

Track Handbook I

G3201

Maintaining plain line track

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1 Purpose

The purpose of this handbook is to offer advice on the maintenance of plain line components and geometry. It is intended to assist managers in their day-to-day decisions. The aim is to ensure that plain line track meets the requirements of track standards and fulfils the corporate objectives of improved safety, quality and asset performance.

2 Scope

This handbook covers the preparatory stages of identifying and planning maintenance work (section 4), the necessary safety and protection measures for work on and about the track (section 5) which complement the content of Track Handbook 16 *Managing track safety*, and the detailed maintenance of plain line components and geometry (section 6 onwards).

The activities relating to track renewals are covered in Track Handbook 2 *Renewing track*, operational boundary fencing, vegetation control and problems associated with cutting and embankment stabilisation are included in Track Handbook 5 *Maintaining the track environment* and structure clearances are included in Track Handbook 14 *Understanding track design*. Resource management is addressed in Track Handbook 21 *Planning maintenance resources*.

3 Introduction

This handbook is one of a series intended to help those responsible for managing the track asset achieve standards and meet LU corporate objectives.

Ballasted track accounts for approximately 70% of the LU plain line network. Concreted track accounts for the remainder, the majority being in tube sections. There are, however, a number of concreted locations in open and sub-surface sections, and depot pit roads, acid and wash roads are concreted.

Plain line track is exposed to a variety of conditions which can impair its quality, for example wet spots, poor top, bad alignment, and (in tube sections) sleeper and pitblock shrinkage, and increase the risk of loss, for example broken rail, track buckle, derailment. The handbook focuses strongly on maintenance of the track support structure, i.e. rails and rail joints, rail supports and fastenings, sleepers, ballast and the formation and drainage.

Maintenance includes preventative activities, which are proactive and seek to stop component failures and excessive wear and tear through a planned sequence of work; and corrective maintenance, which is reactive and responds to asset condition problems as and when they arise. The scope of the maintenance tasks involved extends from the fettling of track to correcting its geometry and adjusting components to the spot renewal of life-expired components.

This handbook offers:

- ◆ practical advice on track activities
- ◆ guidance on choices and alternatives
- ◆ 'do's and don'ts' for use on site
- ◆ technical data and illustrations
- ◆ material to use in staff training.

Before you first use this handbook, you should familiarise yourself with its contents. The subject headings are set out in the Contents list.

You will find in this handbook notes and comments based on the day-to-day experience of staff, outlining methods they have found successful in particular conditions as well as points not to be overlooked in carrying out the work.

At the end of each section there is a list of sources of further information. **In the event of any conflict between this handbook and LU standards, the latter shall prevail.**

4 Identifying and planning maintenance work

4.1 Identifying maintenance work

4.1.1 Inspection

4.1.1.1 Introduction

The information needed to identify maintenance requirements will come largely from inspection reports, data from a track recording vehicle and reports on failures and delays. So far as practicable, this information needs to be expressed quantitatively, whether in the form of discrete measurements of defects (e.g. the dimensions of rail head wear, the extent of chair gall or irregular cross-level) or quality indices derived from the analysis of a range of conditions. The resulting information needs to be logged in a track condition database, maintained by the responsible line managers.

Track quality describes the state of adjustment of the running rail geometry, the condition of the running rail head and the positional adjustment of the conductor rails.

The established means of identifying track quality are by discrete measurements and statistical measurements. One final consideration when identifying work is the different rates of component wear and tear.

4.1.1.2 Discrete measurements

Discrete measurements are used to identify actual or developing faults which require corrective action and may be potentially damaging to the track or trains, for example rail head wear, track twist, errors in top or alignment, and reduced clearances.

Discrete faults are measured by either dynamic or manual inspection.

4.1.1.3 Statistical measurements

Statistical measurements (Quality Index) identify track conditions which will adversely effect ride quality and/or cause unacceptable cumulative damage to rolling stock. These measurements take account of the magnitude and population of defects which are particularly important when assessing the overall roughness of the track.

The statistical measurement of track quality is a dynamic inspection.

4.1.1.4 Dynamic inspection

Specialist dynamic track inspections, using a track recording vehicle, identify parameter defects and the likelihood of vehicle derailments by simulating track behaviour under the passage of normal traffic. The role of track recording vehicles in the track inspection process is described in Track Handbook 10 *Inspecting the track*.

The data recorded by track recording vehicles are used to produce on-line and off-line reports.

4.1.1.5 On-line reports

These reports are generated in real time or straight after a recording run and consist of:

- ◆ an analogue chart giving a visual representation of track geometry
- ◆ a report of Level 1 (Maintenance Target (MT)) exceedences, which are conditions that fall below corporate targets for track quality
- ◆ a report of Level 2 (Maintenance Limit (ML)) exceedences, which represent defects that call for priority maintenance intervention
- ◆ the Level 2 (ML) reports are used to extract a report of Level 3 (Safety Standard (SS)) exceedences which represent defects that call for priority maintenance intervention.

4.1.1.6 Off-line reports

These reports contain analyses of the recorded data and are presented normally in the form of:

- ◆ colour bar chart trend plots
- ◆ quality index trend reports
- ◆ route plots of standard deviations
- ◆ sorted kilometreage summaries by route
- ◆ sorted kilometreage summaries by work package
- ◆ sorted kilometreage summaries by position.

Copies of off-line reports requested by Track Managers are made available within 10 working days of the inspection run.

4.1.1.7 Exceedence levels

The measurements taken by track recording vehicles are classified in three levels of exceedence. S1622 *Glossary of terms* describes them as:

Maintenance Target (MT)

“an occurrence in excess of a set value in any parameter which indicates an isolated feature in the track to which attention needs to be given but below a Level 2 exceedence. The set value is not a safety level and immediate action to remedy the defect may not be necessary”

Maintenance Limit (ML)

“an occurrence in excess of a value in a parameter which indicates a defect which should be considered to be serious. These are individual faults which have mandatory inspection and correction requirements”

Safety Standard (SS)

“an occurrence in excess of the Safety Standard in any parameter which indicates a defect which must be considered serious. Exceedences of the Safety Standard compromises the safety and increases the probability of a faulty vehicle becoming derailed or damage being caused to the track. If necessary an Emergency Speed Restriction may be required until the track fault is rectified”.

4.1.1.8 Quality index

Statistical measurements are described as the Quality Index.

S1622 *Glossary of terms* describes the Quality Index as:

“track quality measured by the track recording vehicle expressed as a standard deviation over 100m of track or the average of those standard deviations over a number of 100m sections”.

A standard deviation (SD) is a measure of the spread or scatter of a series of individual values about their mean. Each 100m of track has its standard deviation evaluated every track recording vehicle run for each of the following parameters: dynamic, cross-level, alignment, right-hand top and left hand top.

The lower the standard deviation the better the track. Thus, a section of track with a Quality Index of 1.0 is described as good, where the Quality Index is between 2.5 and 3.5 the track is average and if the Quality Index is greater than 5.0 the track is poor. Certain specific sites may have a localised problem, for example wet spots, which will increase the Quality Index for that 100m section of track.

Section Track Managers need to ensure that:

- ◆ only 10% of the track exceeds the Maintenance Target (MT) values
- ◆ no track exceeds the Maintenance Limit (ML) values
- ◆ if any track deteriorates to the Safety Standard (SS) values, remedial work is undertaken immediately.

Track maintenance needs to be planned before the Maintenance Limit (ML) is reached. Since each section of line has different deterioration rates, it is essential that consideration is given to optimise resources and maintain some sections slightly earlier.



Use track recording vehicle data to compare the results of runs for an indication of trends.

Table 1 gives the Quality Index standard deviation values (copied from S1159).

For the track construction and replacement Quality Index refer to S1159.

Table 1: Quality Index (standard deviations)				
TrackCategory	Parameter	Maintenance Target	Maintenance Limit	Safety Standard
		MT	ML	SS
All	Dynamic cross-level	2.8	4.5	6.0
	Lateral alignment	3.6	4.6	7.0
	Vertical alignment	3.9	5.0	6.5
	2m Twist	4.2	5.0	5.8

Defects need to be rectified within the timescale described in table 2. Where the 2m twist value is at SS, Section Track Managers need to consider a temporary speed restriction and if twist is over 25mm, impose a 10 mph emergency speed restriction.

Table 2: Quality Index (minimum action)		
Parameter	Minimum action (copied from S1159)	
	Item already identified and monitored	New item identified
All	For an exceedance of one or more of the defined parameters at "ML" level: <u>At 4-weekly intervals, or the recording interval if greater:</u> - Check the individual exceedance reports to identify exceedances within the 100m cell; - Identify any combinations of exceedances that act together to increase risk of derailment; - Review Trace (and, if available, Video) records for the 100m cell concerned to determine whether a condition-based or precautionary TSR is required; - Inspect on site; - Check deterioration rate. Taking account of deterioration rate, plan remedial works and other actions to prevent breach of the SS threshold.	For an exceedance of one or more of the defined parameters at "ML" level: - Check the individual exceedance reports to identify exceedances within the 100m cell; - Identify any combinations of exceedances that act together to increase risk of derailment; - Review Trace (and, if available, Video) records for the 100m cell concerned to determine whether a condition-based or precautionary TSR is required; - Inspect on site within 7 days; - Check deterioration rate. Taking account of deterioration rate, plan remedial works and other actions to prevent breach of the SS threshold.

4.1.1.9 Manual inspection

Manual inspection is a key part of preventative maintenance which helps to identify component defects. The process (covered in Track Handbook 10) provides an early warning about visible defects in track components, adjacent features and any sub-standard conditions.

Manual specialist track inspections assess the effectiveness of track maintenance by Trackmarking which also identifies discreet safety-critical defects, "bads", the proper and safe execution of trackwork and its satisfactory completion being assessed under the acceptance of trackwork .

Depending on the type of track and the site conditions, the 'lead time' for undertaking maintenance work will vary greatly. Since these conditions are mostly governed by material availability and other work loads, you need to take account of this when planning any work. The key actions to be taken, according to exceedance level, are shown in table 3.

Table 3: Identifying maintenance work

Component condition	Action
within the Maintenance Target	monitor deterioration
approaching the Maintenance Limit	prioritise with low priority depending on condition and plan work
beyond Maintenance Limit	undertake corrective maintenance work
Safety standard exceeded	immediate action as described in S1159 or 1-164

4.1.2 Component wear and tear

The use of different materials and the forces the components are subjected to, create different component lifespans. Depending on their usage, similar components have different lifespans; the location of a component will affect its working life and may also determine the criticality of the component to the track section. Therefore, it is essential to determine a maintenance profile for both the component and the section of track, for example rails may require replacement before sleepers while castings may still be serviceable at the time of an entire renewal.

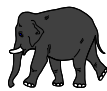
In general, maintenance profiles are established from historical data and, if such data is not available, it can take a considerable time to build up, ranging from a matter of months if the data is readily available, to several years if nothing exists. Track inspection helps to build up and maintain the track profile database.

Effective maintenance can be achieved only when an understanding exists of the various component requirements for a section of track.



If the condition of the track components is poor, Section Track Managers need to avoid 'pumping' money, resources and time into these sections to achieve a good Quality Index.

Instead, these sections need to be proposed for renewal and 'kept going' until renewed (see Track Handbook 22 *Developing proposals for the track renewal programme*).



REMEMBER!

- ◆ The track asset database being an essential part of the record system, focuses attention on specific problems, enabling Section Track Managers to address track maintenance in a more cost effective manner.

4.1.3 Siding maintenance

The type of track used in depots and sidings is mainly bullhead rail with ash ballast, except for pit roads, wash roads, aprons and acid roads which are concreted. The type of track used in tube sidings is mainly bullhead rail on longitudinal timbers. The level of track quality required in sidings and depots is usually lower than that for running lines but it is still necessary to plan siding maintenance when required. Refer to S1159 for maintenance intervention levels.

4.2 Planning maintenance work



Effective track maintenance may be defined as maintenance that provides the longest lasting improvements for the least cost, effort and interruption to traffic (see Track Handbook 19 *Managing the critical aspects of track*).

The benefits to be gained from planning maintenance work are cost savings, improved use of resources including staff, plant, materials, engineer's trains and a reduction in the number of job clashes.

4.2.1 Types of maintenance work

Maintenance work falls into two categories, **preventative** and **corrective**. In the former, the objective is to prevent asset failure or deterioration and this is undertaken through a formal system of planned maintenance activities. The objective of the latter is rectifying faults or repairing damage and is undertaken as and when necessary.

Preventative maintenance work is planned. It may be determined by legislation, experience, or be calendar-driven, and covers:

- ◆ cyclic routine maintenance tasks which are undertaken on a regular basis and include such things as mechanised tamping and lining, point oiling, picking up litter, and lubricator, rail joint, drainage and train arrestor maintenance
- ◆ seasonal maintenance tasks such as reballasting, regulating short rails, restressing long welded rail sites, adjustment and expansion switch maintenance, fishplate lubrication and rail end examination, right of way maintenance, off-track maintenance, leaf clearance and adverse weather precautions.

Corrective maintenance work is, by its nature, unplanned and is identified from customers' and drivers' reports, patrolling, Section Track Managers' inspections, track recording vehicle or ultrasonic inspections and can be:

- ◆ driven by asset condition consisting of reballasting and drainage refurbishment, resleepering, longitudinal timber maintenance, rerailing, rail joint maintenance, rail lubricator maintenance, lifting and packing, mechanised on-track tamping and lining and hand-held mechanised stoneblowing and conductor rail maintenance
- ◆ non-cyclic and ad hoc repairs involving emergency maintenance to rails or fishplates, including weld repairs to wheelburns, rail joint straightening, lineside drainage repairs and wet spot treatment.

Having identified the work activity required, it is essential to allocate a priority to all jobs before adding to the programme. When planning maintenance work, spread it over the year, taking account of type of maintenance work and any seasonal maintenance that may be required. By examining the sites, type of work and their priorities you can plan the work and optimise on the resources for each job.

It is also a good idea to leave spaces in the programme for unforeseen work, uncompleted works and any ad hoc maintenance activities.

4.2.2 Work activities

The main activities covering plain line track maintenance work are described as:

- ◆ fettling
- ◆ comprehensive fettling
- ◆ minor replacement
- ◆ spot replacement of larger components
- ◆ mechanised maintenance.

These are further detailed as follows.

4.2.2.1 Fettling

The generic term 'fettling' is the continual process of correcting the track geometry and restoring it to within the tolerances defined in the standards. Fettling consists of many operations including:

- ◆ slewing
- ◆ lifting and packing
- ◆ renewing defective components
- ◆ replacing and tightening fishbolts
- ◆ regauging track
- ◆ regauging conductor rail.



It is essential that fettling work is kept up-to-date. By doing so, you will reduce the possibility of complete failure, eliminating the need for imposing costly speed restrictions.

4.2.2.2 Comprehensive fettling

Comprehensive fettling describes the refurbishment of a section of track and involves various tasks including:

- ◆ lifting and packing

- ◆ joint shimming
- ◆ measured shovel packing
- ◆ kango packing
- ◆ replacement of conductor rail insulators, clips, packings and shims
- ◆ replacement of rail pads and Pandrol insulators
- ◆ replacement of keys
- ◆ replacement of screwspikes and ferrules.

Like basic fettling, this work is ongoing but usually addresses the problems associated with components that require an overhaul to optimise their life expectancy.

4.2.2.3 Minor replacement

Minor replacement is usually planned and covers installing and renewing of such items as conductor rail ramps, including insulators, packing shims and safety blocks. It also includes the replenishment of ballast and replacement of rail anchors.

4.2.2.4 Spot replacement of larger components

Spot replacement work is the piecemeal replacement of life-expired components. This type of work is always planned and includes essential line works (large value items) which are unidentified or low priority renewals that, through accelerated wear, need replacement before the next Budget Year. These include the changing of sidecut running rail, worn conductor rails, and spot replacement of sleepers, pitblocks and pedestals.

Track Handbook 22 *Developing proposals for the track renewal programme* explains the procedure to be followed when proposing spot renewal of sleepers and rails.

In tube sections Section Track Managers need to plan grouting work before the quality index reaches the maintenance limit (ML) given in Table 1.

4.2.2.5 Mechanised maintenance

Mechanised maintenance is always planned and covers tamping and lining using on-track machines. The lifting and packing of track that does not have adequate ballast conditions for mechanised tamping and lining and treatment of trouble spots can be accomplished by using a hand-held mechanised stoneblower.

Tamping and lining operations cause degradation of the ballast: an average of 2.5kg, and possibly as much as 4kg, of fines can be produced for each sleeper tamped. Excessive tamping will produce more fines, clog drainage through the ballast, shorten the ballast life, contribute to the formation of wet spots and cause premature ballast renewal.

Where track has been treated by stoneblowing or measured shovel packing, no future tamping should be undertaken in these areas.

Section Track Managers need to plan tamping before the Quality Index reaches the Maintenance Limit (ML) given in table 1.

4.2.3 Prioritising maintenance work

By prioritising maintenance work, you allocate a time frame within which the work needs to be completed

S1622 *Glossary of terms* describes prioritisation of maintenance work as:

“the response time with which it is necessary to complete a specific maintenance job”

To manage the workload efficiently you need to prioritise the jobs. Table 4 gives the priorities used in the Asset Management System (e.g. Maximo or Ellipse) with the appropriate lead times.

Table 4: Job priorities	
Priority	Lead time(weeks)
1	1
2	6
3	12
4	52

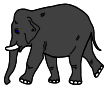
Section Track Managers may choose additional lower priority jobs in the same area as a high priority job to make the most of the resources available at or local to the site for example

Priority	Location	Road	Description
1	Bromley	EB	Wet spot work

The above priority 1 can be accompanied by

2	Bromley	WB	Fettle conductor rail
3	Bromley		Tidy cesses in Bromley area.

By looking for work within the same area it is possible to 'make up' the week and minimise down time in travelling and moving tools and resources to various sites.



REMEMBER!

- ◆ A key point when integrating work is to ensure there are sufficient tools, materials and equipment to cover the different types of work being undertaken.

4.2.4 Planning maintenance work

4.2.4.1 Introduction

It is essential that all maintenance work gives improved safety performance and value for money. This can only be achieved by understanding the various wear patterns that exist for a section of line and planning work in advance to optimise the use of resources necessary for the successful completion of the work (see Track Handbook 21 *Planning maintenance resources*).

The track maintenance planning process is contained within six sections:

- ◆ annual plan
- ◆ rolling period programme
- ◆ job scheduling
- ◆ contracting (if applicable)
- ◆ site supervision
- ◆ performance monitoring.

4.2.4.2 Annual plan

Before the preparation of the annual budget submission, a clear understanding needs to be reached of what delivery targets are required. These originate from the Company's key performance indicators but become more specific as they cascade downwards through the line organisation.

Whenever the specific track delivery targets are known and understood, Section Track Managers need to identify any alterations to the level of renewal, train service frequencies, rolling stock characteristics and annual tonnage which may affect the rates of track quality deterioration in the next year. The information, when considered with a review of past performance and activity levels, will enable Section Track Managers to produce a plan aimed at satisfying the previously set performance targets.

Each Section Track Manager prepares a budget using historical data, track management inspections, track recording vehicle reports and Trackmarking reports.

When identifying work Section Track Managers need to:

- ◆ determine work volumes
- ◆ quantify staff and material requirements
- ◆ identify options and priorities
- ◆ establish any relevant alterations to train frequency.

The Track Manager will discuss the budgets with each Section Track Manager and where there is a lack of finance resulting in budget cuts, Section Track Managers need to identify the safety and quality implications of any changes in their proposed budget.

After agreement has been reached between the Section Track Managers and their Track Manager, taking account of the Line Service Targets, the annual plan (preventative maintenance) is input by the Technical Staff to the Asset Management System (e.g. Maximo or Ellipse).

The annual plan is the backbone for preventative maintenance and the rolling period programme. It is vital that a record of the work done against the annual plan is maintained in order to undertake performance monitoring of the Line Service Targets and key performance indicators.

4.2.4.3 Rolling programme

The annual plan is used to establish routine maintenance work in the rolling period programme which also includes ad hoc maintenance activities, taking into account the time of year, available resources and materials. At this stage, support services need to be scheduled and any random maintenance identified for inclusion in the rolling period programme.

4.2.4.4 Job scheduling

At the beginning of each period, Section Track Managers need to advise the Technical Staff which jobs in the programme they intend to undertake.

Work items are compared with other similar jobs and given a final priority before inclusion in the two-weekly operating plan. When issuing job tickets ensure that a contingency option is prepared for use if required. This is particularly relevant where train cancellations are involved.

Scheduling of track maintenance work, ordering of materials and track access booking, is done using electronic forms in the Company Management System.

Details of staff and materials used need to be recorded before a job can be signed off and, where work is undertaken by a contractor, the Section Track Manager needs to advise the Technical Staff that the work has been completed to his satisfaction and that he authorises payment for the work done.

When the work is complete it is to be signed off by the Section Track Manager who ordered the work.

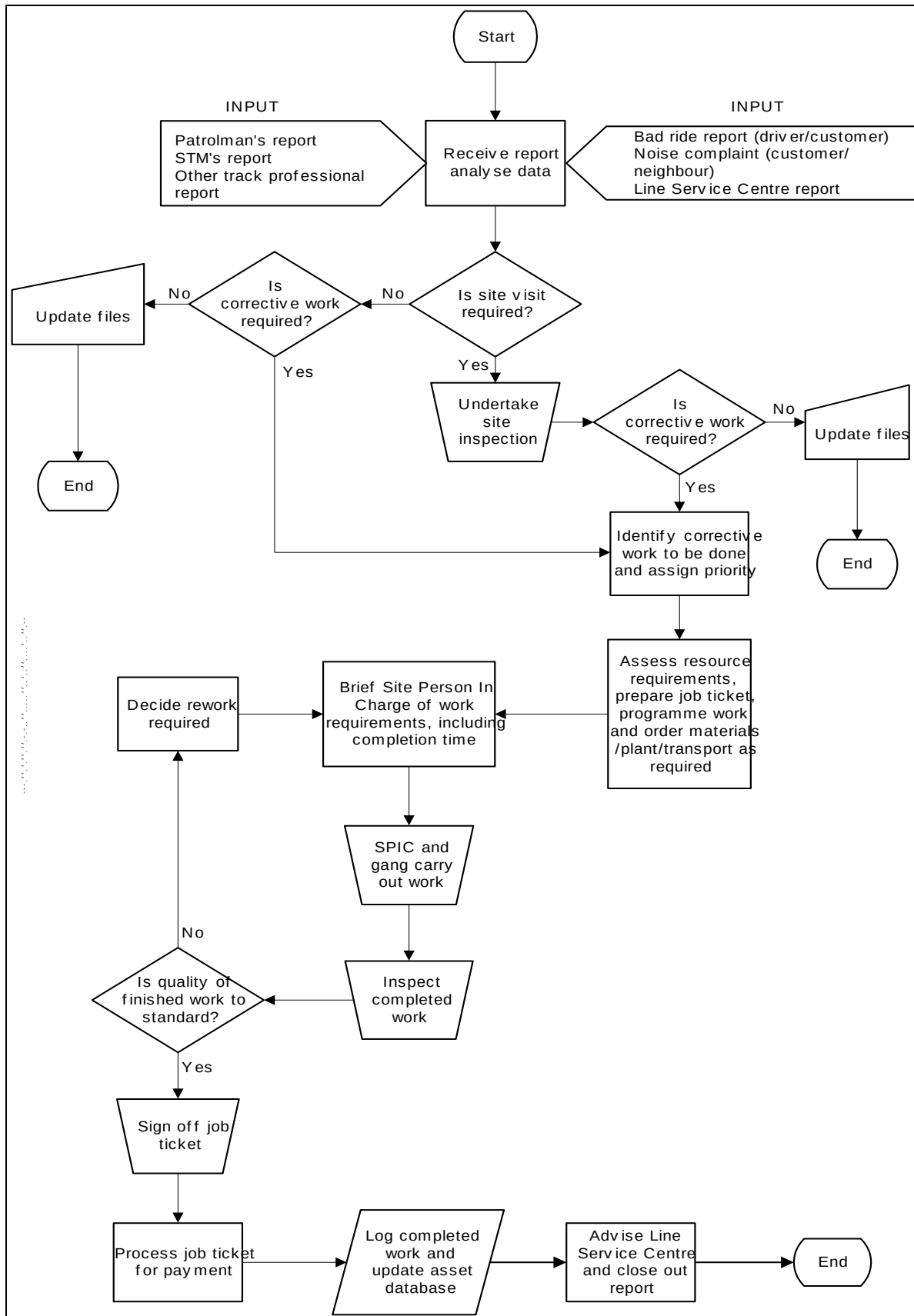


Fig. 1 Getting work done



A job can be signed off the system only if it is fully completed; it cannot be removed from the programme just because the work has been carried out.

4.2.4.5 Contracting

Whenever work is contracted out due to a lack of resources or skills, Track Managers need to authorise the engagement of a contractor, clearly specifying their requirements for both the work and the way it should be undertaken. Refer to the Manual of Best Commercial Practice, produced by LU Procurement, for details of the procedures for tendering and awarding of contracts.

Where a contractor is employed, the order form and subsequent job ticket will be produced as before except that the contractor's name and order number will be required. The contractor will retain the job ticket for the duration of the job. When the job is complete, the Section Track Manager needs to inspect the work in accordance with the relevant standards and, when satisfied, accept the job ticket from the contractor, sign it off and return it to the Technical Staff for entry in the Management System (e.g. Maximo or Ellipse).

4.2.4.6 Site supervision of work

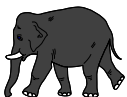
It is essential that the Site-Person-in-Charge supervises all works correctly to meet the required quality targets and planned timescales. If, during a job, the Site-Person-in-Charge anticipates that a delay will occur, he needs to advise the Section Track Manager and the Technical Staff to enable them to make the necessary adjustments to the work programme.

Throughout the duration of the works, Section Track Managers need to monitor the worksites to ensure that track standards are being met.

4.2.4.7 Performance monitoring

An essential part of maintenance work, although not always addressed, is performance monitoring. The reporting procedure feeds the job scheduling, rolling period plan and the annual plan stages with performance information, for example track standards achieved, staff performance, asset performance, work completed on time and at correct cost. It also provides management with performance information that allows corrective action to be undertaken where necessary. Track recording vehicle and Trackmarking reports can be used to measure the improvement after remedial works.

Where faults recur, a more basic approach is required to identify the root cause and rectify the defect (see Track Handbook 18 *Managing track quality*).



REMEMBER!

The four golden rules when managing corrective maintenance are to:

- ◆ correctly identify the root cause of the problem
- ◆ correctly specify remedial works
- ◆ undertake remedial works to the required standard
- ◆ monitor results.

4.3 Fire precautions



LU exercises strict controls over the materials and processes which can be used in, on or near sub-surface or enclosed stations, enclosed locations such as tunnels and on trains, including engineering trains. Components used on the track must have proven fire safety (i.e. low flammability and, in the event of burning, without producing emissions which are toxic, smoky or significantly reduce visibility). Use of petrol-powered plant larger than small hand tools is prohibited. There are controls on "hot work", e.g. welding processes.

If any works require alteration to physical fire precautions at stations (e.g. means of escape in case of fire), those planning the work must consult the relevant Area Manager Stations who will advise on whether engagement with the Fire Compliance Team and/or London Fire & Emergency Planning Authority is necessary.

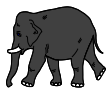
The process for such engagement and for making any necessary alterations to the stations' fire plans is set out in standard Bb224, administered by the Fire Compliance Team.

The main activities associated with track maintenance which could affect station fire safety would be:

- ◆ storage of flammable and/or combustible materials – particularly in public areas, in back-of-house areas without fire separation, or in the tunnels in close proximity to the stations;
- ◆ temporary alteration of the fire detection arrangements (if the works might produce dust or smoke);
- ◆ interference with fire suppression equipment or access and facilities provided for firefighters;
- ◆ temporary closure of platforms or other circulation spaces (might affect the means of escape from other locations);
- ◆ using the station for the passage of flammable materials or gases: the Dangerous Substances and Explosive Atmospheres Regulations 2002 require employers to control the risks to safety from fire and explosions and apply to both stations and tunnels.

The management of track works in enclosed areas also has to comply with the Regulatory Reform (Fire Safety) Order 2005. Additionally, in sub-surface stations the Fire Precautions (Sub-surface Railway Stations) (England) Regulations 2009 apply. The 2005 Order requires that the fire risk associated with all activity in stations and tunnels is assessed by competent persons, the results recorded and any necessary actions managed to completion. The 2009 Regulations have a few more specific requirements, but apply only in sub-surface locations. Further advice and guidance is available on the Intranet at:

http://luintranet.tfl/ops_maintenance/engineering_info/core_assets/9708.html



REMEMBER!

- ◆ **Customer safety is paramount.** If in any doubt about the potential effect of maintenance work in station grounds on customer safety, the London Fire and Civil Defence Authority needs to be approached for advice and agreement.

4.4 Allocating resources



Section Track Managers have the responsibility of resourcing jobs when preparing the job ticket forms. To ensure that the jobs have been properly planned they need to assess the resources required for the job including staffing, materials, plant, transport and engineer's trains. Track Handbook 21 *Planning maintenance resources* addresses this topic in more detail.

4.4.1 Staffing

When planning work, the standard job descriptions in the Work Control Procedures provides details of the time required for one man to undertake a variety of tasks. Section Track Managers need to take account of all the items of work contained within a task to ensure that they achieve the correct level of staff.

If the staffing required exceeds the local resources, Section Track Managers need to decide whether to put the work to contract or replan it for another date when resources are available.

4.4.2 Ordering materials

An important factor to take into account when planning work is the lead time for getting materials to site. In many instances, it will be this lead time that dictates the earliest date a job can be started. The lead time is affected by the type of component and whether it is a stock item or special, whether bought in or manufactured in-house and what quantities are required.

If these factors are not thoroughly explored there is a strong risk that the programme of work will collapse leading to cost penalties, particularly if specialist plant has been programmed for the work. Examples of minimum material lead times are given in table 5.

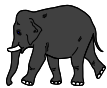
Table 5: Material lead times	
Material	Minimum lead time (weeks)
Cast iron blocks, chairs and baseplates	2
Rail fastenings	2
Small stores	2
Short rail	4
Non-stock item (under £1000)	4
Sleepers	5
Ballast (delivered by train)	8
Long welded rail	8
Non-stock item (over £1000)	12
Stock items (large quantities)	12

Each section of line may require different stock items depending on track types. The Track Manager needs to discuss and agree with each Section Track Manager the stock holding levels for each location. Consideration also needs to be given to the minimum stock level, i.e. when to reorder the stock taking account of the delivery lead times and component usage based on local knowledge and asset data.

Small materials need to be stored securely in a licensed local storage area to prevent theft and need to be recovered from the lineside in keeping with the lineside tidiness policy, particular attention being paid to the disposal of material packaging. Knowledge of the whereabouts of long destressing wooden keys is particularly relevant since they may be required at short notice in the event of a potential track buckle in bullhead long welded rail sites. Larger materials such as rails and sleepers may be laid out on the site pending use but wood sleepers need to be banded together in stacks to prevent theft and potential vandalism.

The Section Track Manager is responsible for ordering, storing and maintaining stock records for the various materials held in each section,

To provide a check, material orders need to be cross referenced against the job ticket for location.



REMEMBER!

- ◆ Do not order up more components than needed: others may require them sooner than you.
- ◆ To provide a check, material orders need to be cross referenced against the job ticket for location.

4.4.3 Plant

Many items of plant used on the system are of a specialist nature. All plant needs to be authorised for use (see S1171) and whenever it is necessary to plan a job utilising specialised equipment, Section Track Managers need to check if the equipment will actually be available on the planned date. If the equipment is not available from the usual supplier, it may be necessary to hire it from another supplier or replan the job. Track Handbook 15 *Selecting and using track plant* covers these problems in more detail.

4.4.4 Transport

Section Track Managers need to ensure that road transport allocated to the section is kept clean, tidy and meets legal requirements. Road vehicles can be utilised to deliver tools and small quantities of material to stations and then barrowed to the site of work.

Since road transport tends to be used on nights to move staff and materials it is essential that work is planned to ensure that the vehicles are available for maintenance on the agreed service dates.

4.4.5 Engineer's trains

Engineer's trains need to be booked through the SABRE (Site Access Booking Railway Engineering) system. Since the number of trains is limited, and to ensure the best use of the resources, book your engineer's train requirements as early as possible, particularly for major works.

Section Track Managers need to ensure that every effort is made to minimise the use of engineer's trains for the delivery of small quantities of materials. Always consider what work is planned ahead and whether the same engineer's train can be utilised to deliver all the materials.



Where to find more information on identifying and planning maintenance work

S1177 Preventing track buckling

TE-HBS-0019 Track Handbook 19: Managing the critical aspects of track

TE-HBS-0021 Track Handbook 21: Planning maintenance resources

4.5 Summary

- ☐ Maintenance work is a continuous process through-out the life of the asset (component).
- ☐ It is important that the track is maintained above the Maintenance Limit (ML).
- ☐ Section Track Managers are responsible for planning the staff in their sections.
- ☐ Keep fettling work up-to-date to reduce excessive wear and tear occurring.
- ☐ Anticipate when repairs or replacements are required.
- ☐ Plan maintenance to ensure resources are optimised.
- ☐ Do not undertake any work without a job ticket.
- ☐ A job can be cleared off the system only when the documentation is fully completed.
- ☐ Do not over order or over stock materials.

5 Safety and protection measures



When working on the track it is necessary to follow the procedures and safety requirements set by LU. Staff need to have **technical competence** when undertaking work on or about the track. Particular care needs to be exercised whenever **working in traffic**. Even during **non-traffic hours** you need to be on the lookout for ballast train movements. An understanding of the **procedures for booking and working in a possession** and for **applying speed restrictions**, both planned and emergency, is also necessary.

The activities involved in managing track safety are fully covered in Track Handbook 16 *Managing track safety*; this section gives a résumé of safety and competence.

5.1 Safety competence

Staff need, as a minimum, to be trained and certified to the level of technical competence described in tables 6 and 7.

Table 6: Technical competence of staff supervising maintenance work

◆ Track Competent Person for Traffic Hours or engineering hours or both by LU or Network Rail as relevant
◆ Competent and licensed where appropriate to handback maintenance works
◆ Electrified track safety training and certification, including the application of Electricity at Work Regulations 1989, the Health and Safety at Work Act etc. 1974
◆ Fire safety training
◆ Emergency first aid training
◆ Appropriate training or certification for the operation of track plant, tools and equipment
◆ Training in the application of the Management of Health and Safety at Work Regulations 1992
◆ Safety and environmental legislation
◆ Training in the application of the COSHH Regulations 1988
◆ Training in Manual Handling Operations Regulations 1992
◆ Training in Personal Protective Equipment at Work Regulations 1992
◆ Assessment approved by the Health and Safety Executive where safety critical track work is involved

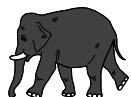
Table 7: Technical competence of non-supervisory staff undertaking maintenance work	
◆	Track Accustomed Person for Traffic Hours or engineering hours or both by LU or Network Rail as relevant
◆	Electrified track safety training and certification, including the application of Electricity at Work Regulations 1989
◆	Fire safety training
◆	Emergency first aid training
◆	Training in the necessary technical skills
◆	Information and instructions on the work
◆	Appropriate training or certification for the operation of track plant, tools and equipment
◆	Training in the application of the COSHH Regulations 1988
◆	Training in Manual Handling Operations Regulations 1992
◆	Training in Personal Protective Equipment at Work Regulations 1992
◆	Training in other relevant legislation
◆	Assessment approved by the Health and Safety Executive where safety critical track work is involved



The requirements in table 8 are additional to those in tables 6 and 7.

Table 8: Technical competence of staff operating or supervising the operation of handtools or mechanised tools, plant or other equipment	
◆	Appropriate training or certification for the operation of track plant or equipment
◆	Knowledge of the manufacturer's or supplier's working or operating instructions
◆	Skill training in the use of the tools, plant or equipment and in the use of any necessary personal protective equipment
◆	Certification in the relevant skill training course
◆	Training in environmental protection measures to minimise the impact of plant or machinery, e.g. noise and vibration

Failure to take adequate account of electrical safety precautions, or where equipment is unsafe, sub-standard or poorly maintained, exposes staff and members of the public to risks. The Electricity at Work Act is the main deciding factor when making the decision whether to work during traffic or at night in Line Safe Areas. When considering the options, you need to look at the safety considerations, relative costs, plant and equipment.



REMEMBER!

- ◆ Do not forget lighting for night work.

5.2 Office of Rail Regulation

The Office of Rail Regulation (ORR) is the independent safety and economic regulator for Britain's railways.

The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) provide the regulatory regime for rail safety and apply to LU. Under these regulations, approval from the Secretary of State for Transport is required before bringing any new or altered railway works, plant or equipment into use. The Safety Directorate (previously known as Her Majesty's Railway Inspectorate) acts for the Secretary of State in the approval process.

Maintenance works and most like-for-like replacements do not normally require approval. However, a guideline from Her Majesty's Railway Inspectorate indicated that track realignment at or near bridges, tunnels or stations requires approval.

5.3 Licences and permits

The site location and type of work dictate which licences and permits are required. When planning a job it is essential that applications for licences and permits are made as far in advance as possible to optimise on resources and minimise job clashes.

Licences and permits are required for:

- ◆ storage of materials and equipment on site
- ◆ storage of plant on site
- ◆ hot working station access
- ◆ use of generators
- ◆ use of escalators and lifts for site access
- ◆ isolation of fire alarms.

5.4 Tools, plant and equipment

It is necessary to ensure that tools, plant and equipment are suitable for the type of work. They need to be approved in accordance with S1171.

5.5 Personal protective equipment

It is essential to use only the personal protective equipment that is approved for use, according to the type of work being undertaken. This may include, for example, conductor rail mats and rubber gloves. When such equipment is to be used, the supervisory staff overseeing the work need to be competent to administer and monitor its correct use.

5.6 Working in traffic hours

5.6.1 Key points to safe working

Most maintenance work is now done outside traffic hours with traction current discharged, but if work is required with the traction current on, it needs to be subject to a risk assessment and a safe method of working. The latter must include the use of conductor rail mats.

When working in traffic hours staff need to follow the procedures and safety requirements set by LU and be trained and certified in electrified track safety, including the application of Electricity at Work Regulations 1989.

It is necessary to observe the key points to safe working which are ensuring that tools, plant and electrical equipment are suitable for the type of work and that protective equipment is used as and when required.

As a minimum, all staff need to observe and practise the following key points to safe working which are:

- ◆ brief all staff
- ◆ observe safety precautions
- ◆ use only approved work practices
- ◆ select equipment with built-in safety protection
- ◆ observe electrical safety precautions particularly in wet weather.

It is necessary for staff to comply with statutory requirements and ensure that they are conversant with:

- ◆ Engineering Instructions
- ◆ Safety Information Sheets, including COSHH, Noise, Electricity and Manual Handling developed as a result of task analysis
- ◆ local track safety working instructions
- ◆ LU wet weather working guidelines.

5.6.2 Safety in wet weather

When wearing a long waterproof coat ensure that it does not come in contact with the conductor rails during wet conditions. Always check that the tools are insulated, for example hammers, slewing bars, spanners, and the equipment is approved for use for working under these conditions (see Tool Catalogue and wet weather working guidelines).

5.6.3 Risk assessment

Whenever new or modified work methods relating to the track or items of equipment are introduced, a risk assessment is required to ensure that the new or modified work method or equipment remains appropriate for the work.

The key steps in risk assessment are:

- ◆ look for the hazards
- ◆ decide who or what might be harmed, and how
- ◆ evaluate the risks arising from the hazards
- ◆ record findings
- ◆ review the assessment from time to time, revising if necessary.

Track Handbook 16 *Managing track safety* explains the five steps to risk assessment in detail.

5.6.4 Safety equipment

5.6.4.1 Conductor rail mat (juice rail mat)



Conductor rail mats are 'U' shaped, fit over the conductor rail, and protect staff working alongside from contact with the conductor rail. They are individually numbered and are used to provide protection when working with traction current on or in emergencies. They are issued, subject to special arrangements, by the Stores Supervisor at Acton who is responsible for maintaining the records of the serial number of the mats in use by each gang on the lines.

The mats are manufactured from black plastic trunking which is a fire hazard and therefore cannot be used or stored in any underground location.

Before undertaking any work which requires a conductor rail mat the Site-Person-in-Charge needs to:

- ◆ brief all staff
- ◆ assess and ensure the correct number of mats required are available
- ◆ examine that they are free from any cracks or splits and are dry and uncontaminated by hazardous substances, such as grease
- ◆ ensure there is at least a 25-second warning distance for the work site and 40 seconds if opening out beds
- ◆ ensure that only the integral carrying strap is used when placing or removing the mat from the conductor rail
- ◆ appoint a member of the gang to be responsible for removing the mat clear of the track when a train approaches.



If not enough warning is given of an approaching train and you cannot remove the mat safely FORGET THE MAT, MOVE CLEAR.

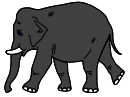


REMEMBER!

- ◆ Before using conductor rail mats, staff are required to undertake specialist training in their safe use.

5.6.4.2 Rubber gloves

Special rubber gloves are supplied for emergency work and to provide protection when undertaking tasks with the current on. The gloves need to be examined for defects before use, for example splits, cracking, abrasion, and have to be returned to the Plant Shop at Lillie Bridge Depot to be tested and re-certified every six months.



REMEMBER!

- ◆ The use of safety equipment is mandatory and is to be used in every circumstance it is identified as required. **If not available, the work cannot commence.**

5.6.5 Protection briefing

At any time, day or night, before going on to a site, the Site-Person-in-Charge needs to brief staff about the type of work and the safety arrangements including:

- ◆ place of safety
- ◆ identify first aider
- ◆ sighting times
- ◆ lookout positions
- ◆ personal protective equipment
- ◆ tool maintenance
- ◆ site housekeeping.

5.7 Working in non-traffic hours

When working in non-traffic hours the Site-Person-in-Charge needs to ensure that the traction current has been switched off before allowing staff to access the track under line-clear or line-safe procedures.

5.8 Booking engineering works

Whenever work requires occupation of a section of line you need to submit a request for engineering work on the railway. Weekly meetings are held to discuss and resolve clashes of requests to work in the same section and overbooking of engineering trains. The agreed plan is then published in the weekly Engineering Works and Safety Arrangements; this is issued every Thursday and contains details of pre-booked engineering work. To accommodate any emergency work and agreed alterations to previously booked work, an Engineering Notice is published daily, Monday to Friday, the weekend work being included in the Friday issue.

When it is necessary to alter train services, for example re-time or cancel first and last trains to have sufficient time available to complete the work, you need to apply for a possession following the same procedure as for booking engineering works.

On the night of the work you need to:

- ◆ book on with the Track Access Control Centre
- ◆ always check for the discharge of traction current with a conductor rail indicator device (CRID)
- ◆ always check for the discharge of traction current with a conductor rail indicator box
- ◆ undertake the work
- ◆ contact the Track Access Control Centre to advise that work is complete and pass the Site Clear message.

On receipt of the Site Clear message the Track Access Control Centre will advise the sub-station that the section can be safely recharged.



When train movements in a possession are altered, particular care needs to be taken to ensure that staff are advised of the change.

The Possession Master is the key safety person on the site and all communications need to be addressed to him to ensure complete site safety. If you require to make any changes to your proposed plan when on site you need to inform the Possession Master and also the Site-Person-in-Charge.



REMEMBER!

◆ These procedures may change from time to time and staff need to ensure that they always use the most recent issue.

5.9 Applying speed restrictions



In defined situations, it may be necessary to restrict the normal operational speed of trains on certain sections of track and reduce them to a safe speed. This may be due to asset condition, maintenance or renewal works.

5.9.1 Types of speed restriction

The three types of speed restriction which may be imposed are **permanent**, **temporary**, and **emergency**.

5.9.1.1 Permanent speed restriction

Permanent speed restrictions can be due to geometric features, the effect of which is that trains cannot operate at the design maximum speed over a section of line.

5.9.1.2 Temporary speed restriction

Temporary speed restrictions are imposed at a speed below the design speed or permanent speed restrictions and depend on the sub-standard condition of the asset or the type of maintenance work being undertaken.

Table 9 details the various criteria for temporary speed restrictions, though it should be noted that these operations are not now routinely carried out in traffic hours. S1158 describes how temporary speed restriction signage is to be located.

To assess the need for a temporary speed restriction in respect of critical rail temperatures, refer to S1177.

Table 9: Temporary works speed restrictions		
Temporary works	Condition	Temporary speed restriction
Lifting track	All conditions	15mph
Resleepering	Temporary speed restriction to remain in operation for 5 to 7 days after completion of work	15mph
Ballast removal	Length greater than 20m	15mph
Destressing	Before rails are unfastened	15mph*
* Speed restriction applies only while work in progress and is removed at end of shift.		

5.9.1.3 Emergency speed restrictions

Emergency speed restrictions can be due to sub-standard asset condition or track irregularities as described in table 10 are imposed as a matter of urgency and S1158 describes how the speed restriction signage is to be located.

Table 9: Asset condition speed restrictions			
Asset	Structure gauge infringement or track condition	Emergency speed restriction	Relevant standard
Structure gauge	0mm to 34mm 35mm to 49mm 50mm to 74mm 75mm and over	No speed restriction 35mph 20mph 10mph	S1156
Wheel unloading	90%	10mph	S1159
Broken, or defective rails or fishplates	Depending on type of defect	Stop traffic, impose a 5mph, 10mph or 20mph depending on type of break or defect	S1158
Hole in running rail	Flame cut hole	5mph until the flame cut rail is replaced	S1158

Once imposed, the duration of an emergency speed restriction is referred to as an 'asset condition' or condition of track speed restriction. Where the duration exceeds 'a couple of days' it is a requirement to publish the emergency speed restriction in the Traffic Circular as a temporary speed restriction.



To ensure that trains only accelerate when completely clear of the restricted area, the termination indicator is to be positioned a train length beyond the work.

5.9.2 Publishing speed restrictions

When publishing a speed restriction, the following details need to be included:

- ◆ location (either at or between stations)
- ◆ location (using Location Coding System)
- ◆ track kilometreage
- ◆ site length
- ◆ road affected
- ◆ restricted speed value.

Table 11 lists the publishing procedures for each type of speed restriction including the action to be undertaken, where applicable, when there is insufficient time available to meet the required standard. Where there is insufficient time to publish a speed restriction, advise the appropriate Line Service Centre and Line Controller.

Table 11: Speed restriction publishing requirements		
Type of restriction	Where published	Exceptions
Permanent	Line Supplements or Driving Technique Guidance documents	Where the "T" sign is omitted and termination point is the headwall at the departure end of the station ahead unless a further sign indicates a continuation of the speed restriction
Temporary	In a Traffic Circular	If there is insufficient time to publish in Traffic Circular, publish in an Engineering Notice
Emergency	In Engineering Notice	If insufficient time to publish in Engineering Notice, apply procedures for emergency speed restrictions via Line Control.

A speed restriction request form, found in the Company Management System, is completed by the requester.

On lines with automatic train operation the permanent speed restrictions are programmed into the train operating system. When it is necessary to apply a temporary speed restriction, the reduced speed needs to be programmed into the train operating system. These systems do not always allow for the particular restriction desired so when planning work on these lines Section Track Managers need to ensure that the job is correctly resourced if trains will run at a higher speed than normal for the specific type of work.

5.9.3 Speed restriction signs

Speed restrictions have speed indicator signs displaying the maximum speed (mph) in numerals and "T" signs at the termination of the speed restriction. Permanent restriction signs are mounted at the side of the line and are illuminated, powered from the positive conductor rail. Temporary and emergency restriction signs are mounted in the four-foot and are reflective. The layout of temporary speed restriction signage is described in S1158.



Where Train Operating require certain sections of track to be signalled for bi-directional use and a speed restriction is necessary, it is essential that the speed restriction signs are provided on BOTH SIDES of the affected area.

5.9.4 Revising speed restrictions

When a temporary speed restriction requires to be revised and the speed is further reduced, the same principles apply and it is treated as a new temporary speed restriction. When the speed is increased, but is still below the maximum permitted speed for the section of line the new speed is published in the Engineering Notice. At all times it is essential that staff are advised of any changes in temporary or emergency speed restrictions.

5.9.5 Removing speed restrictions

When a track defect has been rectified, removed or the work completed, the emergency or temporary speed restriction can be lifted and trains permitted to run at design speed.

The member of staff responsible for imposing the restriction is the only person permitted to remove the restriction. That person must be qualified and appropriately licensed, and needs to:

- ◆ arrange for the publication of the removal in an Engineering Notice
- ◆ arrange for the deletion of entries in future issues of the Traffic Circular
- ◆ advise the appropriate Line Controller
- ◆ advise the appropriate Line Service Centre
- ◆ arrange removal of signs.

5.10 Signalling and communications equipment on the track

Where the signalling system requires electrical continuity in the running rails any plated joints (other than insulated joints) will be fitted with bonds between the rail ends: see plate 6.

LU's lines are gradually being equipped with new equipment for automatic train control. This involves some cabling along the four-foot and, in some areas, axle-counters attached to the running rails.

Radio beacons are situated at the entrance to depots and allow train radios to change frequency between that of the Line Controller and that of the depot or vice versa.

Many trains are fitted with closed circuit television (CCTV) monitors in the driver's cab. The monitors receive a signal from a radiating cable located in the four foot (to the left of the negative conductor rail in the direction of travel) at every station on the approach to the starter signal. If this cable is damaged there could be a loss of picture. This could result in the closure of the platform as the driver would be unable to observe the movement of customers.

It is essential that you exercise great care when planning and undertaking trackwork that may affect this equipment and the safe and efficient operation of trains. Cables in the four-foot can easily be damaged by storing of rails or by welding work, so need to be protected. Axle-counters can be damaged by some types of rail-borne equipment, and the passage of any such equipment will indicate track occupation which has to be corrected before resumption of traffic: see plate 1.



Plate 1 Axle-counter

These monitor track occupation by trains by counting the passage of axles. They are vulnerable to damage if struck. If an axle-counter is stuck ensure that it is reported to the Site Person in Charge so that checks can be made.

Axle-counters also need to be re-set following any track work involving use of wheeled equipment such as trolleys or rail-mounted grinders, which may have activated them.



Where to find more information on safety and protection measures

H S & E guidance note GS 24
H S & E guidance note GS27

Electricity on construction sites
Protection against electric shock

5.11 Summary

- ☐ A site briefing is essential **before** work commences.
- ☐ Staff need to be aware of their duties.
- ☐ Always plan your work in advance and book possessions accordingly.
- ☐ Always assume that the conductor rails are live unless confirmed otherwise.
- ☐ Tools, working equipment and personal protective equipment need to be stored correctly to ensure they are maintained in good condition.
- ☐ Take care not to damage signalling and communications cabling or other equipment when carrying out work on the track.

6 Maintaining running rails and rail joints



On LU's railway network running rail is increasingly 56E1 (flat bottom 113A) but a significant quantity of bullhead (95RBH) rail remains. The policy is to convert as much as possible of the railway to flat bottom section because of its greater strength, stability and long term availability.

Where continuous check rail is installed, it is either:

- 33C1 with 56E1 running rail,
- 95RBH with 56E1 running rail,
- 56E1 with 56E1 running rail (rare), or
- 95RBH with 95RBH running rail..

6.1 Running rail

6.1.1 Overview

Welded rail is the preferred configuration but where curvature restricts its use, short rails are installed. Two configurations of welded rail are employed by LU:

- ◆ continuous welded rail (CWR), which is mainly 56E1, and
- ◆ long welded rail (LWR), which is mainly 95RBH and is gradually being replaced by 56E1 CWR.

Changes in temperature cause rails to expand and contract. In open sections especially, specific maintenance is required to maintain track stability prior to the hot weather period in both short and welded rails. It is also necessary to undertake certain precautions with welded rail during the hot weather period relative to the critical rail temperatures and the posting of watchmen. These are fully explained in S1177.

Unlike open and sub-surface sections, tube sections experience minimal variations in rail temperature which remains around 18C, with a seasonal variation of about 4C.

Standard S1622 *Glossary of terms* defines the different types of running rails as:

Continuous welded rail

"rail continuously welded together to form a single length over 200 m with no maximum length. Continuous welded rail may incorporate insulated joints".

Long welded rail

"locations where up to 91.4 m length welded strings of rail are tight jointed or welded together to form a single rail length over 200 m but not exceeding 730 m. Long welded rail may incorporate insulated joints"

Short rail

“any continuous rail less than 36.6m in length”

The **running rail gauge** needs to be maintained within the tolerances in S1159 to ensure the safe passage of trains. Whenever the **running rail wear** reaches the limit, the rail needs to be transposed (if permitted by S1157) to provide a new gauge face and thus extend the life of the rail, or replaced. To assist in optimising rail life, **rail lubrication** provides a film of lubricant which reduces the wear between the running rail and wheels. Traffic causes corrugation on the surface of the running rail as well as loss of section and the corrugation can be removed by **rail grinding, planing or milling** and reprofiling the running rail. Traffic also causes defects in the running rails and these, as well as those inherent in the running rail, can be identified by **ultrasonic testing** the running rail at regular intervals.

The acceleration and deceleration of trains tend to cause **rail creep** (particularly in bullhead track) which may be prevented by fitting rail anchors. The track is divided into sections for signalling purposes and where rail joints are fishplated, **track bonds** are required to ensure the continuity of the track circuit alternatively **blockjointless track circuits** are used to divide the track into sections.

6.1.2 Loss of rail section

Loss of rail section affects all types of running rails, the maintenance problems experienced being **rail failures** and **rail wear** which affects both the head and the foot of the running rail.

6.1.2.1 Rail failures

The main occurrences are bolt hole cracks, taches-ovales, “squats”, rolling contact fatigue and other head or web horizontal cracks..

6.1.2.2 Rail wear

Apart from corrosion which affects the whole rail, the areas affected by the passage of traffic are the head, foot and fishing surfaces. The rail head suffers from **head wear, sidecut, corrugation** and **damage**. Rail head wear takes place over a number of years while sidecut and corrugation can occur over a short period of time, particularly if the track mounted rail lubricators are not functioning correctly. The rail foot, particularly of bullhead rail, can be affected by **gall**. In short-rail track, the fishing surfaces of the rail can be affected by **fretting** at the ends of the fishplates as the joints deflect under traffic: this must be inspected for when carrying out both track inspections and maintenance work.

- ◆ **Head wear** - when the rail head wears, leading to a loss of rail depth, there is a reduction in clearance between the wheel flange and fishplates. If the permissible head wear is exceeded the wheel flange can ride on top of the fishplate resulting in wear and damage to both vehicle and track components (see table 12).

Table 12 gives the Maintenance Limits for total vertical rail wear for track (a) where only LU trains operate and outside fishplate limits, and (b) where Train Operating Companies operate trains or within fishplate limits. The head wear limits for (b) are reduced to accommodate the heavier axle load of the Train Operating Companies' trains. Part (b) of the table applies within fishplate limits even if only LU trains are used. The head wear values in this table assume that there is no sidecut: see S1159 when there is sidecut in combination with head wear.

Table 10: Permissible running rail wear (Maintenance Limit - ML)					
Rail section	Nominal height new (mm)	Minimum height worn (mm)	Acceptable head wear (mm)	Acceptable foot wear (gall) (mm)	Total acceptable wear (head and foot) (mm)
(a) LU stock only and outside fishplate limits					
flat bottom	159	139	18	2	20
bullhead	145	125	18	2	20
(b) Train Operating Company stock or within fishplate limits					
flat bottom	159	145	12	2	14
bullhead	145	131	12	2	14



When the head wear is within 2mm of the limits in table 12, or gall exceeds 1mm, monitor rail wear by taking measurements at no more than 100m intervals every six months until the limit is reached.

- ◆ **Sidecut** - on curved track, sidecut is normally caused by the action of the wheel flange riding hard against the high rail on curves.

Intermittent sidecut can also occur because of local irregularities in alignment. This is particularly noticeable on sections of short rails where intermittent sidecut is reduced in the vicinity of the rail joints because the more rigid fishplates create a flatter curvature. Where local irregularities are left unattended, eventually the small sections of sidecut will overlap and become continuous. On straight track vehicle 'hunting' can also cause intermittent sidecut on alternate rails.

On curves where sidecut exists, the low rail mushrooms developing lipping, particularly on the outside edge of the rail.

Sidecut requires to be monitored regularly by the Patrolman during his routine inspections, the measurements being taken at the same point so that the rate of sidecut can be determined. When sidecut becomes more severe, Section Track Managers need to undertake assessment every six months at 100m intervals with a minimum of 8 readings per curve.



REMEMBER!

- ◆ Check that the sidecut gauge you use is suitable for the rail section.

- ◆ **Corrugation** - there are two corrugation wave lengths: short wave which is visible to the naked eye with an interval of between 30mm and 80mm and long wave which is greater than 80mm.

Corrugation can be removed only by grinding the rail head and, to minimise component deterioration, the removal needs to be undertaken before the depth of corrugation exceeds 0.04mm. Where corrugation exceeds 0.08mm the increased vibrations and wheel noise will incur public complaints and, if allowed to develop further, result in the premature failure of the track components.

Where corrugation is allowed to develop uncontrolled, the fastenings used with concrete sleepers are particularly susceptible to becoming life expired over a very short time.



Corrugation has been found to occur on urban railways where the same type of vehicles with the same running characteristics travel at the same speed over a section of track.

- ◆ **Rail damage** - under the passage of trains running rails roll out and the rail ends can become lipped (see plate 2). Where this is allowed to continue unchecked, in short rails the expansion gap is reduced and in insulated rail joints there is a possibility of a short circuit, particularly when the rails expand.

If rail end lipping is not removed, it will eventually break off leaving an irregular surface (see plate 3) which can contribute to rail end batter (see table 19) or even flaking of the running surface.

Rail end batter can result from bad rail joints, where the continual pounding of a poorly maintained rail joint causes the rail head to mushroom and the potential for rail failure.

- ◆ **Gall** - under the passage of trains, the continual rubbing between the (particularly bullhead) rail and rail support (fretting) causes wear on the rail foot (gall). Damp locations, such as tunnels, are ideal for developing gall and if debris is allowed to accumulate around the chairs or baseplates the situation becomes exacerbated by the production of a very fine paste which grinds away the rail foot. Gall is less common in flat bottom track since rail pads are normally used.



If gall goes unchecked, the stress concentrations created in the rail foot can cause the rail to break.

- ◆ **Fretting** – this results from rubbing between the ends of the fishplates and the rail fishing surfaces. It appears as a bright mark on the rail. Actions for dealing with it are in S1159.

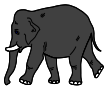


Plate 2 Lipped rail joint

Note the reduction in expansion gap at the running edge.



Plate 3 Rail joint with lipping breaking off



REMEMBER!

- ◆ Section Track Managers need to identify rerailing sites at least two years in advance to enable timely inclusion in the track renewal programme.
- ◆ Remove lipping from rail ends at insulated rail joints to prevent short circuits and delays to trains.

6.1.3 Rail reprofiling

The head of the running rail can be reprofiled by grinding, planing or milling, which can be used to remove corrugation which has been identified from track recording vehicle data on normal track recording runs or manually measured using a 1m straight edge and feeler gauges.

Before undertaking any reprofiling of the running rail, Track Managers need to consider the rail life in terms of age, head wear and sidecut and where reprofiling is planned, the track needs to be fettled with particular attention to top and line.

6.1.4 Turning and transposing rails

6.1.4.1 General

Good rail management will extend the useful life of running rails either by turning or transposing them, depending on site conditions. However, S1157 imposes some restrictions on when rails can be turned or transposed, and the following paragraphs should be read with that in mind.

Section Track Managers need to monitor sidecut rails so that the turning, transposing or replacement of rails takes place before the permissible limits are exceeded.

S1157 gives particular requirements regarding the re-use and relocation of rail. One is that where the proposed new location is in the outer rail of a curve, the field face must be free of sidecut. This effectively precludes a sidecut rail's curvature being reversed when relocated. The following paragraphs should be read with that in mind.

Support blocks are used on concreted track to prevent damage during the off-loading of rail. They are bolted to the concrete sleeper using the insulator holes at intervals of 10m or with a minimum three support blocks for a short rail (60ft). The rail foot is clamped to the support block preventing any contact with the live conductor rails due to traffic vibration.

6.1.4.2 Turning rails

The main difficulties when turning rails are the limited clearance on sites and the tendency for rails on tight curves to retain their original curvature.

Turning of short rails requires a crane with a lifting beam. On single track the likely lack of space may make it necessary for the crane to take the rail to a suitable location for turning it safely. On double track there should be sufficient clearance. Multiple track sites should pose no problems apart from the additional possession requirements.

When turning rails on a tight curve, difficulty may be experienced in getting the rail to seat correctly in the chair or baseplate: this can be overcome by 'crowing' the rail.

It is necessary, at the planning stage, to allow sufficient additional time to enable such additional tasks to be undertaken; this is particularly relevant when booking an item of on-track plant such as cranes.

6.1.4.3 Transposing rails

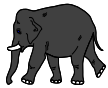
It is impossible to turn welded rail except by loading the rail onto a train and turning the train. The normal method is swapping the high and low rails, providing unworn running faces for the wheels.

Short rails can also be transposed but pay particular attention to identify the whereabouts of the closure rails (less than 60ft) on the inside of the curve to minimise cutting.

An alternative when a rail becomes worn on one hand of curve, is to use it on the next curve of the opposite hand.

Low rails tend to suffer from mushrooming (lipping). If a low rail is transposed, the new gauge face will be tight to gauge giving bad running with an increase in flange squeal until the lip has been worn away by the passage of trains. This is not good practice and mushroomed low rails need to be ground and reprofiled prior to transposing.

Sidecut high rails can be utilised as continuous check rail on an opposite hand of curve.



REMEMBER!

- ◆ S1157 imposes some restrictions on when rails can be turned or transposed.
- ◆ Where cross track cabling exists, insert packings below the rails to ensure that they do not come into contact with the cables causing damage and the possibility of disruption to the train service.
- ◆ When rerailing or transposing rails, any rails left in the four foot need to be secured to the sleepers with screwspikes to prevent them coming in contact with the live conductor rails due to traffic vibration.
- ◆ To ensure that the detraining of customers is not impeded, rails need to be placed on one side of the negative rail only, preferably on the side opposite tunnel lighting (if applicable).

6.1.5 Track bonds



Track circuits are an essential part of the signalling system (except where axle-counters are used) and where rails joints are fishplated, track bonds (pigtails – see plate 6) are required to ensure the continuity of the track circuit. If these bonds are damaged or removed or repositioned without proper authority the integrity of the signalling system is reduced with the potential for disruption to trains.

When undertaking work that requires the removal or repositioning of track bonds, only a signalling competent person can remove or reposition them.

When undertaking rerailing or any operation that requires the temporary removal of the track bonds, Section Track Managers need to obtain an Authority to Work Certificate without which the work cannot proceed.

There are two colour-coded types of track bond in use on LU:

- ◆ **red** - used where stations ("Section 12") are covered by the Fire Precautions Regulation 1989

◆ **grey** - all other locations.

If, during maintenance work, track bonds become damaged, the Site-Person-in-Charge is required to advise the appropriate Line Controller.

6.1.6 Blockjointless track circuits

At various locations blockjointless track circuits (running rails without insulated rail joints) are installed. It is essential that Section Track Managers determine the type of track circuit for a particular section of track before undertaking any work.

The main problems associated with blockjointless track circuits are dampness and vibration. Where wet spots are allowed to develop in blockjointless track circuits, the probability of disruption to trains is increased.

When undertaking rerailing or any operation that requires the temporary removal of the electrical cabling, Section Track Managers need to obtain an Authority to Work Certificate without which the work cannot proceed.

6.1.7 Gauge (running rail)



S1622 *Glossary of terms* defines the gauge (between running rails) as:

“the distance between the running edges of the two running rails on the same track. measured at a point of 13mm below the rail crown of the rail”.

Note that LU standards now use 14mm as the reference point, in line with national and international practice.

Track gauge needs to be inspected to ensure it is within the ranges in S1159. Nominal track gauge values according to track curvature are given in table 13, but note that these are the values used for new work – some bullhead track will have been installed with a gauge of 1432mm at radii above 400m and a gauge of 1438mm for all radii below 200m.

Table 13: Gauge (running rail)	
Radius	Gauge
Radius > 400m	1435
400m, > radius > 200m	1435
200m, > radius ≥ 160m	1438
160m > radius ≥ 130m	1441
130m > radius ≥ 100m	1444
100m > radius ≥ 80m	1447
80m > radius ≥ 70m	1450
radius < 70m	1453

For various reasons the track gauge may widen, for example as a result of the action of wheels pushing hard against the high rail on tight curves, or split or decayed sleepers, and it is essential that the gauge does not exceed the tolerances in S1159. Cyclic variations in running rail gauge will lead to hunting, possible sidecut and generally bad running and customer discomfort. Before these exceedences occur, Section Track Managers need to plan regauging especially if it is tight because of the increased rail and wheel wear. In tube sections Section Track Managers need to plan to grout the sleepers or pitblocks and regauge (see section 8, Maintaining sleepers and pitblocks).

In the case of timber sleepers, thrust plates placed hard against the edge of the baseplate or chair on the outside of the curve and secured to the sleeper with screwspikes provide added resistance to gauge widening.

6.1.8 Controlling rail creep



The passage of trains can induce the gradual movement (creep) of, particularly, bullhead rail. This may be detected by noting the position of the rail joints relative to the sleepers (plate 4).

By noting the position of the rail joints relative to the sleepers it is possible to decide if the rails can be regulated by pulling back, or if there is too much or too little gap at the location.

Creep can be prevented by fitting rail anchors to the foot of the rail and in contact with the chairs (see plate 4). On LU rail anchors are not used on flat bottom rail as the rail fastenings used are considered to provide sufficient longitudinal restraint.

6.1.8.1 Using rail anchors

The use of rail anchors can be grouped into four categories.

- ◆ **On long welded rail sites** where rails are temporarily fitted with wooden keys the installation of seventy-two rail anchors on the running on (approach) end of the site is required.
- ◆ **During hydraulic tensioning of bullhead welded sites** one hundred and thirty sleepers require anchors to be positioned each side of the chairs on the running on (approach) and running off (departure) ends when the rail temperature is between -10C and 21C.
- ◆ **To provide additional longitudinal rail restraint** by installing anchors on each side of the chair where the track is supported on waybeams, when undertaking resleeper operations, during opening out of beds or when ballast under the sleepers has been disturbed.
- ◆ **To prevent rail creep** rail anchors are used to resist any longitudinal movement.

Rail anchors are also used in concreted track in tube sections when replacing running rails. At least ten anchors need to be installed on each end of the rails adjacent to the proposed relay site. This will resist the longitudinal movement of the adjacent rail making it easier to remove and replace the running rails.

6.1.8.2 Signs of rail creep

The signs indicating that rail creep is occurring are:

- ◆ expansion rail joints closed up when rail temperature is low
- ◆ fishplates bearing up tight against chairs (see plate 3)
- ◆ marks on rail caused by rail creeping through fastenings
- ◆ insulated rail joint end posts being crushed
- ◆ missing fastenings
- ◆ sleepers off square.



Plate 4 Rail creep: fishplates bearing against a chair

Here the traffic runs from left to right. There may also be visible marks on the web of the rail from scraping against the chair.

Where rail creep in short rails has been observed, regulate or adjust the expansion gaps and then take action to prevent further rail creep by installing rail anchors over five rail lengths (see figure 2).

6.1.8.3 Fitting rail anchors



It is essential that staff undertaking this work are trained in the correct method of installing and removing rail anchors.

Always fit two anchors per sleeper and where creep is slight six rail anchors per short running rail should be sufficient. On sites where moderate to major creep is experienced, eight to ten rail anchors need to be fitted to each short running rail. In very severe cases, install anchors on every sleeper. Backward creep can be prevented by installing up to three back-up anchors per short rail.

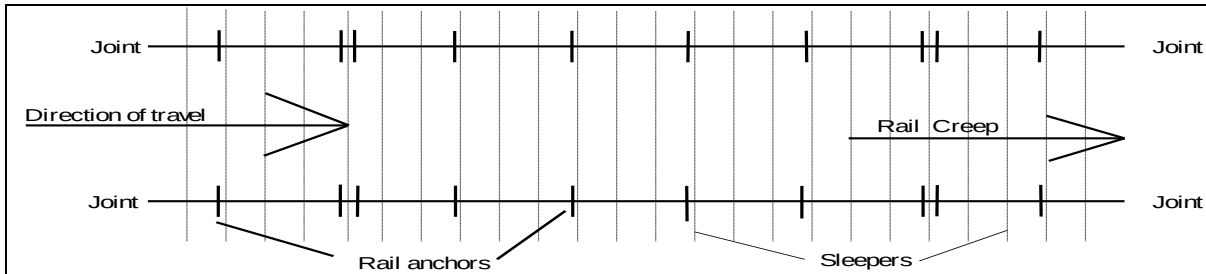


Fig. 2 Positioning of rail anchors for moderate creep on 18.3m nominal (60ft) rail

Position rail anchor by hand on the foot of the running rail with the larger hook end in the four foot. Using an insulated keying hammer, drive on the anchor. The shape of the anchor is such that one correctly delivered blow to the larger hook end is sufficient to attach it firmly to the running rail.

Ensure that the anchor is hard against the chair: see plate 5. If it is not in contact with the chair, do not force it along the rail by hammering it, remove and reposition it correctly.

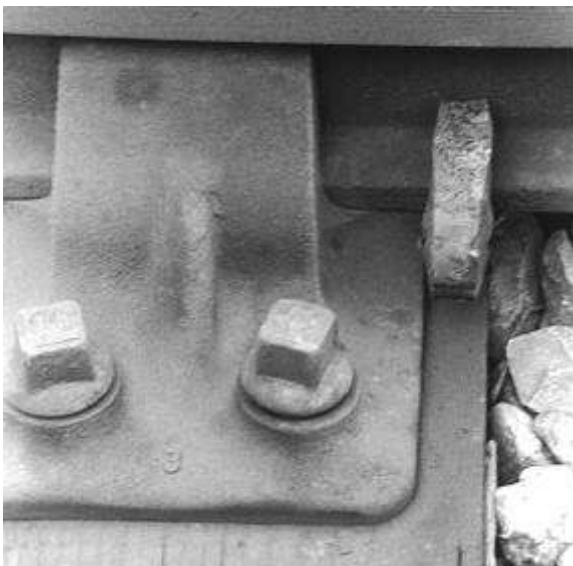
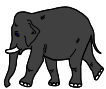


Plate 5 Bullhead rail anchor installed correctly

Note that the anchor has its larger hook end in the four-foot and, is hard against the edge of the chair.



REMEMBER!

- ◆ Fitting rail anchors at running rail joint sleepers restricts the expansion and contraction of the rail and needs to be avoided.
- ◆ Never fit rail anchors at one end of a sleeper, as the rails expand, increased forces will occur on one rail tending to distort the track.
- ◆ If rail anchors are able to slide along the rail they have lost their capacity to retain the rail and need to be replaced.

6.1.8.4 Removing rail anchors

Stand placing one foot on hook end of rail anchor to prevent it springing and 'flying off' the running rail.

Using an insulated keying hammer tap the toe end of the rail anchor once or twice to release it.