INTRODUCTION TO THE PERMANENT WAY INFRASTRUCTURE

Network Rail

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Note

Disclaimer

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November 2003

FOREWORD

Railways have a language of their own and use terms, components and equipment not found elsewhere. This booklet is intended to help you learn the language and to start to learn the names of components, equipment and work which you will see in your working life.

I hope that you will use it as a source of reference.

If you come across anything that you do not understand, ask. Most railway personnel like to talk about their work and will be pleased to help you.

Like any language it is intimidating at first, but you will soon become an expert.

DAVID VENTRY, B.Eng., C.Eng., FICE, FPWI

HEAD OF ENGINEERING

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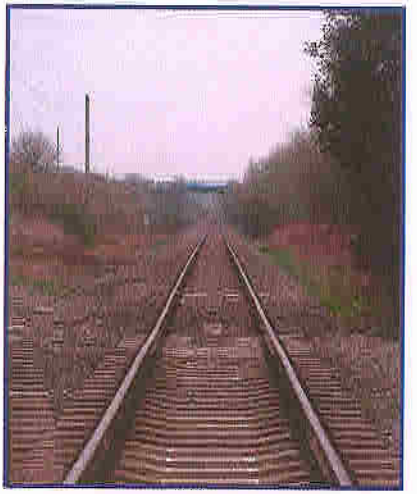
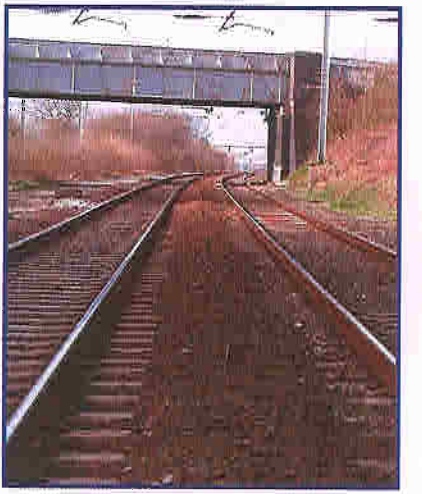
DIFFERENT COMBINATIONS OF LINE

When engineers are constructing a section of line they will take into consideration certain factors particularly the density/frequency of traffic that will use the line. In high frequency areas it would be necessary to plan for multiple lines to manage the traffic. In railway terminology they would be referred to as Fast Lines designed for high speed traffic or Slow Lines used for stopping passenger or freight trains. The direction of traffic is taken into consideration and is referred to as up line, which was historically usually Up in the direction of London or Down line.



Single or Bi–Directional Line



Two Track Situation with Up Line and Down Line

Three Track Situation Consisting of Up Line and Down Line also Bi-Directional Line, allowing trains to travel in both directions over the same portion of line

Four Track Situation Consisting of:
Up Fast Line
Down Fast Line
Up Slow Line
Down Slow Line

POSITIONING OF TRACK

The shortest point from A to B is a straight line. When railways where first being built, early railway engineers would try to achieve this where possible, however this was not always an option. Early trains couldn't climb steep hills and had poor brakes. Today new high speed routes tend to follow much straighter lines and have steeper gradients. Due to the formation and the geology of the land it was necessary to locate the track around problem areas. For the diagrams illustrated below observe the effect of the track construction.

Curved Track

Curves are always referred to as right hand or left hand. Notice how the curves bends to the right.

Straight Track

Reverse Curve

You will note that firstly the curve bends to the Right (right hand curve) then it bends to the Left (left hand curve). This in railway terms is known as a "Reverse Curve".

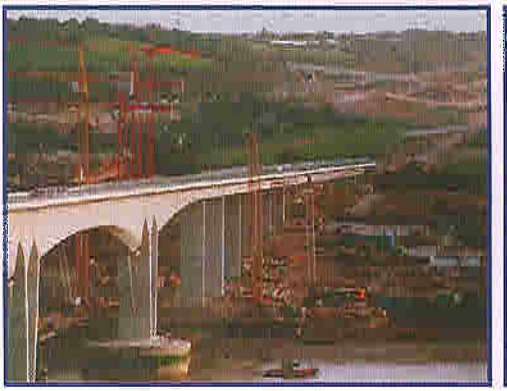
BRIDGES, CUTTINGS, VIADUCTS AND EMBANKMENTS

During Construction of the railways, engineers had many obstacles to overcome. Some of the areas that proved problematic were rivers, roads and valleys. It was therefore necessary to construct bridges, viaducts and through a process of cut and fill, create embankments to ensure the most direct route for track was achieved.

When working in the vicinity of bridges and viaducts special precautions may be required due to limited side clearances. Working in these areas is usually prohibited and work can only be carried out after rail traffic has been stopped through the blocking of lines as specified in standard GO/RT 3000.

Railway Embankment

A Typical River Under Bridge

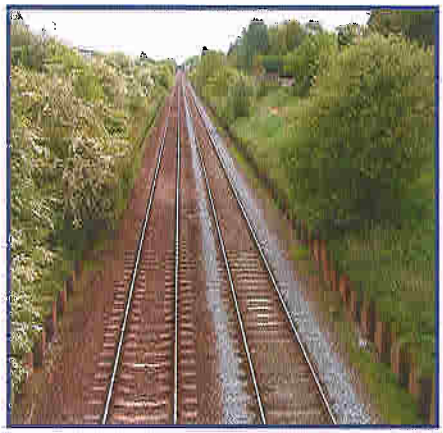


A major item of work, the construction of a new rail bridge

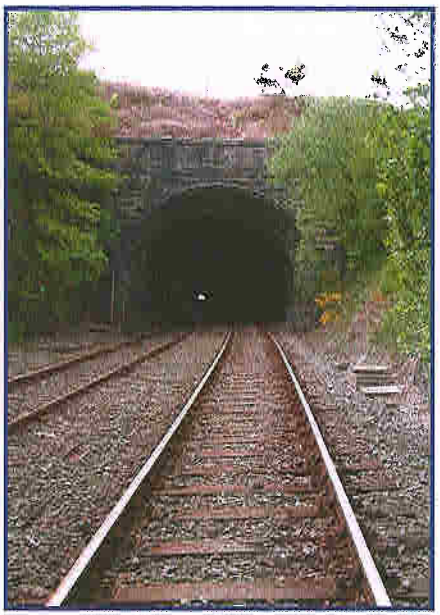
Rail viaduct

BRIDGES, CUTTINGS, VIADUCTS AND EMBANKMENTS continued

When working in the vicinity of bridges, cuttings, tunnels and viaducts special attention must be given to the signs indicated in the bottom diagrams.

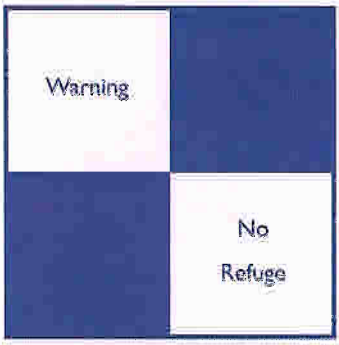


A typical cutting



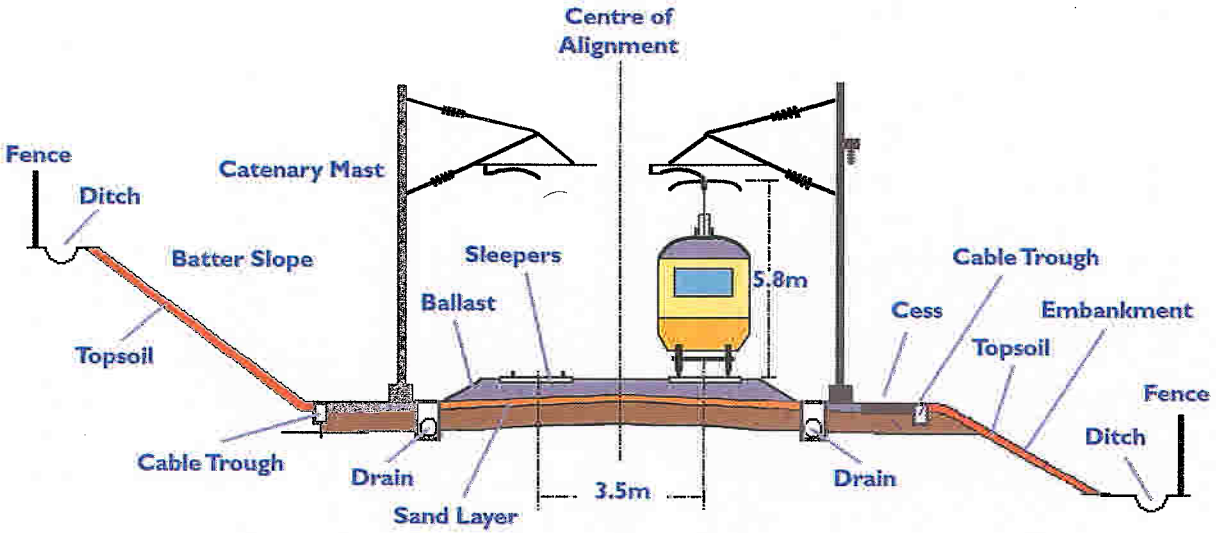
A typical tunnel

A red and white chequered board indicates an area of limited clearance, you are in an area with a limited amount of space, this will mean there is no place of safety at all where the boards are fitted.



The blue and white chequered board indicates in tunnels / cuttings on bridges and viaducts that there are no refuges, a refuge is a safe area cut into a wall or built into a bridge where you can go and stand to get out of the way of on-coming traffic.
This means there is no place of safety on the side of the line where the boards appear.

A TYPICAL CROSS SECTION OF A DOUBLE LINE TRACK WITH OVERHEAD LIVE WIRES (25000 VOLTS)



Cross Section of Double Track Railway Alignment showing names of principal parts of construction

SIGNALS

Signals are necessary to instruct drivers of trains when it is safe to proceed, when to stop, when to start slowing down for an approaching signal maintained at danger or when to cross from one route to another. Signals are normally placed to the left hand side of the track to which they apply, they can however be positioned on gantries or on the ground.

There are three main types of signal

Controlled	Controlled manually by a person in a signal box called the signaller
Semi Automatic	Controlled by the passage of a train through track circuitry, or a signaller
Fully Automatic	Controlled by the passage of trains

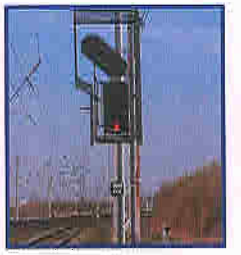
The illustrations below indicate a variety of signals, they are mostly of colour light variety. They can be manual, semi automatic or fully automatic variety. The type is indicated by a sign fixed beneath the signal.

A two aspect signal capable of showing a red or green light

A three aspect signal capable of showing a red, yellow or green light

Four aspect signal capable of showing a red or 2 yellows or a green light
**Note the positioning of these signals on a gantry*

A semaphore signal. This type of signal is controlled by a Signaller
**Note: The red arm with white stripe, is a stop signal, the yellow with black chevron is a distant signal. This gives advance warning of the aspect of an approaching signal to train drivers*



A three aspect signal with route indicator to indicate when trains are to transfer from one line to another

A ground signal to allow for controlling trains out of sidings on to a main line

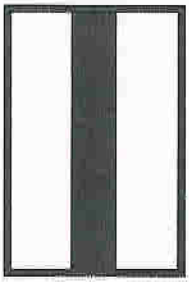
IDENTIFYING SIGNS FOUND ON SIGNALS

All are individually numbered and also denote the type of signal by a signal post plate.

Controlled Signal

Semi Automatic Signal

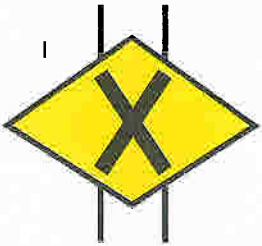
Fully Automatic Signal

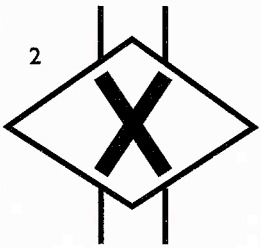


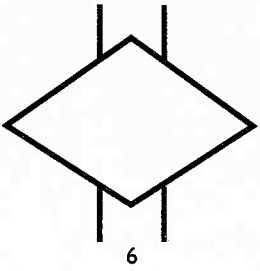
Intermediate Block Signal

Distant Signal

OTHER SIGNS FOUND ON SIGNALS







Signs 1 to 4 indicate there is a telephone on the signal, but positioned in a place of limited clearance as indicated in illustration No 5.

The white and yellow diamonds with black cross are not to be confused with the plain white diamonds illustration No 6 that indicates there is track circuitry in the area.

SIGNS

RED SIGNS INDICATE THINGS MUST NOT BE DONE

No smoking

Do not drink

Unauthorised persons prohibited beyond this point

BLUE SIGNS INDICATE THINGS MUST BE DONE

Keep locked shut

Protective footwear must be worn in this area

YELLOW SIGNS GIVE WARNING OF HAZARDS

Danger Fork lift trucks

DANGER Beware of step

Danger High voltage

GREEN SIGNS PROVIDE INFORMATION

PERSONAL PROTECTIVE EQUIPMENT

Under the Health & Safety at Work Act 1974 the Personal Protective Equipment regulations were introduced. This called for the employer to provide suitable PPE free of charge to protect the employees against risks which have not been controlled by other means and to take all reasonable steps to ensure it is used correctly. It is the duty of the employee to take care and wear the equipment under the required circumstances.

BLUE SIGNS INDICATE SOMETHING MUST BE DONE

Hard Hat Area

Protective Goggles / Glasses Must Be Worn

Ear Defenders Must Be Worn

Standard Hard Hat

Hard Hat with Protective Visor and Ear Defenders built in

Different Designs of Ear Defender

Protective Glasses

Goggles

Hand Protection

To Protect against oil

To Protect against chemicals

To Protect against electric shock

To Protect when welding

HEALTH AND PERSONAL HYGIENE

The majority of railway civil engineering is undertaken in the open. It is essential when working on the track that particular attention is paid to personal hygiene, especially washing hands before eating straight after working. It is also very important to remember to further protect your hands by using good quality gloves and always ensure you protect open wounds, particularly if you are working in areas where there is stagnant water. Lack of attention to detail leaves a person open to diseases such as leptospirosis and dermatitis. Protection is required from noisy environments. When using small plant. Long term use of vibrating machinery without the proper protection can result in a condition known as white finger. Unprotected work in noisy environments leads to hearing loss. Such problems are avoidable if the correct precautions are taken.

How do people get leptospirosis? (Weils disease)

Outbreaks of leptospirosis are usually caused by exposure to water contaminated with the urine of infected animals. Many different kinds of animals carry the bacterium; they may become sick but sometimes have no symptoms. Leptospira organisms have been found in cattle, pigs, horses, dogs, rodents, and wild animals. Humans become infected through contact with water, food, or soil containing urine from these infected animals. This may happen by swallowing contaminated food or water or through skin contact, especially with mucosal surfaces, such as the eyes or nose, or with broken skin. The disease is not known to be spread from person to person.

Rats and other wild animals urinate in stagnant water. This can lead to leptospirosis also known as weils disease

Dermatitis (also known as contact eczema)

This disease develops in the exposed skin of persons sensitive to particular irritants. Even a few minutes contact with the irritant can produce a rash as for example happens coming into contact with certain lubricants. In the first illustration below the person holding the pen had a typical rash like reaction associated with dermatitis caused by the nickel in the pen. Picture 2 shows a reaction to chemicals that have leaked through the persons footwear.

White Finger:

What makes your hands tingle and go numb?

Hand Arm Vibration Syndrome or White finger, is a widespread hazard, with over 1 million UK workers exposed to vibration over the Health and Safety executive action limit of 2.8m/s2. At present at least 300,000 workers have reported symptoms of Hand Arm Vibration Syndrome (HAVS). HAVS is the most common disease assessed by the DSS and is the most common disease reported under the Reporting of Injuries, diseases and dangerous occurrence, regulations (RIDDOR).

Do your hands go white? Have you got problems with your hands in the cold?

Do you have problems with your hands due to using vibrating Power Tools

Noise:

Continual, unprotected exposure to noises louder than 85 decibels (dBa) for 8 hours or more can be dangerous, and may result in hearing loss. Permanent damage by sounds reaching over 100dBa or more, can occur in 2 hours or less. If you are exposed to loud and continuous sound for more than 15 minutes per day at 100 to 110 dBa, you need to wear hearing protection. Even brief exposure to gun blasts or jet engine noise can cause pain and permanent injury if your ears are not protected. Hearing loss is cumulative and once lost, can never be regained. The best way to protect your hearing is to create a habit of wearing comfortable hearing protection.

How do we go about protecting our hearing?

Here are some recommendations for hearing protection, whether you are a worker, manager, or just someone who knows it is necessary.

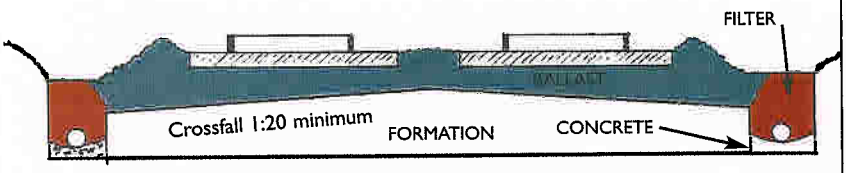
BE SAFE WEAR THEM!!

- Ensure you wear the right ear protection for the work to be undertaken, that it is comfortable for you, and that you will wear it.
- Wear your hearing protection correctly. Each type of hearing protector is slightly different. The important thing to remember is that you need to insert ear plugs correctly, or ear muffs completely over the ears. Then, you must always test the fit. To test the fit, cup your hands over your ears, then release. If you can hear a difference, you may not be wearing your hearing protector correctly. Remove, then fit again.
- Only wear them in noisy environments when instructed to as part of the safe system of work.
- A risk assessment brief given by your C.O.S.S. to establish when they should be worn will be given prior to work commencing.

Following these simple guidelines, you can save your hearing from further hazardous exposure and potential hearing loss.

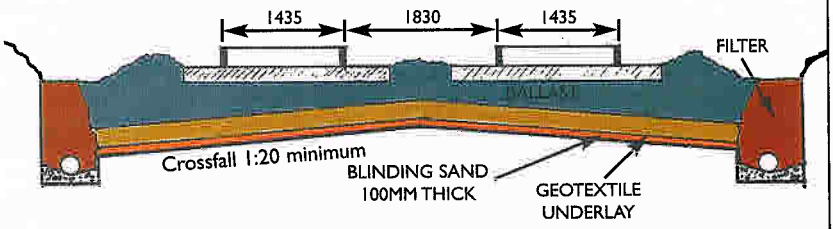
BALLAST FORMATION AND DRAINAGE

During the construction or renewal of a section of track, great emphasis must be given to the formation and drainage, a cross fall towards the drain point is built into the formation at a rate of 1 in 20. Routine maintenance to allow water to be directed away from the track in the direction of the drains is vital. If we do not pay attention to the cleanliness and correct operation of drains serious faults in alignment and top will develop.

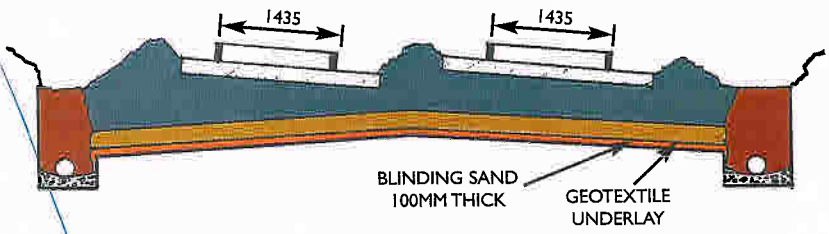


RE-BALLASTING - TYPICAL CROSS SECTION

The depth of dig may be increased dependent on ground and traffic conditions but the Crossfall right to the drain MUST be provided.



SAND BLANKET - TYPICAL CROSS SECTION
FOR STRAIGHT TRACK



SAND BLANKET - TYPICAL CROSS SECTION
FOR CURVED TRACK

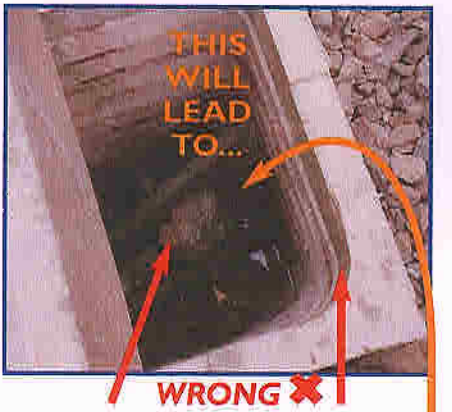
Depth of sand and ballast and therefore the dig must be taken from the lowest end of sleeper. It will be helpful to remember that 75mm cant* = 1:20

* Cant is the amount by which one running rail is raised above the other running rail.

The result of neglected drainage, advanced stages of ballast attrition.

The two pictures below show 2 different catch pits in the same area, the left one shows good maintenance, the right one all that is bad in drain maintenance.

Grill fitted correctly *Water flowing freely*



Waste materials allowed to build up resulting in water not being able to flow correctly *No lid fitted*

On the left we see again an example of bad maintenance, catch pit rings have been damaged, new ones have been brought to the site but nobody seems interested in replacing them, a job that would take minutes. Instead they now provide us with a potential hazard to the underfoot conditions and a risk from vandals placing them on the line.

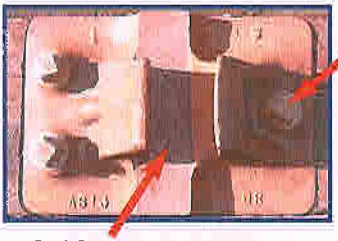
Above we see the digging out and positioning of a new six foot drain and catch-pits. The catch-pits are cut down to size later.

IDENTIFICATION OF COMPONENTS

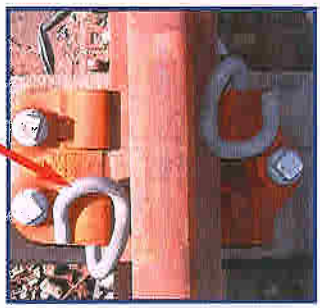
(CHAIRS, BASEPLATES AND ASSOCIATED COMPONENTS)

Chairs are designed as a support for Bull Head Rail. Baseplates are the support for Flat Bottom Rail

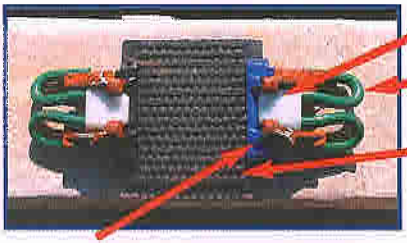
AS1J BULL HEAD CHAIR



PAN11 FLAT BOTTOM BASEPLATE



PANDROL™ FASTCLIP FASTENING



WOOD SLEEPER COMPONENTS

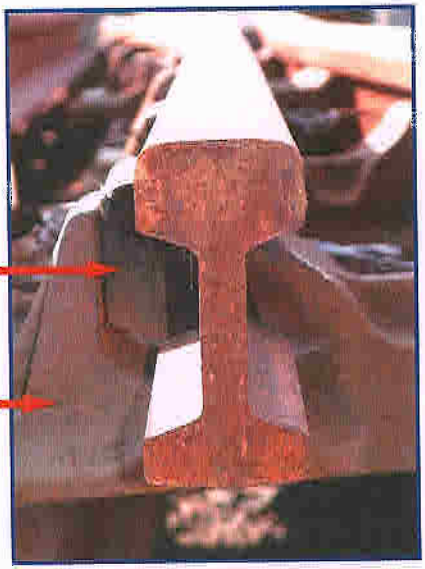
CONCRETE SLEEPER COMPONENTS

IDENTIFICATION OF COMPONENTS (RAILS)

There are 2 main types of rail cross section used in the industry. These cross sections of rail come in a range of sizes (lb/yard and Kg/m). Also different types of steel (eg. hardened) for use in specific locations.

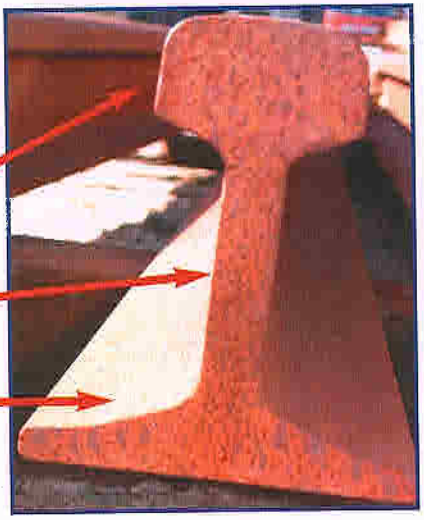
BULL HEAD

Bull Head requires a Steel or Wooden Key to be driven between the Chair and the web of the rail so it is positioned in the upright position correctly.



FLAT BOTTOM

Flat Bottom will stand upright unaided but requires the appropriate fastenings to ensure it is kept positioned correctly under traffic.



MARKINGS FOUND ON COMPONENTS

It is common practise in the rail industry to identify components with markings. In the four diagrams you will observe some of those markings

In this photo reading from left to right we see the markings 60E1-A-DO-00. These particular markings can be found on the more modern type of rail being used in the industry today. The 60 relates to the weight of the rail in kilos per metre, the A is the section type of rail, DO are the initials of the manufacturer, 00 is the year 2000.

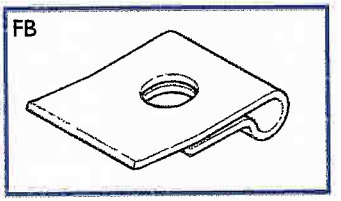
In photo 2 the markings indicated BS 113A-HT-DO-00. These are slightly different from the markings found in the photo above. The BS indicates British Standard, 113 the poundage per yard, A is the section type and the HT heat treated, DO are the initials of the manufacturer, 00 is the year 2000.

In Photo 3 the markings are indicating the type of sleeper. Concrete EF 28 a shallow depth sleeper, with Pandrol™ housing used for 3rd rail areas it has the provision for insulators to be mounted on the sleeper end.

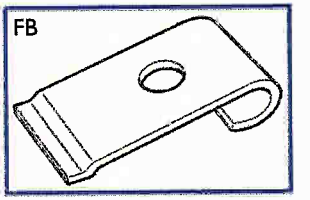
The markings indicated here are typical of the markings found on baseplates or chairs. Shown is a Pan 11 baseplate fastened to the sleeper with AS1 coach screws, the rail is secured in the seating area with Pandrol™ clips.

FASTENINGS AND CLIPS - PART 1 FLAT BOTTOM

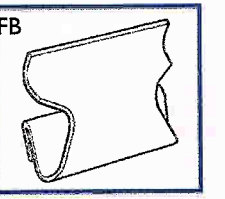
The modern FB rail fastening design originated in the late 1940's from work that highlighted the need for a resilient connection between rail and sleeper. The many designs of resilient fastenings for FB rail developed to date can be grouped into 3 general types: Spikes for timber sleepers eg. elastic or macbeth spikes. Secondly threaded elements used to apply a force to a spring steel element normally a bar or plate (found on BJB's or AD type fastenings for concrete sleepers). Thirdly a fixed element incorporating a slot, hole or recess for example the Pandrol™ or SHC clips which are only found on concrete sleepers whilst the others are found on timber.



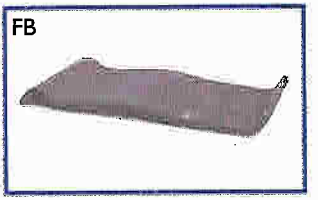
RNB7 Clip



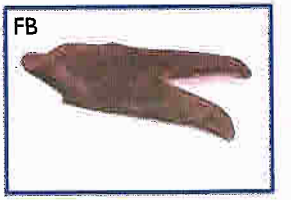
LC Clip



Heyback J8 Maintenance Clip.



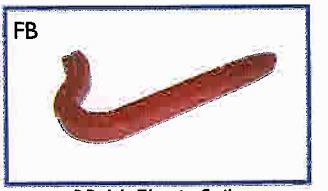
SHC Clip



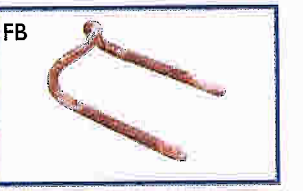
SHC 'V' Clip.

CS3 Clip.

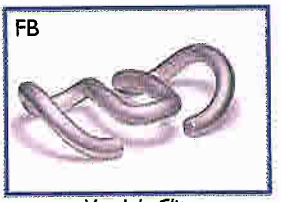
AL 23 Maintenance Spike



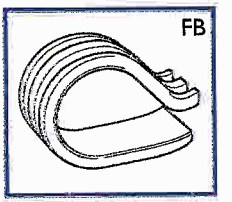
BR A1 Elastic Spike



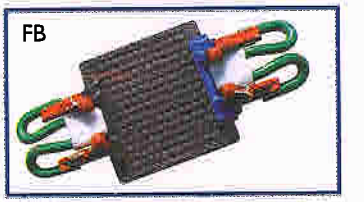
Macbeth Spike



Vossloh Clip



Mills C3R Clip



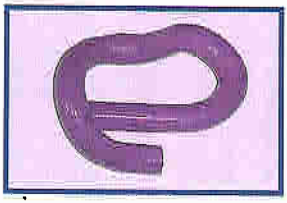
Pandrol™ Fastclip

KEY FB = Flat Bottom Rail BH = Bull Head Rail

There are many different types of clips and fastening used on the rail network below are some of the more instantly recognisable components.

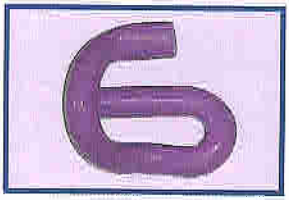
PANDROL™ TYPE FASTENINGS FOR USE ON FLAT BOTTOM RAIL

Pandrol™ e1809 Clip (Sheradised).



Pandrol™ PR427A Clip. (maintenance replacement for obsolete PR303)

Pandrol™ PR401A Clip.



Pandrol™ e2001 Clip.

Pandrol™ PR427A Clip (Sheradised).

Pandrol™ e2007 Clip

Pandrol™ PR402A Clip.

Pandrol™ PR401A Clip (Sheradised).

Pandrol™ PR428A Clip.

Pandrol™ e1809 Clip

Pandrol™ Fastclip Assembly

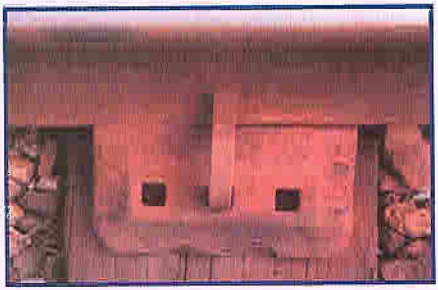
Pandrol™ PR Rail Clip

BJB Fastening

RD Fastening

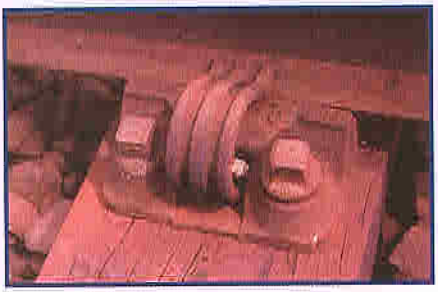
Heyback Fastening

Low Cost L.C. Clip



BR1 Elastic Spike

KT Clip and Saddle

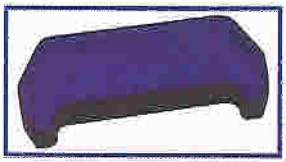


Mills Rail Clip

RAIL INSULATORS

Rail insulators are situated at the foot of the rail. Their major function is to isolate two rails electrically, they also assist in the positioning of the rail. Different colours for different types of sleepers and clips.

Insulator, GRN for use with MV, Pan 14 Baseplates & e2001 clips on concrete sleepers. This product is now white.



Insulator, GRN Blue for F40 Sleeper.

Railfoot Insulator for CS3 Fastenings

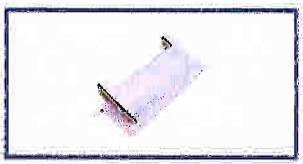
Insulator, Nylon for SHC Fastenings with 110A/113A Flat Bottom Rail

Heelblock Insulator for CS3 Fastenings

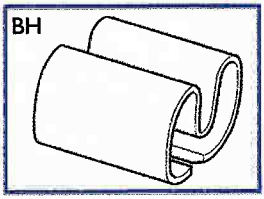
Insulator, Nylon Blue, Pandrol™ 401A/402A/e1809 Clips, Concrete Sleepers with 98/109 Flat Bottom Rail

Insulator, Nylon for SHC Fastenings with 1091b Flat Bottom Rail

Insulator, Nylon Orange Pandrol™ 401A/402A/e1809 Clips. For use on F23 to F27 Concrete Sleepers with 110A/113A Flat Bottom Rail



Insulator, Composite Nylon with Malleable Iron Cover Plate, Pandrol™ 401A/402A/e1809 Clips. For use on F23 to F27 Concrete Sleepers with 110A/113A Flat Bottom Rail and Concrete Bearer S&C Work



Steel Key for Bull Head Rail.

Panlock, 95 RBH Bull Head Rail Steel Key.

Key, Wood, 95 RBH Bull Head Rail
Key, Wood, 97 1/2lb '00' Bull Head Rail.
Key, Wood, 6R (Reversible 95 RBH, BHR.

JBBH Rail Key Panlock, 95 RBH
BH Rail Steel Key (Sheradised)

AS1 Chair Screw

Panlock Steel Key

Tapered Steel Key

INSULATING RAIL PADS

Rail pads are positioned between the running rail and the sleeper surface, there are various types / sizes dependent on the sleeper. They help to protect the sleeper from damage and to act as an electrical insulator.

Although it is one of the less obtrusive parts of the fastening assembly, the pad is a key of the system, and an understanding of its function and behaviour are the key to any understanding of how rail fastenings work. The essential functions of a rail pad are:

1. To cushion the effect of vertical loading;
   (a) by providing a conforming layer between the rail and sleeper the pad ensures an even pressure between on the rail seat area.
   (b) In addition by acting as a spring the pad reduces the transmission of vibration and impact from the rail into the sleeper.
2. To act as a longitudinal spring that assists in the distribution of traction and braking forces along the rail.
3. To provide electrical insulation.

F23 - F27 CONCRETE SLEEPERS

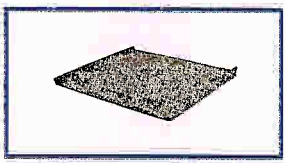
"H" Pad Natural Rubber (5.5mm)

BASEPLATES FOR MORE THAN ONE RAIL

SHC BASEPLATE

STEEL SLEEPERS

"H" Pad EVA Material (5.5mm) (This product has been superceded by 00571048471)



Lipped Pad EVA Material 260 x 250 x 5.5mm for S&C Baseplates ie CV

PAN 11

Lipped Pad EVA Material (10.5mm) for some Concrete Sleepers and Plain Line Baseplates

F41 & G44 SLEEPERS

"H" Pad Studded Rubber (10mm)

MAINTENANCE PAD CONCRETE

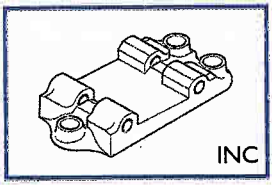
"H" Pad Rubber Bonded Cork (7.5mm) For F23 - F27 Sleepers

"H" Pad Natural Rubber (10.5mm) For F40 Sleepers

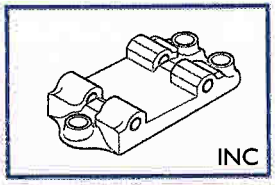
"H" Pad Natural Rubber(7.5mm) For F23 - F27 Sleepers

CHAIRS AND BASEPLATES

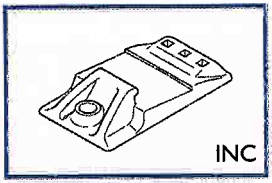
The clip or other means of holding the rail must be securely anchored to the sleeper or other supporting element. The means of doing this is either a baseplate or, in the case of concrete sleepers particularly, some form of direct anchor. Baseplates are essential on timber sleepers, in order to prevent the concentrated loading produced by the rail seat reaction causing damage to the top surface of the sleeper. Castings are produced so as the rail is seated in either a vertical position or slightly inclined inward (to the 4') at an inclination of 1:20.



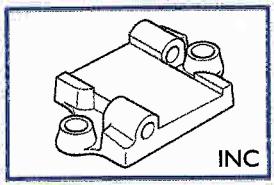
Pan 6 Baseplate



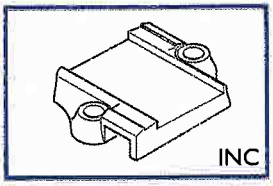
Pan 7 Baseplate



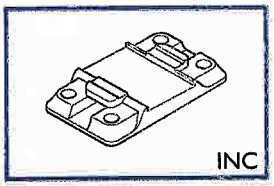
BR3 Baseplate



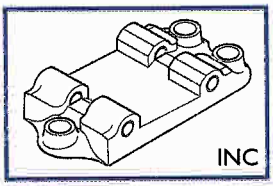
Pan 9 Baseplate



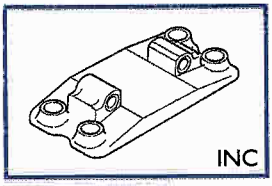
MRC 6/3 Baseplate



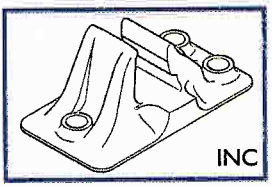
MRC 2/3 Baseplate



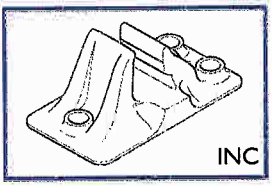
Pan 11 Baseplate



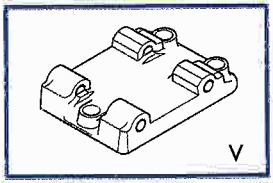
Pan 14 Baseplate



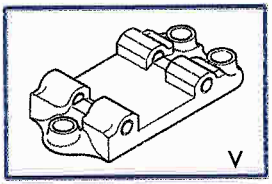
SAI Chair



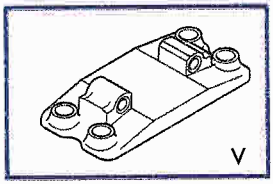
SI Chair



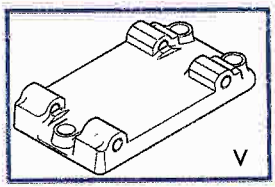
Pan V Baseplate



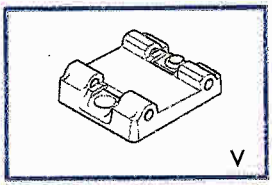
Pan VN Baseplate



Pan V4N2 Baseplate



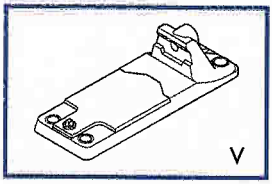
Pan CV Baseplate



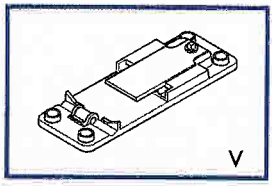
Pan M6 Baseplate

KEY INC = INCLINED RAIL V = VERTICAL RAIL

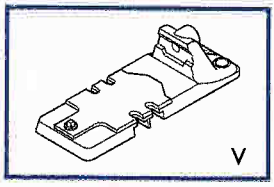
FLAT BOTTOM SLIDE BASEPLATES



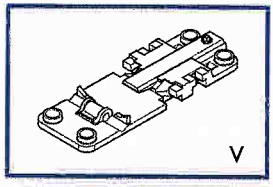
PSV Slide Baseplate & Slipper



RPSV1 Slide Baseplate & Slipper

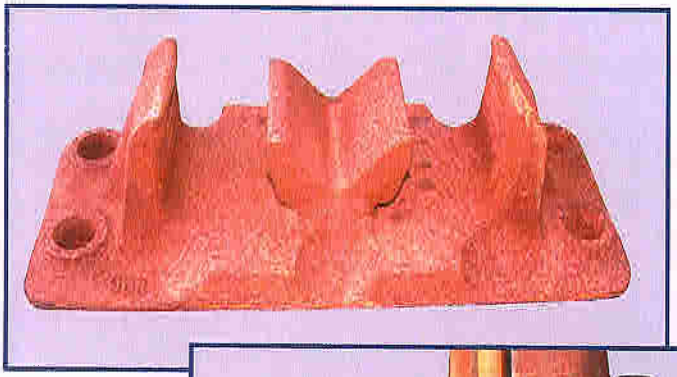


VSP Slide Baseplate & Slipper

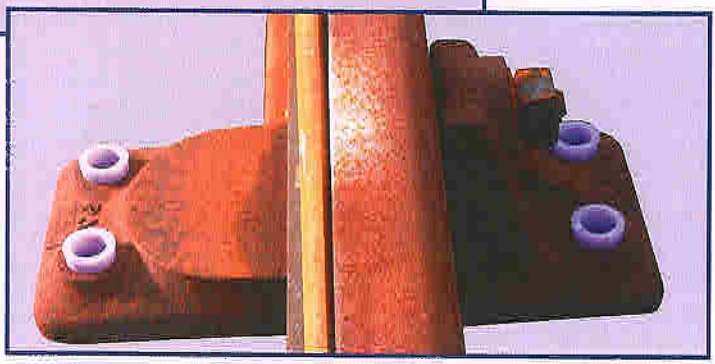


RVSP1X Slide Baseplate & Slipper

BULL HEAD SLIDE CHAIRS



Bull Head Check Chair



PJ Bull Head Slide Chair

FERRULES

Ferrules are designed to be inserted into the holes in chairs or baseplates, the top of the ferrule should protrude 6mm (1/4") above the upper surface of the chair or baseplate. They **must not** be driven home fully into the hole in the casting. Screws must be inserted with care to avoid damage to the ferrule by over tightening.

A typical ferrule

RIGHT ✔

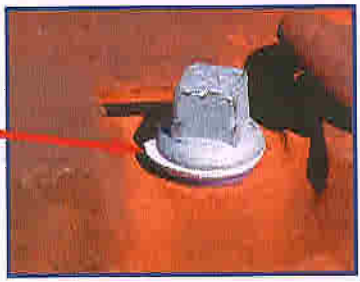
Correct positioning of the ferrule protruding 6mm (1/4") out of the hole in the casting

WRONG ✖

Incorrect positioning, the ferrule has not been driven down far enough, the correct tension between sleeper and screw has not been attained

WRONG ✖

An overdriven ferrule the result of using an impact wrench incorrectly and driving the ferrule further than it is designed to go.
Note that the rule of leaving 6mm - 8mm of the ferrule protruding has not been adhered to.



WRONG ✖

The result of bad maintenance, the ferrule is non-existent, there is no grip between the screw and the chair.

JOINING RAILS BY FISHPLATES (JOINTED TRACK)

What is a Fishplate?

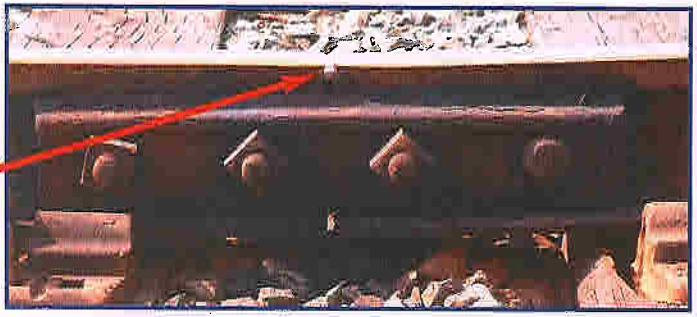
A means of joining two sections of rail. There are many different designs of fishplate. To join two sections of rail of the same dimensions is straight forward, but what if we wanted to join two sections of rail that where quite different e.g. a section of Bull Head rail to a section of Flat Bottom rail. This calls for a very different type of fishplate referred to as a **Junction Plate**. Likewise if we install a new piece of rail next to an old piece, we must ensure that the top of the heads are level. The type of plate used in these circumstances is referred to as a **Lift Plate.**

A typical 95lb Bull Head Fishplate

Expansion Gaps

Rails must be allowed to expand and contract with the changing conditions, the rail temperature determines the size of gap at the joint, in the picture above, the weather is hot the gap is almost closed tight this is correct, in the picture below, the weather is colder you will note the gap is wider due to contraction of the rail again this is correct. When out walking on the track look for signs around the joint, if the weather is hot and rail gaps are wide this could indicate frozen fishplates. The rail cannot expand forward therefore it may try to move sideways, potential for a track buckle. Likewise closed fishplates in cold weather could indicate creep in the rails, the rails will have to be adjusted to a correct gap opening prior to the onset of hot weather.

Expansion gap is open wide, indicating the rail has contracted due to the cold

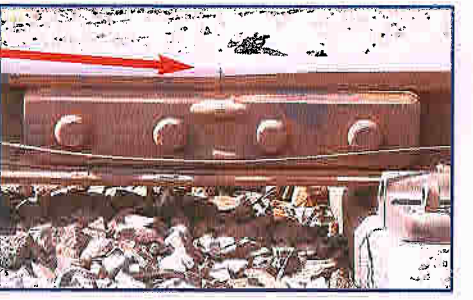


A typical Flat Bottom Fishplate

This shows a pair of insulated FB plates with a lift. Observe the difference in depth of rail head. The left hand rail is more worn than the right hand rail

NOTE

The slight lift in the plate and different depth of rail

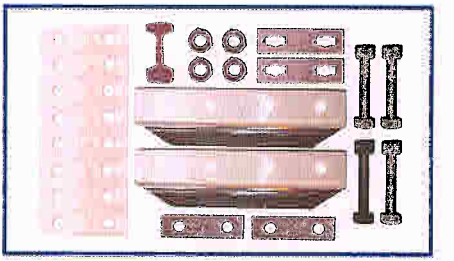


This shows the FB rail on the right is slightly worn more than the rail on the left. To ensure both heads are correctly positioned, a set of lift plates have been fitted

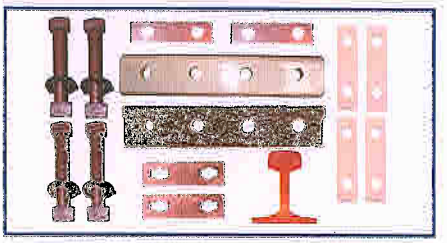
Insulated Joints

Insulated rail joints are required on track circuited routes to enable rails to be physically connected whilst remaining electrically separate for signal requirements.

A manufactured six hole insulated (glued) joint



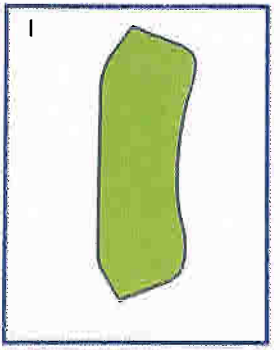
Insulated 4 hole skirted fishplate Assembly for Bull Head rail joint



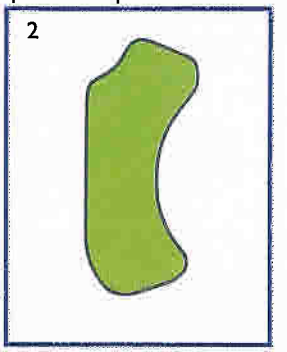
Burns Flat Bottom 4 Hole Insulated Joint Assembly

IDENTIFICATION OF FISHPLATES

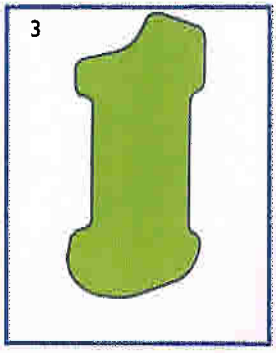
These are cross sections of Fishplates not plan views.



BS 95lb Bull Head Plate 1 1/32" Pear Shaped Hole

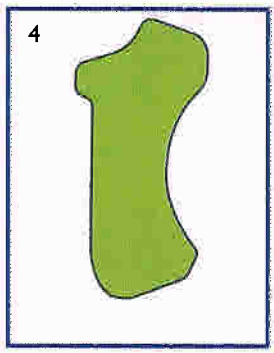


Flat Bottom 98lb Plate 1 1/16" Pear Shaped Hole



BS 110/113A Flat Bottom Plate Round Holes

Fishplates can be ordered in individual poundages ie. 113A, 110A and 109lb as illustrated in the diagrams 3 & 4, however the facility is now available to order a flat bottom fishplate which is suitable for all of these poundages and is indicated on the plate.

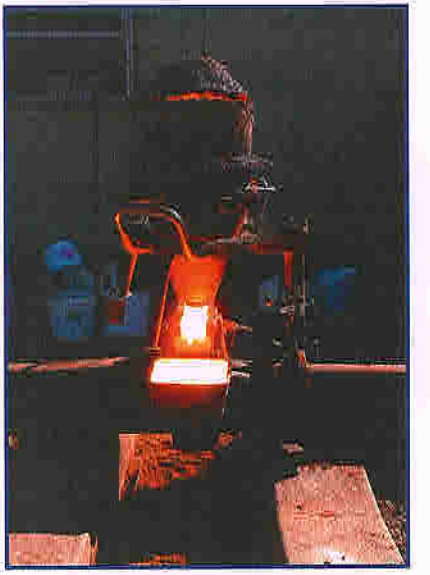


109lb Plate Flat Bottom Rail Pear Shaped Hole

JOINING RAILS BY WELDING

There is another means of joining rails, welding. The welding of rails can be done on site by a process known as Alumino-thermic welding or at the manufacturers using a process known as flash butt welding. The Alumino-thermic method of welding is illustrated in four stages below:

Stage 1
Preheating



Stage 2
The crucible mixture is ignited. When the molten metal reaches the required temperature it is poured into the mould.

Stage 3
The metal is allowed to cool and harden.

Stage 4
Grinding and profiling of the rail

SLEEPERS

Sleepers are designed to support the rail, maintain the gauge (the distance between the rails of one track) and distribute the weight of trains. There are 4 basic types of sleeper used on the railway, but there are many different designs.

Steel Sleeper

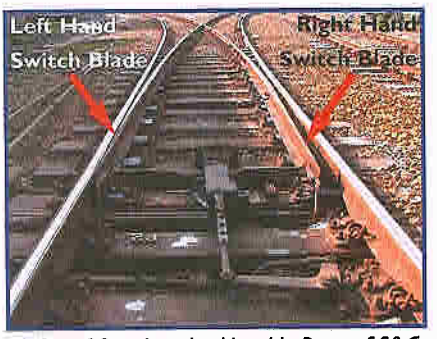
Concrete Sleeper

Hardwood Sleeper

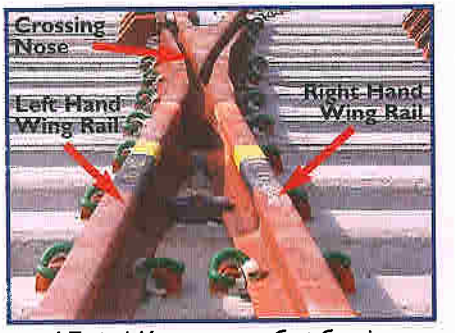
Softwood Sleeper

SWITCHES AND CROSSINGS

Switches and crossings play a vital part in the running of trains, they enable us to re-direct trains from one line to another. Switches and crossings come in a variety of combinations to suit the type of traffic we wish to cross over



A Set of Switches the Movable Parts of S&C



A Typical Manganese or Cast Crossing

Hand of a turnout

The terminology used to determine the direction in which track diverges from the main or principle route, left or right. Observing the pictures shown below we can determine the main route going straight through, standing in front of the switches looking towards the crossing we can see the way the turnout in the left hand picture veers to the left, hence "left hand" turn out. The right hand picture veers to the right, hence "right hand" turn out.

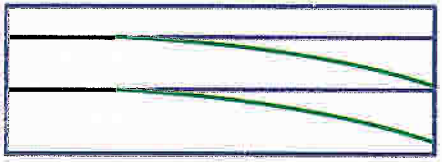
Left Hand Turnout

Right Hand Turnout

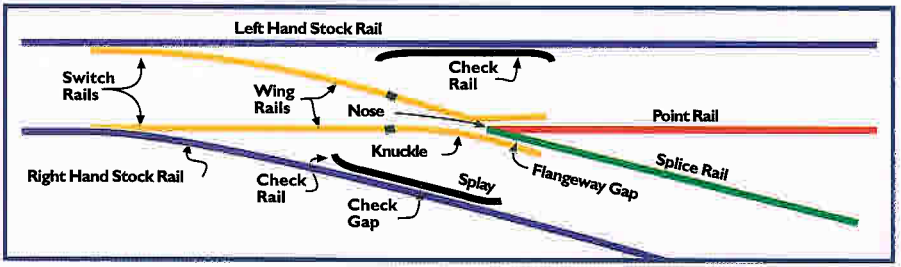
Check Rail

Check rails are bolted and blocked to the running rails opposite the crossing nose to ensure the safe passage of wheelsets running through the crossing gap

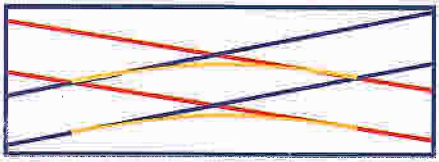
Below are some commonly found S&C Layouts:



Single Lead

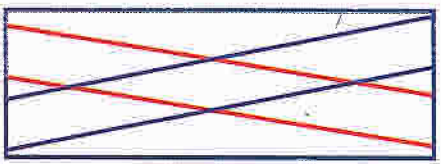


Right Hand Common Crossing

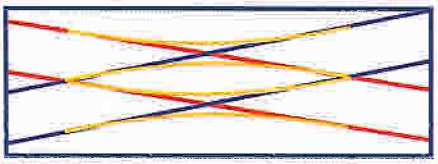


Single Slip

Crossover Road



Diamond

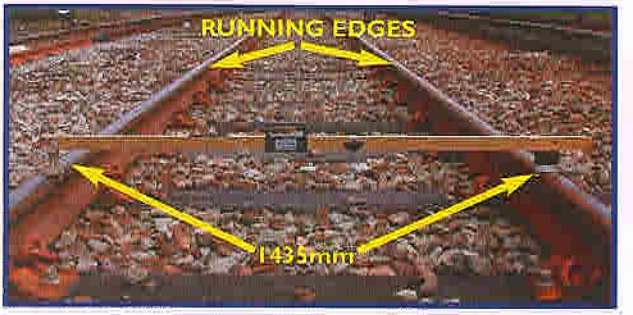


Double Slip

TRACK GAUGE, TOP AND CROSS LEVEL AND LINE

Gauge:

Gauge is the distance measured between the running edge of one rail and the running edge of another rail of the same track. There are two nominal gauges found in modern track, one is illustrated in the diagram below. It is essential to avoid gauge and alignment problems by the monitoring and changing of worn or damaged components. Bad gauge/alignment leads to derailments.



In most types of jointed track and new CWR gauge is nominally 1435mm (4' 8 1/2") from running edge to running edge.

The above picture shows the current standard of gauge measurement, 1435mm (4'-8 1/2") for jointed and new CWR track. It is calculated by measuring the distance between the running edge of one rail (the area of contact with the wheel flange of a train) to the running edge of the other rail. A decision was taken by engineers in the 1960's to reduce the gauge to 1432mm (4'-8 3/8") the theory was that by reducing or tightening the gauge nominally it would assist in a more comfortable ride. This was reversed in 1996 it was decided there were no benefits to be gained from the reduced gauge hence the reversal back to 1435mm (4'-8 1/2").

Gauge Problems:

The 3 pictures below illustrate various causes of incorrect track gauge, that could contribute to the derailment of a train if left unattended.

The baseplate fastenings (lock spikes) have not been fitted to this sleeper because there would be no grip on the spikes as they are driven into the cracks. The sleeper is heavily indented and unable to maintain gauge.

Timber sleeper no longer able to support the track nor maintain gauge, due to internal decay.

Leaning chair screw indicates enlarged screw holes. The outside edge of the chair is now under-riding the upper fibre of the sleeper. Track will be wide to gauge.

Top and Cross Level:

When talking about top in railway terminology, it refers to the rail level both longitudinal (looking along the track) and cross-level (from one rail to the other rail across). There are numerous problems that contribute to bad top and cross-level, wherever this occurs every effort must be undertaken to restore the track back to its original profile.

The first picture illustrates Poor Top. Bad drainage has been allowed to propagate to the extent that it has affected the ballast conditions longitudinally. Inevitably if we were to take cross-level readings it would indicate the existence of TWIST FAULTS (Refer to Twist page 40) due to voids being present under the sleepers. The degree of twist can be measured using a cross-level however these readings will not be completely accurate.

Poor Top in Jointed Track

We can only register the true condition of twist when the track is under load (trains running over). Measuring twist with a cross-level is known as a static reading, readings taken under load are referred to as dynamic readings. To undertake dynamic readings we must employ the use of a gauge known as a void indicator or void meter.

Measuring Static Twist

Cross-Level Readings are Taken

Twist Measurement is Read Off

Measuring Dynamic Twist

A measuring rule is used to provide accurate readings

The Void Meter is positioned under the rail and traffic run over the area. The action of the train pushing downwards gives off a reading on a scale

Poor Top In Continuous Welded Rail(CWR) On Concrete Sleepers

Badly Dipped Joints On Wooden Sleepers

Dipped and poorly aligned joints together with generally poor longitudinal profile of the right hand high rail combine to produce a poor quality railway

Line:

Misalignment in track can be attributed to a number of reasons; it can be created by the force of vehicles pushing outwards on the rails (centrifugal force) particularly in switch & crossing areas and where there is curvature of the line. It can also be caused by misaligned welds e.g. incorrect profiling. Other examples of misalignment can also be attributed to reasons described in previous chapters e.g. frozen fishplates, bad fastenings, poor ballast profile, reduced lateral strength and gauge problems. It does not however have any connection to rail forces introduced on installation or stressing of rails. It is essential that in jointed track the scheduled programme for lubrication of fishplates is adhered to. Where there is Continuous Welded Rail (C.W.R.) present, the installed adjustment switches must be lubricated on a regular basis. Another cause of misalignment is incorrect installation of adjustment switches or lack of maintenance of them.

An adjustment switch is a device which allows longitudinal movement to occur in the last 100 Metres of C.W.R. due to the effect of thermal conditions. Adjustment switches allow for expansion and contraction in C.W.R. because unlike jointed track there are no expansion gaps every 60ft

Straps *A correctly assembled Adjustment Switch* **Switches well lubricated**

Less severe misalignment on left hand rail just off the crossing nose

Misalignment provides a trigger point for track buckles

CURVES, CANT and TRANSITIONS

Curves:

One of the problems engineers faced during the construction of the railways was how to overcome obstacles such as rivers, towns, mountains and hills, the most direct route being preferred, it was therefore necessary in some areas to curve track around those obstacles.

Cant:

The amount of cant applied to a curve is dependant on certain conditions ie speed, the type of trains, the radius of the curve, the transition length, type of track construction, other factors that need consideration when applying cant ie clearances of station platforms and S&C. It should be noted that cant applied is always in increments of 5mm. The highest standard cant that is allowed in the UK is 150mm (6"). Any cant greater than 150mm requires special approval from Network Rail.

Transition:

We cannot go from a straight piece of track, with rails level, to canted track straight away. Any cant design is dependent on the speed and type of traffic running over that portion of line. To get us from a straight piece of track into a regular curve we have to build into it a gradual progression known as a transition. The cant gradient increases very gradually going upwards or downwards continuously over a specific number of sleepers. For example, from the straight track we want the track to raise to a maximum cant of 50mm(2") at the top of the curve. This would be achieved in incremental steps of 5mm. You will observe from the diagram the yellow markings, these are markings where the cant is changing. Tampers and Stoneblowers are designed to smooth out the track between the marked steps to create a smooth finish.

The picture illustrates a Reverse Curve. You will note the top of the curve is showing a cant of 40mm in the direction of the arrow. Behind the arrow we note that the curve is going downwards in 5mm increments to zero, but then rises back up again and the left hand rail becomes higher than the right hand rail.

TWIST

Twist is the terminology used to describe cross level increasing or decreasing too quickly over a short length of track. Readings are taken with a cross level gauge over a distance of 3metres (3000mm) or 5 sleepers. This distance relates to the shortest wheelbase on four wheeled wagons that are most likely to be derailed by twist faults.

HOW DO WE MEASURE TWIST?

Looking at Example 1.

A reading is taken at sleeper 1, another reading is taken at sleeper 5. Both readings indicate that the six foot rail is high, whenever the readings are on the same rail we subtract one reading from another the resulting figure is then divided in 3000mm to give a twist reading of 1 in--- .The lower the final reading the greater the twist (ie the worse the twist)

EXAMPLE 1

Cant / Cross Level

At sleeper no.1

= 25mm (6' rail high)

At sleeper no.5

= 10mm (6' rail high)

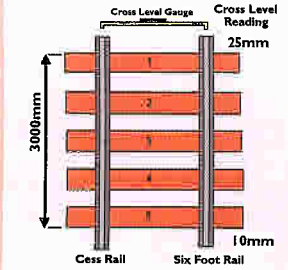
DIFFERENCE between the two readings = 15mm

Therefore Twist

$= \frac{3000mm}{15mm}$

= 15mm in 3000mm

or 1 in 200



Example 2

Cant / Cross Level

At sleeper no.1

= 10mm (6' rail high)

At sleeper no.5

= 5mm (cess rail high)

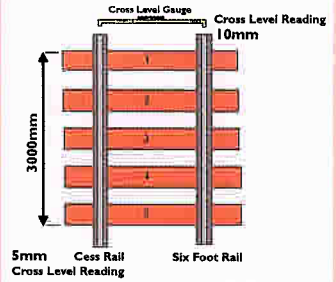
ADDITION of the two readings = 15mm

Therefore Twist

$= \frac{3000mm}{15mm}$

= 15mm in 3000mm

or 1 in 200



In Example 2.

We see the readings over our 5 sleepers (3000mm) are on opposite rails, when readings are on opposite rails the figures are added together to give the final twist reading. There is a simple way of remembering when to add or when to subtract.

OASIS

(O)PPOSITE

(A)DD

(S) AME

(I) S

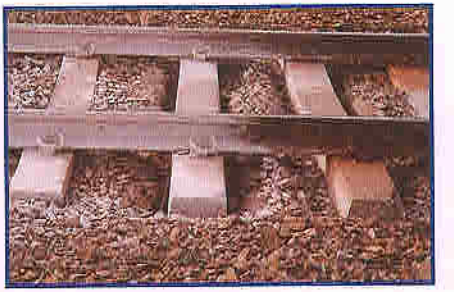
(S) UBTRACT

TWIST continued

In order to eradicate Twist we have to look at the causes and consequences. Firstly how does the process leading to Twist faults start? Looking at the first two pictures we see a typical example of subgrade erosion failure, where the subgrade is composed of fine grained material such as silt or clay and no subgrade protection layer as been installed. The action of dynamic loading (trains running over) and voids / water is evident. The pumping action leads to a slurry effect building up.

If not arrested the erosion will spread from 1 sleeper bed to another

The Wet bed has developed to a point where if the ballast was removed it could result in buckling/distortion of the track.



No Subgrade layer has been installed and conditions deteriorate

Installation of Subgrade layer

Typical area where wet beds have been allowed to develop to a stage where twist has now become a problem.

If we do not pay attention and arrest Twist, derailments become a reality.

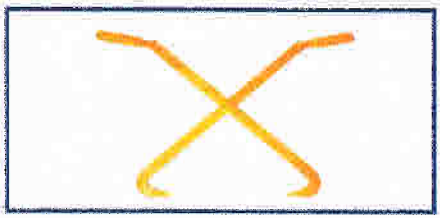
Section 5 Tools and Equipment

HAND TOOLS

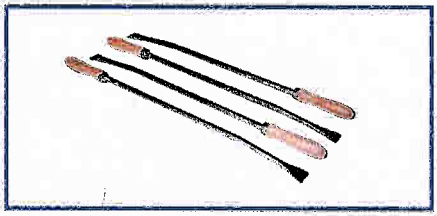
The Railway is a unique industry and the tools that we use are unique to that industry.

Pad Scraper

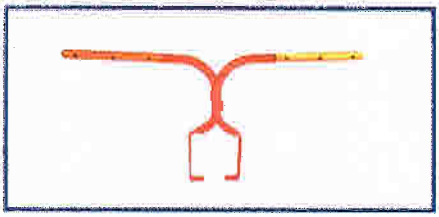
Rail Turning Bars



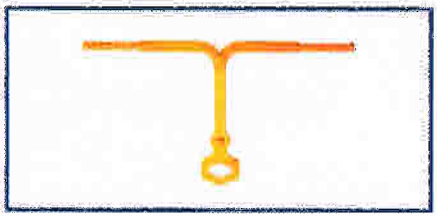
Timber Sleeper Nips



Point Scrapers



Concrete Sleeper Tongs



Rail Tongs

Pan Setter used for lifting sleepers into place.

Panpuller / Extractor used for inserting and extracting Pandrol™ clips

White ePlus Panpuller / Extractor for use with the Pandrol™ ePlus system "pulling in"

White ePlus Panpuller / Extractor for use with the Pandrol™ ePlus system "extracting"

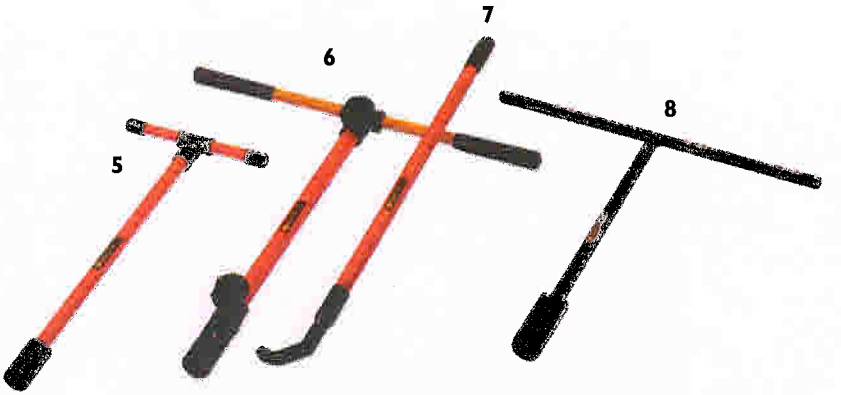
Panlock Insertion / Extraction Tool showing the four stages of insertion and extraction.

1 1st Stage insertion
2 Fully inserted
3 Positioning for extraction
4 Extracting

1. *2.4 kg Insulated keying hammer*
2. *2.7 kg Insulated keying hammer*
3. *2.7 kg Insulated sledge hammer*
4. *Ball Peen Hammer*

6. *Insulated elastic spike extractor with chisel*
7. *Insulated lifting lever for 3rd rail*

1. *Insulated heel rail bar*
2. *Non-insulated chisel and point slewing bar*
3. *Insulated ratchet rail turning bar*
4. *Insulated rail turning bar for flat bottom*

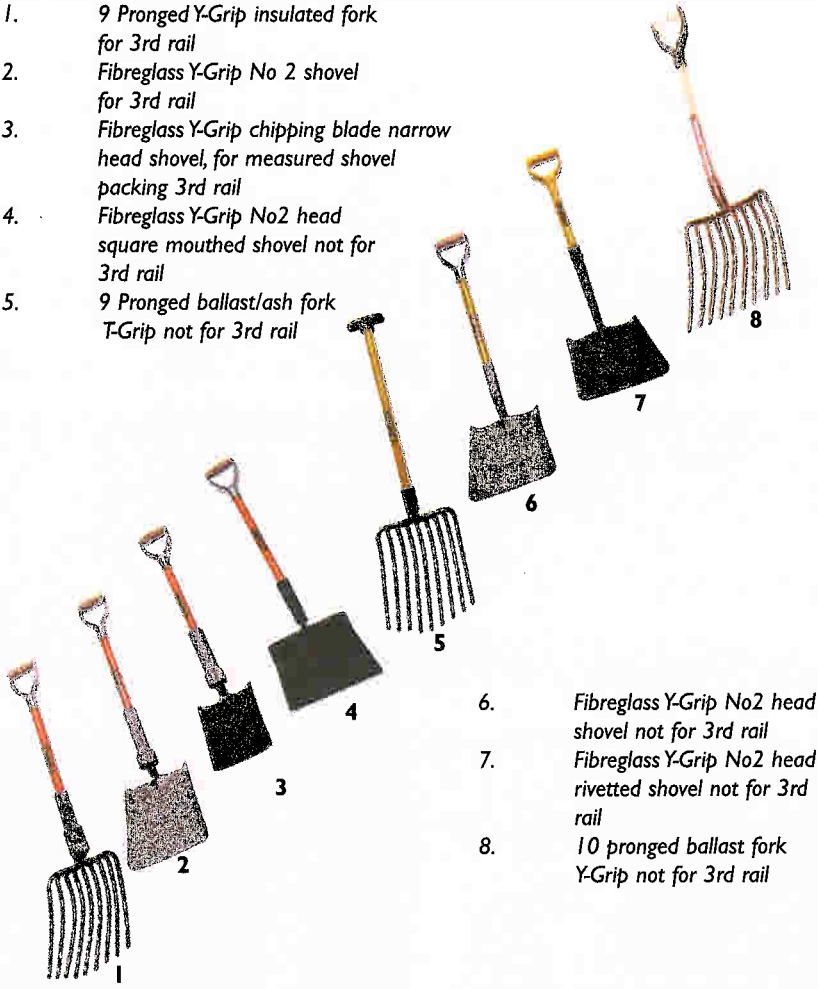


5. *Insulated box spanner for live rail pot screws*
6. *Insulated T- Spanner for head bolts (Type of coach screw that holds the third rail insulating pot to the sleeper/timber via brackets known as cleats.)*
7. *Insulated persuader arm*
8. *Non-insulated T- Spanner (for Coach Screws & KT Clips)*

1. *Insulated universal Pan puller*
2. *Insulated Pan setter*
3. *Pan lock puller for extracting pan lock Bull Head keys*

1. *Insulated open jaw fishbolt spanner for $1^{3}/_{4}$ nuts.*
2. *Fishbolt spanner open jawed non-insulated not to be used on 3rd rail for $1^{5}/_{8^{th}}$ nuts.*
3. *Open jawed fishbolt run on spanner $1^{5}/_{8^{th}}$ square nuts*
4. *Insulated check rail spanner $1^{5}/_{8^{th}}$ square nuts*
5. *Insulated multi purpose spanner for $1^{5}/_{8^{th}}$ and $1^{7}/_{8^{th}}$ square nuts*
6. *Spanapuller for $1^{5}/_{8^{th}}$ and $1^{7}/_{8^{th}}$ nuts also doubles as a Pandrol™ puller*

1. *9 Pronged Y-Grip insulated fork for 3rd rail*
2. *Fibreglass Y-Grip No 2 shovel for 3rd rail*
3. *Fibreglass Y-Grip chipping blade narrow head shovel, for measured shovel packing 3rd rail*
4. *Fibreglass Y-Grip No2 head square mouthed shovel not for 3rd rail*
5. *9 Pronged ballast/ash fork T-Grip not for 3rd rail*

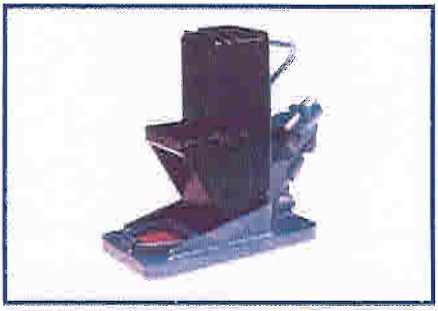


6. *Fibreglass Y-Grip No2 head shovel not for 3rd rail*
7. *Fibreglass Y-Grip No2 head rivetted shovel not for 3rd rail*
8. *10 pronged ballast fork Y-Grip not for 3rd rail*

Various types of forks and shovels used in the railway industry

TRACK JACKS

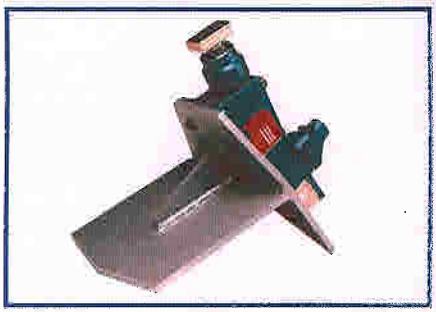
Track jacks are pieces of specialised equipment for lifting and aligning rails only. The use of track jacks is strictly controlled. They are specialised pieces of equipment. Different jacks have different functions. **Precautions** must be taken before any type of mechanical or hydraulic jack is used each day. They **must be** inspected by the user for obvious damage. Jacks found to have defects **must not** be used.
Jacks should be **inspected and certified** yearly.



Kenhi Hydraulic Toe Jack designed for use on Switches and Crossings

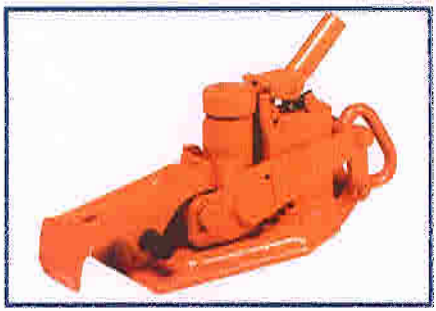
Kenhi Hydraulic Toe Jack can be used under traffic

Kenhi Hydraulic Mini Track Jack Can Be Used Under Traffic Has Overload Safety valve Fitted



Kenhi Hydraulic Track Aligner For Aligning and Slewing Track

Duff Norton Mechanical Trip Jack, for Lifting the Track Cannot be Used When Traffic is Running Mainly Used on Renewal Items



Stumec Hydraulic Track Aligner For Aligning /Slewing and Lifting Track Can be Used Under Traffic

TRACK MAINTENANCE

There are two distinct areas in railway track engineering, **MAINTENANCE** and **RENEWALS**. Everything has a life span, we as people have a life span but how we look after ourselves determines our longevity. It is the same with railways we only have to replace something if it is no longer able to perform the function it was designed for Renewals however we can extend the life span of a railway with properly applied maintenance. It should be emphasised that railway work in certain aspects when talked about in maintenance terms is a seasonal function, many of the activities we carry out can only be completed at certain times of the year. The following illustrations are of typical every day maintenance activities and the tools/components that are used.

WHEELBARROW

FIG 1.shows what looks like a typical wheelbarrow, however looking closely you will note the wheel is of the inflatable type. This allows us to move a load across the ballast freely. However it is not suitable for use on the 3rd rail system.

RAIL SKATE

Fig 2. Shows a device that can be positioned on one rail to enable small heavy items such as fishplates, bags of chippings, bags of bolts etc to be pushed to the site of work by one person. (maximum weight permitted 25kg)

RAIL TROLLEY

Fig 3. The device shown is known as a rail trolley, is more robust than the rail skate, running on both rails it allows the workers to carry larger items for example sleepers, timbers, large tools, small plant etc (only to be used with the permission of the signaller and under strict controls.)

As previously stated a lot of the work done under MAINTENANCE is seasonal. Fishplate lubrication plays an integral part in jointed track assisting in the expansion and contraction of the rails. This can be achieved in two ways, the pictures below illustrate one method, application by brush, a more modern method is to apply the lubrication by spray and backpack. This work if not completed before the on-set of hot weather can be a contributory factor in the buckling of track.

Firstly the bolts are eased off with a long handled fishbolt spanner.

Secondly a small spanner can be used to ease the fishplate off (not fully) to a position where the lubricant can be applied behind the plate.

NOTE
The fishplate has now been run off to the correct position

Now the lubricant can be applied with a long handled brush, this type of brush allows the worker to get right inside the rear of the fishplate keeping fingers clear a all times.

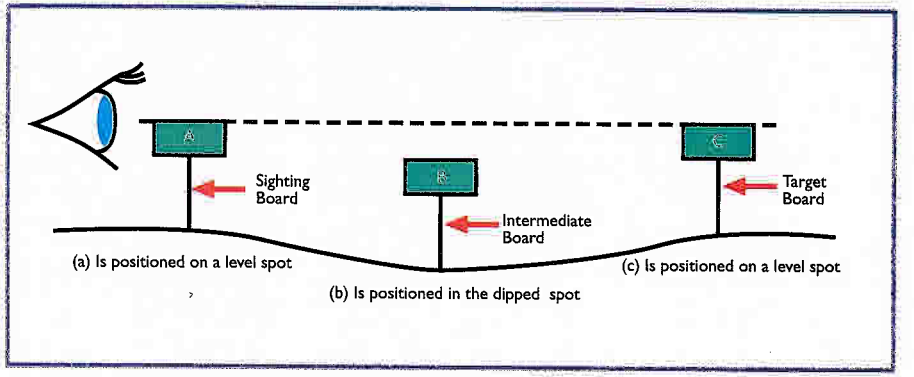
Lastly the fishplate bolts are run back up to the correct torque, the diagram illustrates the finished product.

The next sequence of diagrams relate to a specific item of work, that of measured shovel packing (MSP). Measured shovel packing calls for a variety of skills, some routine and some very specialised. The following pages of this book are designed to emphasise that working in a railway environment is all about working as a team with each person fulfilling their role. The item of work to be measured shovel packed in this instance is high speed Switch and Crossings.

LIFTING BOARDS

The above picture shows a set of lifting boards used to determine how much lift will be required on the Switches and Crossings

The boards are designed to work in the following manner. The sighting boards (a) and distant board (c) are positioned on a high spot, the intermediate board is then positioned on every fourth sleeper or less if considered necessary between (a) and (c) and adjusted up or down until all the boards are level when readings are taken from the numerical scale on the board stem as per manufacturers instructions (Abtus). The amount that (b) has to be lifted out of the dip to bring all 3 boards level is then measured. This is the amount of lift required, which is then marked on the sleeper ends. The track is lifted with track jacks to the desired height / lift and the correct amount of chippings placed under the bottom of the sleepers. The track is then lowered and traffic allowed to run over the area to BED IN the lift area. The boards are then re-positioned and using the same method we gradually work our way along the track lifting it back to its desired profile.



Before any track can be lifted it is vital that any broken or loose fastenings must be renewed /replaced to TIGHTEN DOWN the area to be lifted. It is absolutely fundamental that this is undertaken prior to undertaking the work. The whole exercise becomes useless if we do not prepare the track properly. Broken and loose fastenings are contributory reasons for top and alignment problems in the first place.

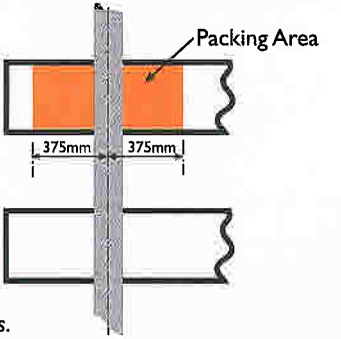
1. *The Supervisor has positioned the sighting boards and is now measuring the amount of lift required. *Note: Behind the Supervisor new screws have already been installed prior to work commencing.*

2. *In this picture you will note that readings are being taken at the intermediate board in relation to the distant board positioned behind.*

3. *The team members now remove the ballast from the area to be lifted with shovels, this process is known as OPENING OUT the beds, sometimes known as cribs or bays.*

4. *The track jacks are now positioned under the rails and the the track lifted to the desired height.*

5. *On the right the bottom of the sleepers are revealed in the open cribs/bays/beds. After the track has been lifted to the desired height exact amounts of chippings will be placed under the sleeper bottom before releasing the jacks back down.*



6. *The amount of chippings required is measured in canisters. The above picture shows a typical canister used for the measurement. One canister of chippings equates to 2mm of lift. The chippings should be spread under the sleeper, 375mm either side, measured from the centre of the rail.*

7. *The correct amount of canisters / chippings are placed on the shovel then SPREAD under the sleeper.*

8. *Shows the completed packed out area with the new chippings*

9. *The jacks are then lowered and the bays / cribs / beds are then filled or BOXED IN with clean ballast, this will hold the chippings in place.*

10. *The final stage, a train is allowed to run over the lifted piece of track*

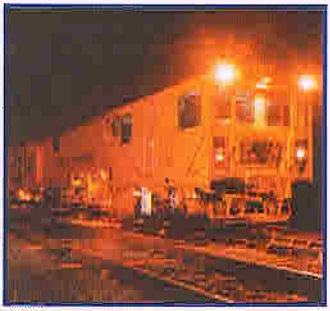
HEAVY PLANT ON-TRACK MACHINES

07-16 Series Plain Line Tamping and Lining Machine

Designed for lifting the track and packing ballast under the sleepers uniformly. The machine also corrects the alignment.

High Performance Ballast Regulator

The ballast regulator is capable of ploughing large amounts of ballast, profiling the cess, picking up ballast by brushing the four foot and the ends with rubber brushes and distributing it to areas where there are deficiencies. Used correctly a very useful item of machinery.



Rail Mounted Stoneblower

Designed for lifting the track, and packing the ballast under the sleepers by means of compressed air. An alternative to conventional tamping.

Dynamic Track Stabiliser (DTS)

This machine is used after the track has been renewed, it simulates through vibration, the action of many thousands of tons of traffic. This enables the track to stabilise very quickly.

By stabilising the track we can get traffic back to line speeds very quickly.

Twin Jib Track Layer

The twin jib track layer is self descriptive. It allows us to take out or lay track in by attaching a clamping device over the rail head and with the sleepers attached run in 60ft panels of track.

By attaching a device called a loose sleeper beam (a frame with chains attached), it can run in 60ft lengths of track minus the rails.

The picture shows a loose sleeper beam being used. A purpose made locking clip is attached to the end of each chain and inserted into the Pandrol™ housing of the sleeper.

Road Rail Vehicles Undertaking a Tandem Lift

Another alternative when taking out or putting in track, is by means of tandem lifting with 2 smaller machines.

This method is fine for small amounts of track and less costly, however for large items of work with a large amount of track to be renewed we would use the tracklayer. Tandem lifting is acceptable but not ideal and should only be used when there is no other alternative.

Excavators

After the track has been removed, the excavators get to work. The old formation or SPOIL is removed and placed into the wagons HOPPERS. It is then removed from the site and taken to a designated tip area.

Laser Levelling

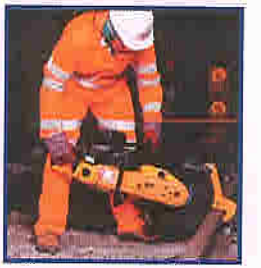
Before the new track is put in, a new formation is designed. In the picture on the left a laser levelling device has been attached to a gantry and the information regarding the new formation is entered.

The Laser Dozer

The information from the laser is transferred to the dozer (Note the 2 receivers over the dozer blade) the machine then automatically profiles the new formation.

SMALL PLANT

One of the main developments in the rail industry was the increased usage of small plant in favour of less versatile manual techniques, that had been used in the industry for a long time. The illustrations below are just some of the more familiar small plant items used on-track everyday.



Rail Mounted Disc Saw for cutting rails

Cembre Rail Drill for drilling rails

Impact Wrench
Used for removing bolts and screws from sleepers and rails can also be used for drilling holes in timber sleepers

Vibrating Whacker Plate
Used for compacting formation prior to sleeper installation

FENCING

Different types of fencing used on the rail infrastructure.

Steel Palisade

Post and Rail

Post and Wire

Temporary Fencing

TRACK VEGETATION

Vegetation is a very real problem on and off track. The presence of trees which pose a potential problem must be reported, particularly in areas where vegetation may affect signals, level crossings, foot crossings and where sighting distance could be affected.

PERNICIOUS WEEDS

There are several weed species which landowners have legal responsibilities to control. In particular one such notifiable agricultural weed is **"ragwort"** which may be poisonous when eaten by live stock, spreads by wind borne seeds and is very common on Network Rail property. Japanese Knotweed is another problem species listed as a **"controlled plant"** consequently it is an offence to plant or allow Japanese Knotweed to grow. Himalayan Balsam is also on the register. Care should be taken in disposal or re-distribution of soil containing these plants, so as not to spread them around.

Japanese Knotweed

Japanese Knotweed at various stages of growth

Blisters caused by Giant Hogweed

Ragwort

Tansy Ragwort (Senecio jacobaea) Ray flowers distinguish this plant from common tansy (Tanacetum vulgare)

Giant Hogweed at various stages of growth

Himalayan Balsam

Giant Hogweed Health Hazard

The hollow stems are attractive to children who use them as "pea shooters" and "telescopes". However, the stems and edges and undersides of the leaves bear small hairs which are coated with poisonous sap and even the slightest touch can cause painful blistering and severe irritation. This reaction can occur up to 48 hours after contact and in some cases results in recurrent dermatitis. As the hairs can penetrate light fabrics, protective clothing should be worn to safeguard against contact with the sap.

Specialist advice must be obtained and complied with when any noxious or controlled weed is found or reported.

COLD WEATHER

Track staff working in the open in cold weather conditions must be aware that the correct type of clothing and footwear should be worn. This must be flexible and permit a full range of movements to accomplish the required task, as well as keeping them warm and dry. It is far better to wear a number of thin layers rather than two thick ones, each layer traps a layer of still air and thus heat. As the body warms up a thin layer can always be removed and replaced if work stops. It must be pointed out that certain colours of clothing are not allowed when walking on or near a railway line. These are Red, Green and Yellow. From a distance these can be mistaken as a hand signal to the driver of an approaching train.

The Body or Torso

The main idea of underwear is to keep the body temperature stable, thermal underwear is ideal but a string vest, a closely fitting rugby shirt that has long sleeves with a top coat is effective for short term exposures that we normally undertake.

The Head

Up to one third of body total heat can be lost through the head. A woolly hat can help to reduce the heat loss.

The Hands

Fingers are often the first parts to go numb in cold weather conditions. Woollen or cloth gloves will help retain heat.

The Legs

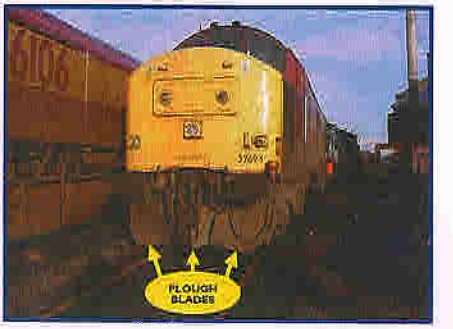
Thermal long johns will restrict the loss of heat, even a pair of tights underneath jeans or pants provide a limited amount of extra protection in cold weather. Jeans are not the best form of leg covering, they are very strong but they do absorb water in wet conditions making them heavy and increasing the cooling effect.

The Feet

Nylon and artificial fibres have little insulation value and hold perspiration, pure wool socks are recommended in addition to correct fitting safety boots with mid sole steel protector.

Cold weather can bring a railway to a halt, or certainly affect it severely. With the onset of cold weather, precautions must be taken to try to avoid the problems in areas that are at risk. Some of the more critical problems that can arise are from lifting of track in severe weather conditions especially if it is being lifted by machines. Maintenance tamping can literally move a curve downhill. Rail failures, joints, especially insulated joints (cracking), frozen ballast in the track, ice on rails and frost heave, are just some of the problems encountered.

Rail Mounted Snow Ploughs



In the above picture a track worker wearing the new type of wind proof and waterproof clothing. It allows rain to run off the outer surface but allows perspiration to move outwards.

Track workers applying anti-freezing agent, this ensures that points do not freeze and traffic is kept moving.

HOT WEATHER

The onset of hot weather brings with it the risk of track buckling. This will not be solely due to the high temperature but also at least one other defect in track conditions. Ideally all such defects should be eliminated before the hot weather season starts; if not, then the appropriate precautions must be taken to safeguard traffic. We prevent buckling in CWR (Continuous Welded Rail) by using plenty of ballast on the sleeper ends. Also in CWR, adjustment switches are installed to allow for expansion and contraction at the ends or where it abuts fixed points, such as S&C. After installation, CWR is put through a process of stressing the rail, a tensile force is introduced into the rail, this ensures the rail will expand and contract only within the parameters that we design it to. In jointed track we reduce the risk of buckling by having gaps at the rail ends to allow for expansion in hot weather and contraction in cold weather. One of the main causes of track buckles is shortage of ballast. Special attention must be given to areas of trespass unauthorised persons crossing the railway in a specific area over a period of time will lead to erosion of the ballast shoulders, in hot weather this area would then become a prime buckle site. If a rail cannot move forward it will move sideways.

In the picture above we can see the result of hot weather on incorrectly maintained track - in this case poorly installed ballasted steel sleepers.

Hot Weather Precautions:

With the on-set of hot weather track workers must take certain precautions. It is mandatory that hard hats are worn at all times when working on or near the line.

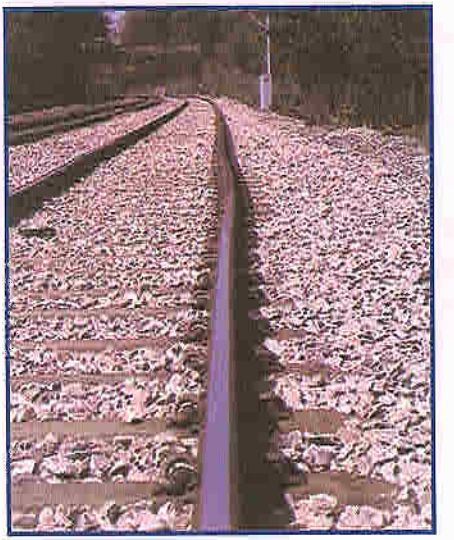
Modern protective clothing provides for track workers to be comfortable in all weather conditions. Always ensure that your face and exposed parts of the body are fully protected with a good sun block, when working in the open during hot weather.

This picture shows an expansion gap at a joint. The gap width is dependent on the ambient temperature, and therefore varies seasonally. This photo was obviously taken in cold weather. There are specific measurements to be adhered to. The table below shows the different gaps for different temperatures

EXPANSION GAP TABLE

TEMPERATURE	STATE	GAP SIZE (mm)
Below 10°C	(Cold)	10
10°C and below 24°C	(Cold to Warm)	6
24°C and below 38°C	(Warm to Hot)	3
Over 38°C	(Very Hot)	0

This picture shows a situation where the rail has actually buckled, this has become a critical situation, under these conditions all traffic must be stopped until the temperature has dropped to a point that will allow emergency work to be carried out.



Section 10 Glossary

GLOSSARY OF RAILWAY TERMS

Absolute Block
A signalling system which allows only one train to be in the Block Section at the same time

Adjustment Switch
Also known as breather switches, a device installed at the junction of CWR, jointed track and unstrengthened switches to permit longitudinal movement caused by thermal effects.

Alignment
Longitudinal direction of track either design or as a result of traffic effects.

Alumino Thermic Welding
The process of casting or welding of a joint between rails that have been prepared, on site.

Anchors
Fittings that are attached to the foot of the rail, tight against the sleeper to increase the resistance of rails to longitudinal movement (moving forwards).

Aspect
The visual indication of a colour light signal as displayed to the driver

ATWS
Automatic Track Warning System - A warning system which detects an approaching train and automatically alerts persons who are on or near the line by means of lineside or individual warning systems and is sufficiently portable to be brought to a site of work and temporarily installed for the period of the work. (Note this definition does not include TOWS see separate entry in this glossary)

Automatic Level Crossing
Includes any of the following level crossings:
Automatic half - barrier **(AHB)**
Automatic barrier crossing, locally monitored **(ABCL)**
Automatic open crossing, locally monitored **(AOCL)**
Miniature red / green warning lights **(R/G)**

Back Edge
Non-gauge face of a rail also referred to as the Outside Edge, or Field Face.

Ballast
Crushed stone, graded in size and angular of shape to support sleepers, timbers and bearers both laterally and vertically.

Ballast Cleaner
A machine for separating fines (waste product) from the ballast.

Ballast Shoulder
Ballast at the end of sleepers, timbers or bearers to give lateral stability (sideways) to the track.

Ballast Train
Engineers train used for the transporting large amounts of ballast to renewal sites.

Barrow Crossing
A crossing (often at the end of a platform) for use by railway employees. Protection, if provided, is by means of a steady white light and the crossing should not be used if the light is unlit.

Baseplate
Supporting device for flat bottom rail, fastened to the sleeper or timber and forms part of the track fastening system.

Baseplate Pad
A piece of resilient material placed between a baseplate and the supporting sleeper, timber or bearer.

Bearer
Wooden or Concrete supports for Switches and Crossings.

Bed, Bay or Crib
Space between adjacent sleepers or timbers.

BH (or RBS BH)
Bull Head section rail

Bi-Directional Line
A line on which the signalling allows for trains running in both directions

Bond Wire
Connection between two rails to provide electrical continuity (Track Circuitry)

Boxing In
Filling of the sleeper spaces (bed, bay or crib) with ballast and the reforming of the ballast shoulder(s) on a piece of track or tracks.

Braking Distance
The distance a train needs in which to stop or to reduce speed, from travelling at a given speed to a given lower speed.

Buckle
A heat induced misalignment usually at a place on the track where there are irregularities:
Ballast shortage
Rail creep/tight joints/inadequate fastenings
Unstressed CWR

Cant (or Super elevation)
The amount by which one rail; usually the outside rail of a curved track, rises above the lower rail on the same piece of track. (See gauge/cross level)

Catch Pit
A covered chamber constructed of either pre- cast concrete, brickwork, plastic, glass reinforced plastic, rock or timber built into a track drain to provide access for maintenance to trap waste products and for the removal of silt.

Catch Points
Points provided for derailing a vehicle(s) running back on a gradient in the wrong direction. These points may be **unworked** if trains normally pass over the points in one direction only

Cess
Narrow strip of ground between the ballast shoulder and the adjacent natural ground, cutting slope or structure.

Chair
Supporting device for bull head rail that is fastened to the sleeper/timber and forms part of the track fastening.

Chair Pad
A piece of resilient material placed between the chair and supporting sleeper/timber.

Check Rail
A rail fitted on the inside of either or both running rails and to the running rails opposite crossing noses and knuckles at a distance known as the flangeway. The function of a checkrail is to provide guidance to one or both wheels of a wheel set.

Conductor Rail
A rail through which electricity is supplied to electric powered trains.

C.O.S.S.
Controller-Of-Site-Safety, person responsible for setting up a safe system of work prior to commencement, and maintaining it throughout the work.

Creep
Longitudinal movement (forward or backward) of rails because the fastenings or ballast conditions are deficient.

Crossing
A component of the permanent way, which is required when a running rail of one route crosses the running rail of another route.

Cross Level
1. Difference in rail levels measured at right angles to the centre line of the track.
2. An instrument for measuring the difference in rail levels as above, and sometimes referred to as a cross level transfer gauge, cant stick, cant gauge or cross level gauge.

CWR
Continuous Welded Rail formed by welding together rails to form a rail of any length greater than 36.5metres.

Cyclic Defects
Defects in the top, alignment or rail side wear which occurs at regular intervals along the track affecting one or both rails.

Detonator
A small disc-shaped warning device, designed to be placed on the rail head for protection and emergency purposes, which explodes when a train passes over it.

DTS
Dynamic Track Stabiliser, a self propelled on-track machine that is used for the inducement of settlement into re-ballasted or recently tamped track to improve the lateral resistance. One pass of a DTS equates to approximately 100,000 tons of rail traffic passing over the track.

Electrified Line
A line which is electrified either by 25,000 volt AC overhead lines or by 750 volt DC conductor rail(s).

Emergency Clamped Fishplates
Specially forged fishplates held together with G – Clamps, which can be applied to a rail at a defect to hold the rails to line and level. Will also fit around all types of track weld.

End Post
A pre-fabricated piece of non-conducting material, corresponding to the rail section, which acts as an insulator between two rails at an insulated rail joint.

Engineering Supervisor
The Person supervising engineering activities at a site of work on a track or tracks normally within marker boards and under the overall control of a PICOP (Person In Charge of the Possession) unless he/she is also the PICOP.

Engineers Train
Includes an on-track machine.

EWI
Emergency Warning Indicator. Known as an EROS board or metal Mickey.

Facing Crossing
A crossing installed such that trains normally travel from the wing rail fronts towards the crossing vee.

Facing Lead or Turnout
A turnout installed such that trains normally travel from the switches towards the common crossing.

Facing Point Lock
Equipment that physically locks the points so that they cannot move.

Facing Switch
A set of switches installed that trains normally travel from the switch toe towards the switch heel.

Fastening
A device for securing a rail either directly to a sleeper, timber or other type of support or to a chair or baseplate that is then fastened to the sleeper, timber or other support.

FB
Flat bottom rail section.

Fettling
Repairs to the track that may include localised lifting/lining, tightening of fasteners, boxing in and regulating ballast.

Fishing Surface
Contact surface between rail and fishplate.

Fishplate
A pre-fabricated length of rolled machined or drop forged steel or prepared timber. Used in pairs to connect rails together.

Flash Butt Weld
Weld between abutting rail ends made by the electric flash welding process usually at a rail welding depot.

FLAWS
A computer database of rail flaws reported by ultrasonic rail flaw operators or analysis of ultrasonic test train recordings.

Fourfoot
Space between the running rails of one track.

Gall
The wearing away and indentation of the rail foot where it is in contact with chair or baseplate.

Gauge
Specified distance between the rails of a railway track 1432mm or 1435mm dependent on the type of arrangement.

Gauge Face
The inside edge of rail from which the gauge is measured (also referred to as the running edge).

Gauge Stops
Metal plate fixed to the upper surface of a sleeper or timber against a chair or baseplate to resist gauge spread.

Goods Line
A line which has not been signalled to the standard required for running passenger trains.

Green Zone
A method designed to protect staff working On or Near the Line by the stoppage of trains.

Ground Frame
A control point containing levers or switches to permit the local operation of points in running lines and sidings, and where provided, the associated signals. This local operation is only possible when a release is given by the controlling signal box. Also includes a ground switch panel.

Hand Points
Points which are worked manually by an independent lever.

High Rail
Outer or highest rail of a curved track.

Insulator
A piece of preformed non-conductive material used to insulate the track fastenings from the rails.

Interval / Wide way
Space between 2 adjacent tracks, i.e. six feet, ten feet etc.

IRJ, IBJ, Block Joint
Insulated rail joint/insulated block joint. Provides a break in the electrical continuity of the rail for signalling purposes

IWA
Individual Working Alone. For the purpose of patrolling and inspecting the track.

Joints
1. Ordinary
Non-insulated connection of two rails by means of a fishplate and bolts, leaving an expansion gap.

2. Tight
Non-insulated connection of two rails by means of fishplates and bolts but without an expansion gap.

3. Insulated
The connection of two rails by means of fishplates that are insulated from the rail steel and bolts by non-conducting medium. (see IRJ)

Joint Sleepers
The sleepers either side of bolted, MGL pinned or welded joint.

Junction Fishplates
Fishplates used to connect rails of different sections eg. Bull head to Flat bottom.

Junction Lift Plates
Fishplates used to connect together rails of different sections where there is also a difference in the headwear.

Junction Signal
A signal that controls more than one running route and can display an indication of route.

Key
A specially shaped piece of timber or steel that is used to hold Bull Head rails securely in the supporting chair.

Knuckle
The point in front of an S&C nose where the Switch Rails converge to join the Wing Rails.

Level Crossing
A device to permit the easy passage of a road vehicle across a railway at the same level as the railway.

Lift (Fish) Plate
Fishplates used to connect rails of the same section eg. flat bottom to flat bottom but of different depths.

Line
Alignment of a track or rail.

Local Manager
Where authorised, includes a person who is a Supervisor and has been passed as competent in the appropriate Rules and Regulations.

Long Welded Rail
Rails welded together to a minimum of 36 metres and usually 200 metres in length.

Longitudinal Levels
General track gradient.

Longitudinal Timbers (Way beams)
Timber bearers for the running rail. The rails are carried in chairs and baseplates fixed to the upper surface. The timbers run parallel to the rails (unlike sleepers, which lie at right angles).

Lookout
Person appointed by the C.O.S.S. to advanced warning of approaching trains on lines open to traffic in a Red Zone. The person who is appointed lookout must have no other duties and not take part in the work.

Low Rail
The inner rail of a curved track

Main Aspect
The red, yellow, double yellow, flashing yellow, double flashing yellow or green aspect of a colour light signal.

Manned Level Crossing
Is any crossing that is manned.

Mechanical Points
Points which are mechanically operated **without** any form of power operation.

No Block Line
A line on which there is no monitoring of the condition of the block section by the signaller.

Nose
The inner (pointed) end of the vee of a common crossing.

OLE
Overhead Line Equipment fitted to an electrified railway, electrified at 25,000 volts AC.

On or Near the Line
Within 10' of the nearest running rail.

Opening Out
The process of removing ballast from the inter-sleeper spaces (beds, cribs, bays) and from the ballast shoulder usually to the level of the underside of the sleepers. (Opposite to boxing in).

Outside Edge
Non-gauge face or back edge of the rail. (Non-running edge). Also known as Field Face.

Over Bridge
A bridge over the railway.

Overhead Line Equipment
The equipment suspended over the railway line for supplying electricity to electric trains, and includes the overhead wires, insulators and any associated equipment.

Packing Area
That part of a sleeper, timber or bearer that should be supported by the ballast. The area is 375mm either side of the centre line of the rail for plain line sleepers this varies for S&C timbers and bearers and is dependant on the number of rails supported.

Pad

1.Railpad
A piece of non-conducting resilient material placed between the rail and baseplate, concrete or steel sleeper or bearer. The functions of a rail pad are to:

(a) Cushion the impact loading on the baseplate, sleeper or bearer.
(b) Provide electrical insulation.

2. Baseplate or Chair Pad
A piece of non-conducting resilient material placed between the rail and baseplate or chair and the sleeper or bearer to cushion the impact loading.

Permissible Speed
The maximum permitted speed as shown in the sectional appendix.

Person Operating Signalling Equipment
Signaller, Signalman, Signalwoman, Signal Person, Signal Operative.

PICOP
Person in Charge of the Possession, a person responsible for controlling a train movement in an engineers absolute possession of the line (See Tiii).

Pilotman
A person who has been appointed to manage the passage of trains over a single line during a failure of equipment, or repairs or due to an obstruction.

Point Rail
The rail that is machined to form the nose of a common crossing, the common crossing point rail is machined to form a splice into which the splice rail is fitted. Point and splice rails fitted together form the vee of a crossing.

Points Run Through
A movement which runs through a trailing set of points which are not set in the correct position for the movement.

Power Operated Points
Points which are operated by means other than manually.

Protection
Means of ensuring that a line is protected and includes signals maintained at Danger, placing detonators on the line, use of a track circuit operating clip and displaying a hand Danger signal.

Protection Controller (PC)
Person responsible for controlling one or more C.O.S.S. in a Tii.

Pumping
The vertical movement of sleeper, timbers or bearers caused by traffic depressing the track supports into voids caused by incorrect packing and/or ballast attrition. It causes the movement of water in wet ballast leading to pumping of fine material through the ballast.

PW
Parallel Wing (rail)
Permanent Way

Rail Anchor
Device, fitted to foot of a rail to prevent rail creep.

Rail Seat
The area of a chair, baseplate, sleeper, timber or bearer that directly supports a rail.

Red Zone
A method designed to protect staff working On or Near the Line when lines are open to movement. A C.O.S.S. is required to set up a safe system of work and one or more Lookouts appointed.

Running Edge
The area of contact with the wheel flange.

Running Line
A line as shown in table A of the Sectional Appendix.

S&C
Switches and Crossings

Scotch or Plug
A piece of wood designed to fit between either the stock rail and switch rail of a half set of switches, or between the wing rail and switch rail of a switch diamond, to keep the switch rail in the open position.

Sectional Appendix
A reference document used for determining line speeds and direction of traffic.

Section Signal
A stop signal which controls the entrance to a block section or intermediate block section ahead.

Senior PICOP
A person responsible for the controlling of one or more trains in an engineers absolute possession of the line (See Tiii).

Shimming
The positioning of metal inserts (various sizes) behind the fishplate to compensate for wear in the railhead at the joint.

Shovel Packing
Packing sleepers, timbers or bearers with full size ballast using a shovel.

Shovel Packing (Measured) MSP
Packing sleepers, timbers or bearers with measured quantities of granite chippings using a cant gauge, sighting boards or an optic, to permit careful calculations of the lifts.
1 canister of chippings equal to 2mm of lift when spread evenly over the packing area.

Shuffle
Alternate outward (under traffic) and inward (unloaded) movement of a chair or baseplate leading to indentation of the supporting timber or sleeper.

Side Wear/Side Cut
Wear of the running face of a rail caused by the wearing effect of wheels. This phenomenon is usually associated with curved track.

Signal Box
A signal box which is open.

Signal Post Replacement Key
The key used to operate a signal post replacement switch.

Signal Post Replacement Switch
A switch on the post of an automatic or semi-automatic colour light signal which can be operated by a key in order to turn it to, and maintain it at, Danger.

Single Line
The only line available that can be used by movements in both directions.

Six Foot
The area separating two lines

Sleepers
Softwood, hardwood, concrete or steel beams that provide vertical and lateral support and gauge retention to plain line i.e. line without switches and crossings.

Slide Baseplate
Baseplate for FB rail having a horizontal flat surface upon which an FB switch rail can be moved laterally.

Slide Chair
Chair for BH rail having a horizontal flat portion upon which a BH switch rail can be moved laterally.

Slide Table
Horizontal flat portion of a slide chair or slide baseplate.

Slip
1. Movement of a cutting or embankment slope.
2. Diamond crossing fitted with slip switches to provide additional directional facilities.

Slurried Ballast
Ballast contaminated by fine particles of sand, ballast, silt or clay suspended in water.

Sole Plate
Metal plate beneath both the running rail slide chairs and baseplate at the switch toe, to provide additional gauge restraint.

Spalling
Breaking away of material, usually under conditions of high loads. This term is used to describe the breaking away of concrete around the fastenings of concrete sleepers or bearers as a result of high lateral loads.

Spent Ballast
Ballast no longer useful for the support of a railway track by virtue of shape, size or because of material type and/or contamination.

Splice Rail
A machined rail that fits into the splice machined into the point rail of a common crossing.

Spoil
Excavated material e.g. spent ballast, clay, sand soil and rock.

Square
At right angles to the centre line of a track or to the centre line of a diamond crossing.

Station
Terminal, depot, yard or halt.

Stock Rail
Fixed rail of a switch half set.

Stop Signal
Any main signal which can display a stop aspect or indication.

Stress Transfer Blocks
Cast iron or steel distance blocks fitted at the heel ends of strengthened switches and to strengthened switch diamonds to transfer thermal stresses from one rail to another.

Stretcher Bar
Connection between the two switch rails of a set of switches or between pairs of switch rails of a switch diamond to maintain a designed relationship between the two rails.

String
A number of rails welded together to form a longer length of rail for site welding.

Super Elevation
See "cant"

Swing Nose Crossing
A common crossing having a "switchable nose".

Switch
A device for diverting a rail vehicle or train from one track to another track.

Switch Rail
Moveable rail of a switch that registers with the stock rail.

Tail Lamp
An illuminated built-in or portable red light or blind at the rear of a rail vehicle.

Tee Piece
See "end post".

Ten Foot
The area separating three or more lines

Throughbolt
A fastening for a chair, baseplate or the rail foot extension of a BH common crossing which consists of a bolt passing through the component and the timber, sleeper or bearer.

Through Timbers
S&C timbers supporting more than one track. Also known as tied timbers.

TIC
Track Inspection Coach.

Tii
A method of arranging for the stoppage of trains on one or more lines i.e. Green Zone working, for minor engineering work working under the control of a C.O.S.S. (Controller-Of-Site-Safety).

Tiii
Suspension of normal train running by the engineer (absolute possession of the line), to allow engineering work to be undertaken. Not to be considered a Green Zone when there are engineers trains present.

Timbers
Soft wood or hard wood beams that provide vertical and lateral support and gauge restraint to switches, crossings and adjustment switches.

Token
An implement given by a Signaller and held in the possession of a Senior PICOP, PICOP, Protection Controller when the engineer has been granted absolute possession of a single line in the form of a token, staff or tablet

Top
Longitudinal level of the track over a short distance.

TOWS
Train Operated Warning System - Audible warning system provided at locations listed in the Sectional Appendix which when switched on is used to warn persons on or near the line of an approaching train. (Note this definition does not include ATWS see separate entry in this glossary).

Track Category
Description of a track, in terms of line speed and tonnage.

Track Circuit
Part of the signalling system. Line fitted with track circuits are divided into separate section by insulated joints and as the train wheel sets complete the circuit between the rails. Interlocking the switches and signals so that conflicting routes cannot be set up and, on multisignalled lines, each signal immediately behind the train is set at danger.

Track Circuit Actuator
Equipment provided on certain trains to improve the operation of track circuits.

Track Circuit Block
A method of signalling trains in a section of line where safety is ensured by the use of track circuits or other means of automatic train absence detection and without the use of block instruments.

Track Circuit Operating Clip
A device which can be used in an emergency to place on top of each running rail so as to operate the track circuit and so provide a means of protection of an obstruction.

Track Circuit Operating Device (T-COD)
A special device which can be placed on the line to provide protection by operating the track circuit (Rule Book Section T. (Part ii)applies).

TRC
Track Recording Coach. A track geometry-recording vehicle.

Train
Light locomotive, self propelled rail vehicle or road/rail vehicle operating in rail mode.

Train Operator
The company responsible for the operation of a train.

Train Register
Any written record used by the Signaller for recording train times and exceptional circumstances.

Trap Points
Facing points provided at an exit from a siding or converging route used to derail an unauthorised movement, so protecting the adjacent line.

TRU
A track recording unit. A track geometry-recording vehicle.

Tunnel
A continuous over line structure more than 50 metres long.

Twist
A defect in the track top where there is a difference in cross levels over a short distance which may cause one or more wheels of a vehicle to lose contact with the running surface of a rail.

Twist Rail
A length of rail having a workshop produced twist built into the rail to run out the vertical attitude of a running rail in vertical S&C to the normal 1 in 20 inclination of plain line rail.

Under Bridge
A bridge under the railway.

Unworked Points
Points which are not operated from a signal box or ground frame.

URFDO
Ultrasonic rail flaw detector operator. A member of staff who uses a portable rail flaw detector to examine for rail defects.

Vertical Design S&C
Rails are vertical throughout the S&C units.

Versine
The offset to the circumference at the centre of a chord of a circle measured at right angles to the chord.

Voids
Spaces under sleepers or S&C timbers or bearers, especially in the packing area, where the ballast is not tightly packed to the underside of sleepers, timbers or bearers.

Worked Points
Points which are operated from a signal box or ground frame.

Wet Spot (Slurry Spot)
An area of slurried ballast in the track.