wise bended Pandrol “e” brand/series ERC.

However the situation has changed now in India with the wider spectrum of ERC applications on Metro Rail.

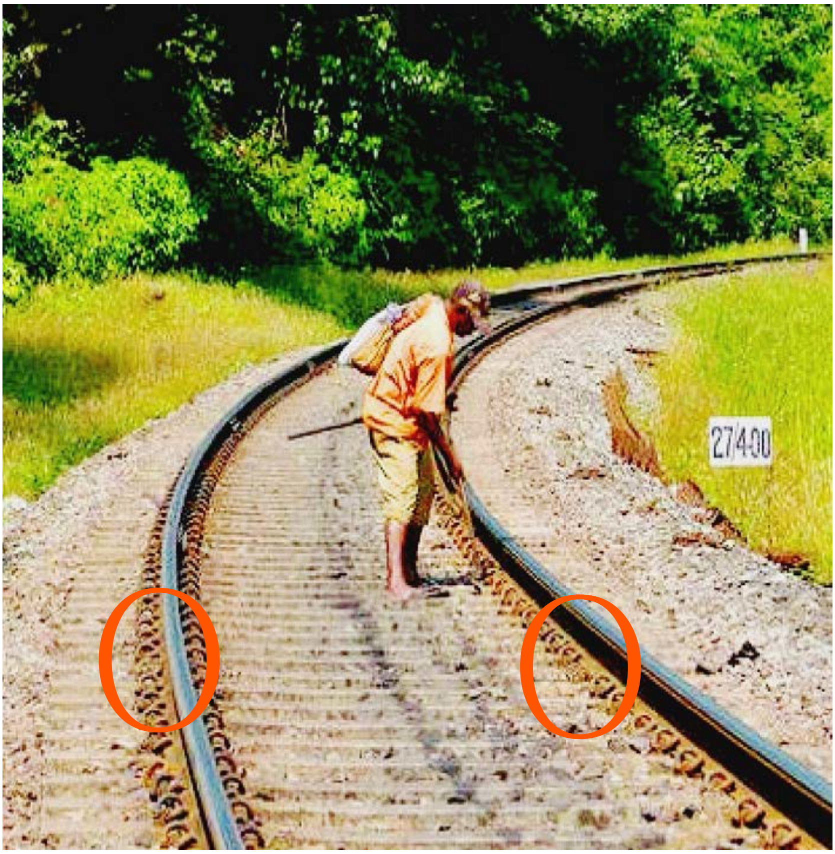
According the traditional Indian application based terminology for ERCs in case of Chennai Metro Rail the structural element of the middle part of the installed ERCs will be called ***“HEEL”*** and in case of the neighboring INR tracks the same structural ERC element of the middle part will be called ***“TOE”***. This is absurd.

Therefore the author strongly suggests defining in future the designations of ERCs not according the application, but uniformly according the structural elements.

Last-Not-Least

MARK III ERC - by far not *“FIT-AND-FORGET”*:

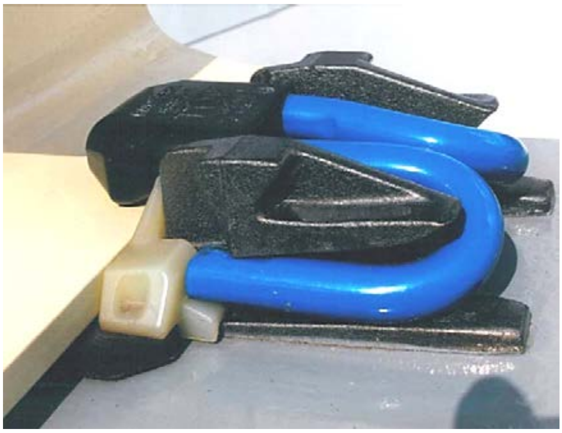
Tracks with MARK III ERC need patrolling Key-Men



Missing MARK III ERCs

Patrolling Key-Man at Risk while attending MARK III ERCs

Pandrol-Type self-tensioning ERCs get superseded by self-tensioning Fast-Clips:



Fast-Clip, Rahee Industries; pict. by F.A. Wingler

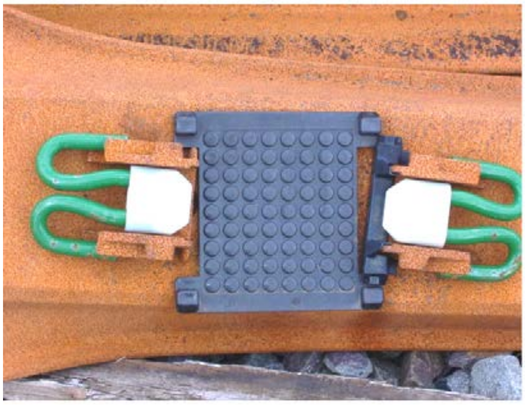
Worldwide the self-tensioning Pandrol-Brand Fast-Clips are increasingly superseding the self-tensioning Pandrol "e"-Brand ERCs. This Fast-Clip takes a trumped around the globe especially in England, Germany, France, Poland, Sweden, Estonia, Georgia, Lithuania, Russia, Serbia, Hungary, Corsica, Sri Lanka, Cambodia, Malaysia, Saudi Arabia, Australia, China and USA.

In England, wherever new sleepers get installed, the rails will be fastened by Fast-Clips. Even in Germany, the motherland of direct Vossloh Screw/Tension-Clamp SKL Fastenings, the Fast-Clips are nowadays installed on tracks with tight curvatures, where in 4-5 years interval due to high wear the high outer curve-rails have to be re-railed by robotic heavy-duty on-track machinery (River Rhine Valley Lines).

The Fast-Clip Sleepers are delivered on site with all components held captive, and the clips with the toe-insulator are at parked position. Once the sleepers are placed and the rail has been threaded, the Fast-Clip is simply pushed from the parked to the installed position. This can be done by mechanized/robotic procedures. The correct clamping force in the range up to 17 kN is achieved automatically when pushing the clip in parking position.

The Fast-Clip is virtually maintenance free and a true ***"fit and forget"*** Rail-Fastening. Even under harsh conditions the Clip does not dislodge. No key-man is needed to push in regular intervals clips back, as it is needed for conventional parallel to the rail installed elastic Rail Clips, which can get loosened by rail-creep and vibration.

The Fast-Clip is nowadays the favorite clip for new installed **Steel-Sleepers**, and it helped them for a come-back in European countries (England and Corsica) and in Sri Lanka:



Pre-assembled Fast-Clip with Cab-Insulator on Steel Sleeper, British Rail; pict. by F.A. Wingler

Close-up of FD 1408/1300 Fast-Clip Assembly with Insulator-Liner on Rahee Steel-Sleepers in Sri Lanka - a *"fit and forget"* Rail-Fastening

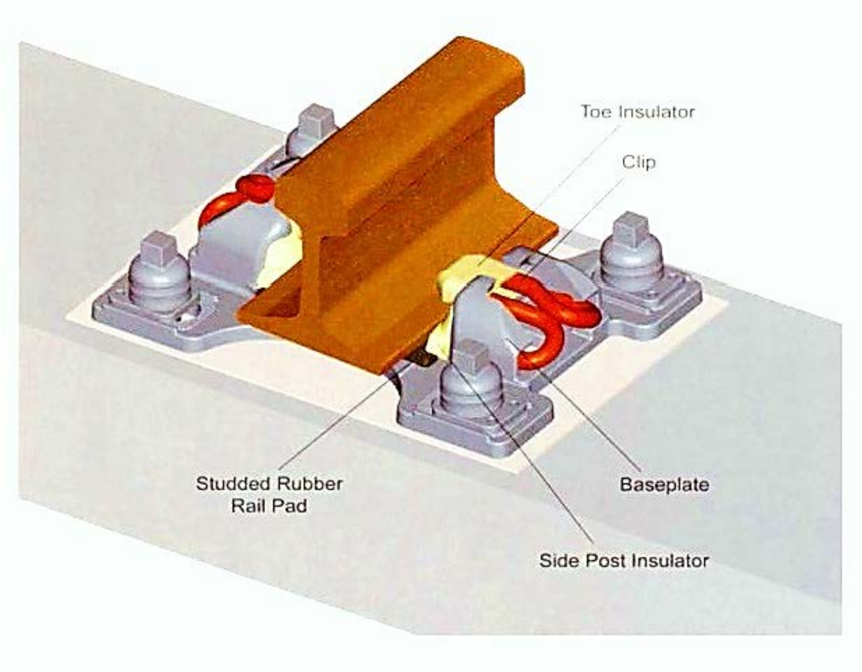
Reactivation of abandoned Railway Line in Scotland, UK, with Rheda 2000 Ballast-less Track and Fast Clip by RAIL ONE on Tunnel Section

In his Paper No. 7, Session I of the IPWE International Seminar, held 12th & 13th January 2017 at Mumbai, Mr. Gopalakrishnan reveals: *"The Indian Mark III ERCs due to various reasons do not sustain designated toe load (clamping force), and it is high time to turn towards modern Fasteners"..." It can be stated, if someone develops a new fastener and if it passes through the tests successfully as prescribed in EN-13481 specification, the fastener is ready to be used on track". The Pandrol Fast-Clip is indeed in compliance with the European Norm EN 13481. PANDROL FAST-CLIP FE 1400 series fastenings are compliant with the requirements of EN 13481-2:2012 and the High-Speed Interoperability Directive (TSI). PANDROL FAST-CLIP FE 1500 series fastenings are compliant with the requirements of EN 13481-8:2012 - fastening systems for track with heavy axle-loads. Some configurations of Pandrol Fast-Clip FE 1400 and FE 1500 series fastenings are compliant with the requirements of AREMA Manual Chapter 30, Part 4.*

Mechanized / robotic Track Sleeper Laying with pre-assembled Fast-Clips, Rail-Threading and Clip-Locking in China

Demonstration Ballast-less Slab Track at Vadodara for Indian High-Speed Project with Fast-Clip Rail Fastening

French Dublex TVG HS World Record Train on Track with Pandrol Fast-Clip Rail Fastening



Adjustable Pandrol Single Fast-Clip, SFC, Assembly for BLT

The Pandrol SFC system takes full advantage of the Pandrol Fast-Clip captive fastening system, whilst allowing vertical adjustment to be achieved through the use of simple under-plate shims, and lateral adjustment by use of slotted anchor points. Thy system is available with a 2 holes and 4 holes base-plate.

It is fully compliant with the requirements of EN 13 481-5-2002.

The SFC base-plate has been designed to easily transfer the advantages of the Fast-Clip to BLT/Slab Track applications.

The design allows the full advantage to be taken of the Fast-Clip captive fastening, making it an ideal installation for BLT, where the speed and ease of mechanized/robotic installation and alignment, both in the initial construction and subsequent re-alignment phases, are critical.