Design and Maintenance Guide 09

# Permanent Way

DEFENCE ESTATE ORGANISATION
MINISTRY OF DEFENCE

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# Contents

# Foreword

The Ministry of Defence (MOD) operates and maintains a number of railway systems at diverse establishments for the movement of material both within establishments and between establishments, UK ports and the Channel Tunnel. In addition the MOD Estate includes specialist railway systems for mobile targets and dockside cranes.

Operation of railway systems requires that permanent way is constructed and maintained for the safe passage of railway vehicles. Inherent within this requirement are standards of permanent way management, design, construction and maintenance which ensure the safety of all personnel and vehicles encompassed by the operations and maintenance of a railway.

External guidance upon permanent way is concentrated within Railtrack and is much concerned with the high speed running of heavy freight and passenger traffic. MOD railway systems are predominately freight carrying and operated at low traffic speeds.

This Guide is for the use of Top Level Budget Holders by application through their Property Managers, Railway Operating Staffs, Project Sponsors, Establishment Works Consultants, Works Services Managers, consultants, project managers and works contractors.

Defence Estate Functional Standard Design and Maintenance Guide 09 was prepared under the patronage of Headquarters Quartermaster General. It supersedes the DOE/PSA document Technical Instruction Civil Engineering (TICE) 37.

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# 1 Introduction

## 1.1 SCOPE

This manual sets out the policy, practice and standards for permanent way design, construction and maintenance and is applicable to all MOD railway facilities. It must be read by all staff engaged in or responsible for the procurement of such work.

This manual supersedes Technical Instruction CE37 : Railways Permanent Way Standards for Design, Construction and Maintenance 1989 amendment, and therefore includes changes in railway design, construction and maintenance. It provides current MOD organisational structure within the context of current permanent way good practice and legislation.

The aim of this manual is to give a broad overview of permanent way design, construction and maintenance, recognising that the reader may not be familiar with the subject but may have responsibility for a railway installation. Some aspects of permanent way are considered in depth particularly health and safety matters, procurement of works, inspections and maintenance work.

## 1.2 THE PERMANENT WAY

### 1.2.1 General

The track commonly found in MOD facilities falls into two main types, each specified according to function. **Standard gauge** track is similar to that found in most British railways and is normally chosen for its ability to support high tonnages, faster speeds and compatibility with the European rail network. **Narrow gauge** track is comprised of lighter components and is therefore likely to be used for transporting lighter, smaller loads using tighter radii within a self contained railway.

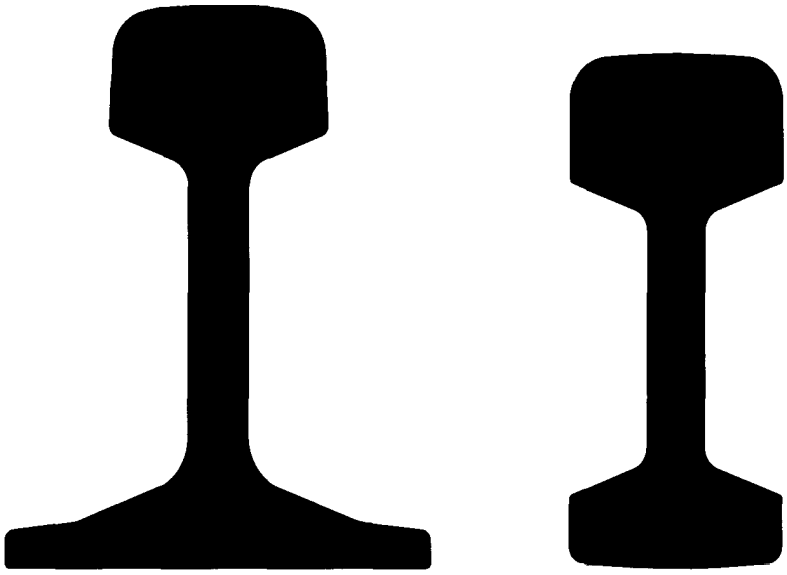
### 1.2.2 Standard Gauge

Standard gauge has traditionally been 1435mm (4' $8^{1}/_{2}$) and refers to the distance between the inside faces of each running rail. However, there has been a recent move towards the use of 1432mm (4' $8^{3}/_{8}$") as standard gauge. The dimension is fixed and is widened only to facilitate movement of rail vehicles around tight curves.

### 1.2.3 Narrow Gauge

Narrow gauge railways may have a track gauge within the range 600mm (23.62") to 1000mm (39.37"). Typical gauges are 600mm (23.62"), 610mm (24"), 762mm (30")and 1000mm (39.37").

**Figure 1.1** Rail types



FLAT BOTTOM RAIL BULLHEAD RAIL

### 1.2.4 The Rails

There are two main section shapes of rail that are used for railways : the bull-head section and the flat-bottom section.

Each section has in common a 'head' on which the wheel runs, a 'web' and a 'foot'. In the bull- head section the head and the foot are of the same width, but the head is deeper than the foot in order to allow for wear. In the flat-bottom section the head is of similar shape to the head of the bull-head section, but the foot is much wider and is flat on the under side.

Flat-bottom rail is now the general standard for MOD railways but there is still a considerable amount of bull-head rail in existence which will be replaced by flat-bottom rail only when it becomes due for renewal.

Rails are joined by means of fishplating or welding. Fishplates are pieces of metal which are fitted between the underside of the head, and the top of the foot of the rails to be joined, and are held together by 'fishbolts' passing through holes in the fishplates and the web of the rails. Welding of the rails is predominantly used on main line railways where it offers significant advantages in terms of increased line speed and passenger comfort. Therefore the practice of welding rails on MOD Railways is not widespread or economically feasible. However, welded joints are to be found in hardstandings where their use eliminates the maintenance problem which arises through inaccessible fishplates.

### 1.2.5 Fastenings

The method of fastening the rail is dependent upon the rail section being used.

Bull-head rail requires the use of a chair and a hardwood or steel key. The chairs are made of cast iron and a number of different patterns are required for turnouts. They are normally fastened to wood sleepers by means of coachscrews or fang bolts which pass through the sleeper.

The method of fastening flat-bottom rail is dependent upon the weight of rail used, the type of sleeper i.e. wood, concrete or steel, and the standard of fastening required.

The most basic of fastening methods is the dog-spike (timber sleepers only) which can be used with or without a baseplate and relies upon the spike holding the foot of the rail in position. The spikes are square in section with large heads which overhang the edge of the rail foot. They serve to hold the rail to baseplate and baseplate to sleeper. The baseplate forms a bearing for the foot of the rail and also serves to spread the load over a much larger area of the sleeper than the rail foot alone if it were placed directly on the sleeper.

Spring spikes, similar to dog-spikes perform a double function, holding the rail to the baseplate and baseplate to the sleeper. Their advantage over the dog-spike is that they provide a good grip on the foot of the rail and restrict movement of the rail due to oscillation.

Another method of fastening is the rigid or spring-steel clip with bolts, or spring-steel clips, without bolts, to hold the rail to the baseplate and bolts or spikes to hold the baseplate to the sleeper. The advantages of this method are that it provides good purchase on the foot of the rail and using bolts with the clips the load of this purchase can be varied.

### 1.2.6 Sleepers

Sleepers perform the task of holding the rails the correct distance apart (gauge), and distributing to the ballast the load imposed on the rails by the rolling stock.

As the chief qualities required are a certain amount of flexibility combined with toughness and resistance to shock, timber, prestressed concrete and steel are the most common materials from which sleepers are made. The development of prestressed concrete has made it favourable over timber, providing greater strength to carry higher axle loads and increased lifespan.

### 1.2.7 Ballast

Ballast is the name given to the material placed between the sleepers and the formation. It's functions are to:

- distribute the load of traffic from the sleepers to the formation without progressive settlement
- permit drainage of the track
- prevent lateral movement of the track
- prevent longitudinal movement of the track, and
- afford a convenient medium for packing the track to cross level and gradient.

The depth of the ballast provided varies depending on a number of factors, but within limits the deeper the ballast the better, since the greater the depth the less the intensity of pressure on the formation and the less maintenance required. However, there are limits put on ballast depth due to economic constraints.

To assist in the prevention of lateral movement of the track an adequate width of ballast shoulder must be provided, particularly on the outside of curved track.

A variety of materials are used as ballast according to the category of the line, the proximity of the sources of supply of materials and the possibility of subsidence.

The following materials are in common use as ballast:

- Crushed granite or whinstone
- Crushed slag
- Crushed limestone
- Gravel
- Crushed flints

Previously ash has been widely used to ballast MOD permanent way. However, it is not now preferred as it crushes to dust and drains poorly.

### 1.2.8 Formation (Subgrade)

The natural or constructed formation has to bear the weight of traffic transmitted via the rails, baseplates, sleepers and ballast. This weight must be distributed sufficiently so that the formation can take the load without significant deformation.

### 1.2.9 Drainage

Drains are provided to carry away water which has percolated through the ballast and down the cross- fall of the formation to the cesses, otherwise it may soften the haunches of the formation. On embankments this usually presents no problem as the water runs over the edge and down the slope of the bank. In cuttings the water must be collected and carried to a discharge point, usually nearby streams or ditches.

# 2 Management of MOD Permanent Way Works

## 2.1 RESPONSIBILITIES WITHIN THE MOD

Within a rail served establishment the responsibility for the design, construction and maintenance of permanent way lies with the Property Manager. Assisting the Property Manager are the Establishment Works Consultant (EWC) and the Works Services Manager (WSM). The roles and duties of each body are currently defined in Defence Estate Specification 005 Issue 003.

The Defence Estate Organisation (DEO) provides the technical and procedural support to Property Managers on request.

The Establishment Works Consultant and Works Services Manager may engage and utilise specialist sub-consultants and contractors who have detailed knowledge of permanent way work.

The maintenance of the permanent way is achieved through the Works Services Manager who undertakes the works services as requested by the Property Manager. This may involve either the use of specialist contractors or direct labour managed by the WSM.

Close liaison must be maintained between the Property Manager and the Railway Operating Manager (Superintendent, Yardmaster, Railway Officer) responsible for all movements of rolling stock. Army rail served establishments are administered locally with advice from the Railway Staff Office located in Andover. Royal Navy bases are administered by the Director Naval Bases and Supply Agency/Mov.l, Block F, Ensleigh, Bath BAl SAB, again the Railway Staff Office provides advice.

## 2.2 RESPONSIBILITIES OF THE RAILWAY INSPECTORATE

Her Majesty's Railway Inspectorate (HMRI) is part of the Health and Safety Executive and is the approving body responsible for all UK railways. All railway construction and operations must be approved by HMRI prior to use which will usually involve a detailed site inspection of the facility. Further information on the approval of works by HMRI can be obtained from the HSE publication *Guide to the approval of railway works, plant and equipment.* In addition HMRI may carry out inspections of a railway facility at any time which may result in temporary closure of a railway or a reduction in operating.

Liaison with HMRI shall be via the Railway Staff Office.

## 2.3 INTERFACES WITH OTHER RAILWAY COMPANIES

Railtrack is now responsible for the track and signalling of what used to be British Railways. The operation of freight and passenger services has been allocated to various franchises. Where a maintenance agreement was previously reached with British Rail this arrangement will normally be perpetuated by Railtrack. Track which is under Railtrack maintenance must be marked by maintenance limit plates which are usually affixed to the nearest sleeper to the boundary. Rights of access for inspection, maintenance, repair and procedures for approval of alterations or additions to the track will be in accordance with the Sidings Agreement between Railtrack (British Rail) and the MOD. If the Establishment has any reason to consider that the standard of maintenance achieved by Railtrack is below that required by this manual advice should be obtained from the Railway Staff Office.

All connections to Railtrack mainlines and their associated signalling are the responsibility of Railtrack and are renewed and maintained by them as necessary.

A number of MOD railways are used by mainline locomotives and rolling stock for the delivery of goods. Where this is the case it is important that the tracks are maintained to Railtrack Group Standard GC/EH0005.

With the increased use of the Channel Tunnel for the movement of freight by rail, rolling stock with profiles larger than the UK standard will become more common. There is therefore a necessity to check that an MOD railway facility has the necessary clearances to suit any proposed incoming rolling stock. This subject is discussed further in the chapter 'Loadings and Structure Gauges'.

### Effects of different rolling stock

Rolling stock will affect the permanent way in differing ways. For instance, if rolling stock from other railway companies using MOD facilities has been poorly maintained there is a strong likelihood that component wear will be accelerated thus increasing permanent way maintenance costs. It is therefore important for a Railway Operating Manager to monitor all rolling stock using a facility.

## 2.4 TRAINING

It is important that each person involved with permanent way, in whatever capacity, receives training appropriate to that person's responsibilities. Training may be available on a local basis but considering the specialist nature of permanent way work it is more likely that courses run at a central location will be required.

A number of specialist training companies offer courses at various levels and will attract industry wide attendance.

Generally, the EWC and WSM are to ensure that the training of their staff and the staff of any sub- consultant or sub-contractor is consistent with discharging the duties they are required to carry out as part of DEO(W) Specification 005.

### Appreciation Course

A one or two day course giving a general appreciation of permanent way. This course is recommended for those with a management responsibility for an Establishment railway and will include:

- types of track system
- plain line track

- switches and crossings
- track geometry
- clearances and curves
- ballast, formation and drainage
- maintenance of track
- legal and safety requirements
- specifications and standards

**All Persons Working on the Railway**
A half to one day course giving basic instruction on how to work or walk safely on the railway. The course will include an examination, the successful completion of which will result in the issue of a permit to work. It should be noted that staff must also be certified as physically fit to work. This course may also be supplemented by a basic first aid course. If a person wishing to work on MOD railways is in possession of a current Railtrack Personal Track Safety certificate then attendance at an alternative course may be waived. The Railway Staff Office can assist and advise in this matter.

**Staff carrying out work on the track**
Staff may attend two specific types of course. The first type is designed to train staff in the basic techniques of track maintenance and will cover subjects such as sleeper changing, manual packing, rail fastenings, lifting components, maintenance of joints etc..

The second type of course will be equipment driven and involve specialist certified training in the use of particular tools or techniques. It is likely that training will be given by individual manufacturers on site or at the manufacturer's premises. Examples of typical courses will be rail grinding, welding, on track plant etc.

EWC's and WSM's are to ensure that their staff, subconsultants, subcontractors, etc. satisfy the above two paragraphs and in addition are competent to undertake the work with which they are tasked.

**Approval of work**
All work carried out on the permanent way must be approved prior to releasing the track for the safe running of trains. Such approval must be carried out only by a person who is competent to do so.

It should be noted that due to the reduced line speed of MOD facilities and certain differences from Railtrack lines, certification to work on MOD railways may not be valid on other systems.

## 2.5 PERMITS TO WORK

**Applications For Permits**
All contractors carrying out work on Ministry of Defence property require permits to work, which should only be issued by the Railway Operating Manager via the WSM. A railway specific permit to work will be issued to contractors carrying out work on or about the railway. The area bounded by the term "on or about the railway" is within a limit of 3m (10' 0") outside of either running edge.

For tasks to be carried out on or about the railway a method statement must be submitted by the WSM (or other party carrying out the work) to the Property Manager a minimum of 10 working days prior to carrying out the work so as to

allow for an assessment of the safety implications to be carried out. From this assessment (carried out with the assistance and approval of the Railway Operations Manager) the needs for possessions will be identified.

**Person In Charge of Works (PICOW)**
When the WSM (or other party) submits a method statement for consideration by the Property Manager a person shall be nominated to be held responsible for the work. This person will be known as the PICOW and must be certified suitably fit and competent for carrying out the task.

When the permit to work is issued, the PICOW will be briefed by the Railway Operating Manager on safety implications affecting the work. The PICOW will be responsible for setting up a safe system of work with an Engineering Supervisor being responsible for the work.

**Safety**
Railway operating staff require briefing regarding site locations and the nature of the work for which permits have been issued. A temporary speed restriction deemed suitable by the Railway Operating Manager shall be imposed on the line passing the site.

Trains approaching permitted worksites shall sound an audible warning to provide sufficient warning for those undertaking work on or about the track to stand clear of the line.

The operating staff shall inform the Railway Operating Manager if staff are observed carrying out non-authorised work on or about the track.

## 2.6 POSSESSIONS

**Requirement For A Possession**
The need for a possession shall be submitted by the WSM through the Property Manager to the Railway Operating Manager and should include a risk assessment. This may be based upon a method statement submitted by a sub-contractor. This requirement shall be established a minimum of 5 working days prior to carrying out the work so as to allow for sufficient notice to be given to all those affected by the possession.

All works to be carried out by a contractor involving the removal of rail from the track shall be covered by a possession.

**Person In Charge Of Possession (PICOP)**
When a possession is necessary to undertake work the nominated PICOW shall be held responsible for taking of possession and may be referred to as the PICOP (Person In Charge Of Possession). That person should be certified as fit and competent for carrying out the task.

When a WSM takes a number of possessions in parallel and these possessions are within a reasonable distance of each other (100m), one man may be appointed to be responsible for all of the possessions. Otherwise an individual PICOP will be required for each possession, this requirement shall be specified and provided by the WSM.

**Demarcation Of Possession Limits**
The limits of a possession should be defined where possible by the turnout identification numbers at either end of a track section or a suitable immovable reference object such as a level crossing or building entrance.

Limiting turnouts where possible shall be clipped and padlocked out of use so as to safely isolate the worksite. The keys for the padlocks to remain in possession of the PICOP at all times.

Where it is not possible to isolate the section of track where the possession is to be established, the limits of the possession are to be normally defined by the positioning of at least a suitable red marker board or banner and a red flashing light at a pre-determined position specified by the Railway Operating Manager.

**Responsibilities For Possessions**

The Railway Operating Manager shall have sole responsibility for issuing the authority for taking a possession; the PICOP shall be the only person authorised to establish the possession and shall be held responsible for handing back the track within the possession to the Railway Operating Manager in a safe condition suitable for use. The PICOP shall be solely responsible for putting down and removing the method of demarcation for the possession and work may only commence after the system of demarcation has been established.

# 3 Health and Safety

## 3.1 WORKING ON AN OPERATIONAL RAILWAY

The most common single type of fatal accident to railway workers has been to be struck by a train while on foot on the track. The risk of fatality is higher than for general industry as railway workers are frequently exposed to hazards (moving trains).

The introduction of the Health and Safety at Work etc. Act 1974 required by implication a form of risk assessment to ensure measures are taken to reduce risk. This risk assessment was made mandatory with the introduction of the Management of Health and Safety at Work Regulations 1992.

The safety of railway staff was further enhanced by the introduction of the Railways (Safety Case) Regulations 1994 and the Railways (Safety Critical Work) Regulations 1994.

Everyone who is in charge of work on the track and those directly at risk should be familiar with and apply the following principles.

1. *Work on or about the operational railway should be minimised*

- all railway lines must be considered operational
- so far as is reasonably practicable, work should be done when trains are not running at all
- if this is not possible work should be segregated from trains e.g. by diverting trains onto other tracks or providing fencing or if separate from the nearest running line remaining open by at least 2m (6'6"), appointing one or more site wardens
- if this is not possible work may be undertaken in traffic provided that protective systems are in place to give adequate warning of the approach of trains. It is the duty of the PICOW to set up such a system.

2. *Only appropriate people should go on or near the track when trains are running*

- they must be fit to do so
- they must have received appropriate training
- those responsible for the safety of others should be further trained and carry certificates to demonstrate their competency

- they should wear protective clothing in accordance with The Personal Protective Equipment at Work Regulations 1992, including high visibility clothing of an approved colour (usually orange with reflective stripes)

3. *Safety features for workers should be provided*

- a safe means of access to the railway should be provided and maintained
- where people may be on or near a track open to the passage of trains, places of safety should be provided and maintained
- track safety information should be provided in a convenient and comprehensible form to everyone who needs it

4. *Safety systems to warn of trains*

- the use of technology is the preferred approach for warning of trains
- if this is not practical lookouts should be used; these should be clearly identified, have a reliable means of communicating warnings and have no other duties
- the system of work will ensure that sufficient warning time is provided to clear the track of obstructions and move to a place of safety
- on receipt of any warning people must immediately leave the track safe, move to a place of safety and acknowledge the warning

5. *Procedures for safety*

- a responsible person will be in charge of the safety of each individual or group (i.e. PICOW)
- recording of accidents and near misses should be encouraged
- safety systems should be planned, monitored and changes implemented if necessary

## 3.2 STATUTORY REGULATIONS

The last 150 years have produced a number of statutory regulations concerned with the safety of railways. This manual seeks to give an overview of current specialist legislation applicable to the design, construction and maintenance of permanent way within MOD establishments.

### 3.2.1 Management of Health and Safety at Work Regulations 1992

These regulations are not industry specific and therefore apply to all work activities. The general requirements of the regulations are:

- the need for risk assessment
- the need for effective planning, organisation, control, monitoring and review of preventative and protective measures
- the need to identify procedures for serious and imminent danger and for danger areas
- the need to provide health and safety information and training to employees

### 3.2.2 Railways (Safety Critical Work) Regulations 1994

These regulations place a duty on employers in the railway industry to ensure that employees carrying out work which is vital to the safe operation of the railway are competent and fit to carry out that work. Work defined as vital to the safe operation of the railway includes work carried out by—drivers; guards; signalmen; workers maintaining permanent way, signals or electrical power; inspectors of vehicles; workers involved in the coupling and uncoupling of vehicles.

It is important that a record is kept of assessments carried out to determine competence and fitness and employees must be issued with a means of identification stating that they may carry out the safety critical work for which they have been trained. For workers involved with maintenance or renewal of the permanent way up to the Property Management limit, the WSM must ensure that the above records and identification are available.

### 3.2.3 Railway (Safety Case) Regulations 1994

The Railway (Safety Case) Regulations require railway operators and infrastructure controllers to prepare and secure acceptance of a safety case before starting (or, in the case of an existing operator, continuing) to operate. Within the MOD the term 'railway operator' will apply to the Railway Operating Manager and the term 'infrastructure controller' to the Property Manager. The object of the safety case is to demonstrate that risks are appropriately controlled and to act as a working document for the ongoing management of risk.

A typical safety case will contain the following:

- a description of the railway operations, premises and plant
- technical specifications
- operations and maintenance procedures
- safety policy
- a risk assessment
- arrangements for the management of health and safety
- monitoring of health and safety performance
- safety management organisation
- details of competence and training
- arrangements for the flow of information between employer and employee and between employer and employer
- investigation of accidents
- management of contractors
- emergency response procedures
- procurement of premises and plant
- audit of the safety case
- timescale for remedial measures

Whilst the preparation of a safety case may appear to be daunting most of the above mentioned items will already have been prepared under different health and safety legislation and may be referred to by cross reference.

### 3.2.4 Construction (Design and Management) Regulations 1994

These regulations place new duties upon clients, designers and contractors to rethink their approach to health and safety so that it is taken into account and then co-ordinated and managed throughout all stages of a construction project; from conception, design and planning through to the execution of works on site and subsequent maintenance and repair.

The regulations apply to any permanent way construction or maintenance work where five or more people are engaged in construction work as defined in the regulations. Should however the work be of greater than 30 days' duration or will involve more than 500 person days of work, then the project must be notified to the Health and Safety Executive.

The application of the regulations involves the appointment of a Planning Supervisor at project conception who will prepare a Health and Safety Plan which brings together health and safety information obtained from the client and designers. The Health and Safety Plan is passed to the Principal Contractor during the construction phase who will draw upon the Company health and safety policy to prevent health and safety risks created by sub-contractors and other contractors on the site.

On completion of the construction work the Health and Safety File is handed to those who will be responsible for management of risks associated with the future repair and maintenance of the asset. The Health and Safety File is built up during the project by the Planning Supervisor and will contain relevant safety information e.g. positions of underground services, maintenance instructions, etc.

DWS Technical Bulletin 95/24 (and its addendum 12 Dec 95) provides advice on the CDM regulations as applied to Property Management. DWS Technical Bulletin 95/23 provides advice on the CDM regulations as applied to Projects.

## 3.3 PERSONAL PROTECTIVE EQUIPMENT

All personnel working on or about the permanent way should wear high visibility clothing of an approved orange colour. This may include reflective strips for night work. In addition safety footwear shall be worn which will have a steel toecap and, optionally, a steel midsole.

Other protective clothing such as gloves, ear defenders, face masks and eye protectors must be worn if demanded by the nature of the work being carried out. The risk assessment prepared for the item of work should determine what equipment should be used.

## 3.4 REPORTING OF ACCIDENTS AND DERAILMENTS

Reporting of accidents and derailments should be carried out by the Railway Operating Manager on MOD Form OPS18 and sent to the Establishment Commanding Officer, the Property Manager and the Railway Staff Office.

# 4 Maintenance

## 4.1 STANDARDS

The standards to which permanent way is to be maintained must provide for the safe and efficient operation of rolling stock having regard to overall economy.

## 4.2 CATEGORISATION OF TRACK

It is the responsibility of the Railway Operating Manager in conjunction with the Property Manager to identify the maintenance category of each track. This is to be reviewed on a regular basis to take into account changing trends of traffic flows using the railway. This review is to be undertaken after the Property Managers' discussion with the Railway Operating Manager and conveyed to the EWC so as to be able to target maintenance effectively.

Figure 4.1 gives the categories of use that are to be used on standard descriptions.

**Figure 4.1** Track categories

| | |
|---|---|
| A1 | Main strategic route, the loss of which would halt or cause a serious disruption to the running of an Establishment. |
| A2 | Secondary strategic route, the loss of which would cause a disruption or inconvenience to the running of an Establishment. |
| B1 | Secondary route or location which is only occasionally used. |
| B2 | All routes or locations under care and maintenance. |

## 4.3 PLANNING OF MAINTENANCE

A schedule or drawing of all sections of track within a depot has been an extant requirement. This shows the Property Manager the categories of all track within a depot. The limits of a category of plain line will be defined by features such as turnouts or buffer stops which will enable a section of track to be isolated. Switch and crossing units are categorised independently.

The schedule/drawing shall be agreed with the Property Manager and Railway Operating Manager and signed accordingly. The categories of track lengths shall be reviewed as above and the schedule/drawing amended as required.

## 4.4 FREQUENCY OF INSPECTION AND MAINTENANCE OPERATIONS

The following section sets out a frequency recommended, if there is no higher frequency required by HSE legislation, for each inspection and routine maintenance operation relevant to the particular categories of use together with details of each maintenance operation. Actual frequencies are determined by Operation la.

### Maintenance Operation Frequencies

**Figure 4.2** Suggested Maintenance frequencies

| OPERATION CATEGORY OF TRACK | | | | |
|---|---|---|---|---|
| | A1 | A2 | B1 | B2 |
| OPERATION 1a (Inspection of Maintenance Regime) | Yearly | Yearly | Yearly | Yearly |
| OPERATION 1b (Report of Inspections and Works Services Regime) | Yearly | Yearly | Yearly | Yearly |
| OPERATION 2 (EWC Inspection) | Quarterly | Quarterly | Quarterly | Yearly |
| OPERATION 3 (Minor Maintenance) | Continuous | Continuous | Continuous | Only when specially ordered by the Property Manager |
| OPERATION 4 (Programmed Maintenance) | Twice yearly | Twice yearly | Twice yearly | Only when specially ordered by the Property Manager |
| OPERATION 5 (Programmed Maintenance) | Every two years | Every two years | Every two years | Only when specially ordered by the Property Manager |
| OPERATION 6 (Programmed Maintenance) | Twice yearly | Twice yearly | Twice yearly | Only when specially ordered by the Property Manager |
| OPERATION 7 (Remedial Work) | As required | As required | As required | As required |

Operation la
An overview of the permanent way arising from EWC Technical (Defect) Inspection or other reports. To include a risk assessment covering :-

Railways (Safety Case) Regulations 1994
Railways (Safety Critical Works) Regulations 1994
Carriage of Dangerous Goods by Rail Regulations 1994

and hence to reflect on the site specific Technical (Defect) Inspection frequency (Operation 2) and all works services activities (including Operations 3 to 7 above) in relation to the above regulations. This overview will be carried out by the Railway Staff Office as part of the annual technical review and a formal report will be provided to the Property Manager for action by the EWC as appropriate.

Operation1b
EWC's report upon implementation of the Railway Staff Office report (Operation la).

Operation 2
EWC's technical inspection by a suitably qualified engineer of the whole of the permanent way including formation, drainage, overgrowth and all other items necessary to keep the permanent way in safe running order and within 5 working days from the completion of inspection submit a written report of all defects to the Property Manager. Any urgent items found during the course of the inspection are to be reported to the Railway Operating Manager on the day they are discovered.

Operation 3
(1) Tighten or tension as required spikes, coachscrews, through bolts, keys and any other rail fastenings.

(2) Tighten as required fishbolts, bolts in turnout assemblies, check rail bolts in plain track, bolts in wheel or buffer stops and all other rail fittings.

(3) Top up rail lubricators.

(4) Clean out all flangeways including space between switchblades and stock-rails.

Operation 4
(1) Clean and oil slide plates with warm weather lubricant or de-icing lubricant, according to season.

(2) Adjust switch blades and stretcher bars.

(3) Adjust and oil lever boxes connecting rods and gauge tie bars.

Operation 5
(1) Take off all fishplates, wire brush and grease plates, rail bearing flanges and bolts, turn plates (except junction) and refix all plates. Oil and retighten through bolted sleepers

(2) Report all defects in rail ends, plates or bolts.

Operation 6
(1) Oil crossing gate hinges and catches.
(Note: level crossing barriers subject to special maintenance procedures as defined in the manufacturers maintenance manual.)

Operation 7
(1) Correct defects not covered by Operations 3-6.

The Property Manager will issue a MOD Form 1097 order for all works under Operations 3-7.

Items defined as urgent within an inspection report will be dealt with within 24 hours of the fault being reported. If it is not possible to deal with the fault within 24 hours the section of track on which the fault occurs will be closed to traffic.

## 4.5 THE EWC DEFECT INSPECTION

### Site Inspections

This independent inspection of the permanent way should specifically address defects which affect the safe running of the railway. Annexe B comprises a List of Common Defects which may be found whilst inspecting the permanent way. It should be recognised that this list is not exhaustive.

### Reporting

To maintain continuity of reporting the inspecting engineer should be afforded access to the previous report. A sample track inspection sheet is included in Annexe A of the standard. Access to the preceding report should also avoid duplication and allow for efficient monitoring of work undertaken to remedy defects. Once a year the EWC Defect Inspection Report shall detail the whole network and its identified defects. This report is to be timed to be that immediately preceeding the Railway Staff Office Inspection (Operation la).

The report should be presented to the Property Manager within 5-10 working days so as to enable the WSM to act promptly in procuring services to address items which have been reported which affect the safe running order of the railway.

Any urgent defects (those which affect safe operation) verbally reported to the Railway Operating Manager will be followed up by fax prior to inclusion within the report.

The report to be presented to the Property Manager shall be available in digital and hard copy formats.

## 4.6 TRACK UNDER CARE AND MAINTENANCE

Where a section of railway track is taken out of use and placed under Care and Maintenance, maintenance should be carried out as listed below in a manner such as to enable the track to be used immediately by the MOD during an emergency.

1. Liberally grease in place all fishplates, through bolts, fastenings and turnout parts with an approved long life grease.
2. Inspect track annually and make such renewals as necessary to achieve maintenance aims.
3. Keep ballast and formation surfaces free of weeds.
4. Keep drainage ditches and pipes in working order.
5. Keep structure gauge free of obstructions.

The nature of the work required under Care and Maintenance is variable and it should not be included as part of a term contract but should be derived from annual inspections.

A MOD Form 1097 order should be issued when any maintenance work is required.

## 4.7 MAINTENANCE PRACTICE

### 4.7.1 Formation and Drainage

The formation must be kept as dry as possible and any spoil above cess level should be trimmed off and removed from site to allow surface water to drain away.

Where drainage is poor the formation can "pump" under traffic and cause wet spots.

Drains and catchpits effecting the permanent way drainage must be regularly examined and cleared as necessary to ensure they are kept in good working order. Clearing of a blocked drain should always be started from the lower or outfall end as flooding may occur if drains at a higher level are cleared first. Where ditches, water channels or pipe drains are provided these should be kept clean and free flowing. Particular attention should be paid to the outfall of any drain or water course and any obstruction which is outside MOD property should be reported to the Property Manager. Any attempts by outside parties to divert water onto MOD property or any interference with the drainage system should be reported to the Property Manager.

Catchpits must always be fitted with lids or grids as appropriate. They must not be left uncovered, or otherwise be a danger to staff.

### 4.7.2 Cuttings and Embankments

The examination of cuttings should take place regularly, particularly after severe frost, heavy rainfall or snow thaw, to check whether any material has been loosened or has fallen so as to endanger traffic. Clay cuttings and embankments should be regularly examined for cracks, especially during periods of very dry weather and such cracks should be reported to the Property Manager who will arrange for any remedial work to be carried out.

Tracks laid over peat formations often suffer from significant settlement and special inspections and maintenance may be required.

Any signs of slips in cuttings or embankments must be reported to the Property Manager and any further developments watched carefully.

If a slip has occurred the following should be investigated:

| | |
|---|---|
| Cross Levels | One rail may tend to sink or heave relative to the other, leading to twist. |
| Alignment | The gradual introduction of "flats" or sharpenings into curves or of misalignments in straight track. |
| Interval between tracks | One track moving towards or away from an adjacent track. |

Leaning fence posts and signal posts, where previously upright, can indicate the presence of slips. A simple method for detecting movement in a slip is to drive a series of pegs at intervals in a straight line across and beyond the extent of the area believed to be affected. Occasional sighting along this line of pegs will disclose whether further movements are occurring, since the pegs move offline at such places.

When a slip occurs, the slip material should not be removed from the toe of the slope, except to the limited extent necessary for the passage of traffic pending the carrying out of full remedial measures, since the weight of material at the toe helps to retard further movement.

Where grouting of embankments is being carried out, particular attention should be paid to the site as there is the possibility of the injected grout lifting the track. Care must be taken to remove any grout contaminated ballast and replace it with clean ballast.

Slurried ballast from wet spots and other materials must not be piled upon cutting and embankment slopes but spread evenly over a larger area to minimise the risk of triggering bank slips.

Care and attention to trees and shrubs on slopes may be beneficial to the stability of banks.

### 4.7.3 Ballast

The functions of track ballast are to spread the load on the formation, to provide lateral and longitudinal stability of the track, to enable the track to be maintained to line and level and to permit the rapid dispersal of water. To ensure that these functions can be carried out properly it is necessary for ballast to be clean, well consolidated and correctly profiled.

The minimum ballast depth(below bottom of sleeper) to be provided is 150mm. However the actual depth will be dependent on line speed, tonnage, rolling stock type and formation type. Using these factors the correct ballast depth should be checked prior to maintenance of the track.

Adequate quantities of ballast should be provided prior to lifting, tamping or lining work and on completion of the work any deficiencies made good. Ballast regulation will normally be carried out manually but on-track ballast regulators are available for major items of work.

Stone to be used as a packing material should be 12-14 mm broken stone chippings, clean and free from dirt. The stone should be of a hard durable quality (Wet Attrition Value 4%) and angular in shape.

Track must be supported by adequate ballast shoulders, the width of which should be as follows for CWR

| | |
|---|---|
| Straight track | Min. 380mm (1' 3") |
| Curved track of radii greater than 800m | 460mm (1' 6") |
| Curved track of radii 800m and less | 530-600mm (1' 9"-2' 0") |

In all CWR track including S&C the shoulders should be heaped 125mm (5") above the top of sleeper level.

For jointed track ballast shoulders should be a minimum of 300mm (1' 0") wide.

The four-foot and six-foot must be fully ballasted so that the vertical faces of the sleepers, timbers or bearers are not visible.

Where there is a substantial difference in level between adjacent tracks, special precautions may be required to provide stability to the higher track.

On CWR track not more that six alternate half cribs or two consecutive full cribs within a 9m length may be opened out at the same time.

Particular attention must be paid to the packing of sleepers in the area of the transition from a bridge deck or paved track to ballasted track.

**Ballast Deterioration**
Deterioration of ballast is brought about by erosion from the movement of sleepers because of the action of trains, the action of tamping machines, contamination from wind blown debris and wagon spillage. The products of deterioration will clog the ballast, reducing the drainage properties, the effectiveness of tamping and support to the sleepers.

Concrete sleepered track, if not well packed with clean ballast, will quickly develop wet spots or ballast contaminated with a ballast/concrete sleeper slurry which in dry weather sets into a hard material. The removal of this material is essential if the stability of the sleepers is to be restored.

**Repair of Slurried Track**
Wet spots are symptoms of one or more problems which may include: dipped joints, poor quality welds showing dips and humps, ballast and drainage deficiencies, loose or missing fastenings, missing rail pads and rail surface irregularities. It is essential that the reason behind the formation of the wet spot should be remedied before, or at the same time as, the wet spot treatment is undertaken.

A minimum depth of clean ballast must be provided below the bottom of the sleepers and the bottom of the excavation must fall towards the nearest drain or suitable ground. A crossfall of 75mm over the length of a sleeper is required. Work should progress towards the predominant direction of traffic.

### 4.7.4 Sleepers

**Spacing**
The recommended spacings between the centres of sleepers are:

| | |
|---|---|
| LWR/CWR track (concrete sleepers) | 650mm (2' 2") |
| LWR/CWR track (steel or timber sleepers) | 700mm (2' 4") |
| Jointed track | 750mm (2' 6") |

These spacings apply if BS113A rail is used, supporting a 25t axle load. If BS75A(R) rail is used the above sleeper spacings will only support a 17.5t axle load.

At sites with known formation difficulties or curves sharper than 800 metres radius additional sleepers down to 650mm spacing may be used.

When replacing or installing additional sleepers in existing sleepered track, compatible types must be used, preferably of the same design. It is not mandatory to replace existing sleepers with new sleepers.

Equivalent No of Sleepers per Track Panel for BS113A rail

750mm (2'6") = 24 sleepers per 18.3m (60') length
700mm (2'4") = 26 sleepers per 18.3m (60') length
650mm (2'2") = 28 sleepers per 18.3m (60') length
600mm (2'0") = 30 sleepers per 18.3m (60') length

BS75A(R) rail may be upgraded from an axle load of 17.5t to an axle load of 25t by inserting an extra four sleepers per 18.3m length.

**Lateral Resistance of Sleepers**
The lateral resistance of CWR laid on concrete sleepers on sharply curved track can be increased by employing lateral resistance end plates which are fitted to the ends of concrete sleepers to increase the cross sectional area of the end of the sleeper.

The sleepers must be drilled to provide fixing holes for these devices. Lateral resistance end plates are suitable for concrete sleepers, timber sleepers and S&C timbers. Ballast must be well consolidated immediately after installation using ballast tamping equipment.

Care must be taken to ensure that the holes are drilled clear of the pre-stressing wires or strands in concrete sleepers.

**Voids under Sleepers**

It is important to keep the rail bearing portion of each sleeper well packed and free from voids. Voids can be detected by watching the vertical movement of the sleeper under traffic and in the case of timber sleepers by sounding, near the chair or baseplate, with a hammer or accurately measured using void meters. Tell-tale white, rounded pieces of ballast on or at the ends of concrete sleepers, which may also show white dust, will indicate the presence of voids.

**Defects**

When isolated sleepers become defective and/or decayed they should be removed and replaced with sound serviceable or new sleepers of compatible type. The number to be consecutively removed will generally depend on site conditions, ie obstructions, traffic interruptions, etc, but on CWR track only one sleeper may be removed in a 9m length at any one time.

When screw fastenings have become loose and left untightened or where ferrules have not been replaced when they have become worn or damaged, then the action of passing traffic will cause the chair or baseplate to push the screws outwards thereby elongating the holes in the sleepers. Once started, the to-and-fro motion of the chair or baseplate (shuffling) will abrade the surface of the timber causing an indentation which will retain water and accelerate decay of the sleeper.

Where sleepers have enlarged or elongated baseplate/chair screw holes which are not capable of being treated with maintenance liners but where there are no indications of indentation or adzing, then it is permissible to pull the sleeper through.

In the process of "pulling through" sleepers all the baseplate/chairscrews or spikes are withdrawn, the rails and chairs or baseplates eased off the sleepers and the affected sleeper pulled laterally under the track. The rails and chairs or baseplates are then lowered back onto the sleepers and the chairs or baseplates re- fastened, new holes being drilled for the screws or spikes.

The precise distance that the sleeper is to be moved must be determined on site but any new baseplate/chairscrew holes must not be closer than 75mm to existing holes under any circumstances.

Where sleepers are pulled through there must be not less than 150mm from the outermost edge of the chair or baseplate to the end of the timber. Only in an emergency should this minimum dimension be reduced and a new sleeper installed as soon as possible.

All redundant chair/baseplate screw holes in timber sleepers must be either plugged with timber plugs or, if softwood, have borate rods inserted and the holes capped. Softwood sleepers cut on site must have the cut surface(s) treated with creosote and cut ends of hardwood sleepers should be given a coating of an approved switch lubricant.

**Inspection of Wooden Sleepers**
There are three inspection methods for wooden sleepers currently available:

1. Visual Examination In-situ

Visual examination of the exposed surfaces of the sleeper in track will not reveal the presence of decay on the underside or within the sleeper. Similarly, severe weathering of the top surface, indicating poor condition, may mask timber which may be quite sound internally. This method is suitable for general assessment only.

2. Examination of Sleepers Removed from Track

Sleepers which have been removed from the track can be examined for condition as follows:

(i) by using a small hammer, the sleeper can be "rung" by striking one face of the sleeper after the sleeper has been stood on edge. A sleeper which is internally sound will produce a distinctive clear note whilst a sleeper which is internally decayed produces a dull tone;

(ii) by using a small hand pick to probe for areas of decay. This method is more or less destructive and the examined sleepers may be of no further use. Examination of the sleepers by pick should concentrate on the chair or baseplate seating areas especially around the screw or spike holes, splits, areas of damage and on the underside of the sleeper.

3. Sleeper Integrity Tester for use on Softwood Sleepers

A device known as the Sleeper Integrity Tester (SIT) which uses a non-destructive technique based on the simple principle of the wheel tapping hammer has been designed to simplify the assessment of the condition of plainline softwood sleepers. This principle, although modified, has been applied successfully to wooden sleepers, where the SIT impacts the sleeper and monitors the response. An analysis technique built into the instrument quickly identifies the overall condition of the sleeper.

**Borate Rod Preservation of Softwood Sleepers**
For maintenance purposes sleepers having the potential for repair should be treated by installing borate rods into holes drilled vertically into the sleeper. Fungal growth in sleepers can be delayed for up to six years from one treatment with the borate rods but, once one set of rods has been dissolved, they must be replaced to provide continuous protection.

**Gauge Spread on Timber Sleepered Track**
Where gauge spread has taken place then the fitting of gauge ties or tie bars (which must be of the insulated type on track circuited lines) can be undertaken as a temporary measure (up to three months) to return the track to gauge.

Permanent repairs, which may include the installation of replacement sleepers or S&C timbers, attention to fastenings and the fitting of gauge stops, must be put in hand as a matter of urgency.

**Banding of Timber Sleepers**
It is possible to prolong the useful life of sleepers where splits are present but the sleeper is otherwise sound by fitting stainless steel bands adjacent to the chair or baseplates both inside and outside the fourfoot. It is necessary to open out the beds at the locations where the bands are to be applied but the process can be undertaken between trains.

**Inspection of Concrete Sleepers**
There are two methods of inspecting concrete sleepers.

1. Visual Examination In-Situ

Visual examinations of concrete sleepers should be made to determine the presence of transverse and longitudinal cracks in the vicinity of the fastenings, rail seat and in the fourfoot, the latter indicating centre binding. Loose and/or skewed cast-in housings and the breaking up of the ends of the sleepers can also be detected.

This method of inspection will not usually reveal the presence of abrasion of the underside (soffit) of the sleepers nor the presence of longitudinal horizontal cracks.

A more thorough examination of the longitudinal vertical faces of the sleepers can be made if the beds are opened out.

2. Examination Out of Track

A thorough examination of the undersides of concrete sleepers can be made only if the sleepers are removed from the track. Replacement sleepers must be of the same type.

Where soffit abrasion is severe then the lower stressing wires or strands will be visible on the underside of the sleeper for more than 100mm (4") from each end of the sleeper and if this condition exists then the sleepers must be replaced at the earliest opportunity. Similarly, the presence of exposed stressing wires or strands away from the sleeper ends must be taken to indicate that the sleeper will fail at an early date.

### 4.7.5 Switch and Crossing Timbers and Bearers

**Types**
Hardwood timbers, softwood timbers and concrete bearers are used with switches and crossings. However, softwood and hardwood timbers must not be mixed in the same layout.

**Maintenance Requirements**
The maintenance requirements for S&C timbers are similar to those for wood sleepers and those for concrete bearers are similar to the requirements for concrete sleepers.

**Indentation**
Indentation of S&C timbers can occur, especially in vertical design layouts on sharp curves, where the outside rails of both the main line and the turnout are subjected to high lateral loading. In such cases the outer ends of the baseplates are being driven into the timbers and galling of the baseplate, clip shoulder and rail foot may be present with resultant gauge widening.

**Gauge Spread**
Fitting of gauge stops to timbers at the outer face of high rail chairs or baseplates and/or to the outer face of low rail chairs or baseplates when the timbers are new will greatly assist in preventing gauge spread. It is necessary to treat all timbers likely to be affected by gauge spread in a layout otherwise any benefits will soon be lost. Fitting gauge stops to timbers after they have been in

the track for some time is of doubtful value since the chair/baseplate screw holes are already worn and, whilst there will be some short term benefit, overloading of the gauge stop screws will soon occur.

If the fitting of gauge stops has not been done or has failed then the most satisfactory solutions are either to pull the affected timbers through to provide a new bearing area for the whole length of the baseplate, or to replace the timbers.

The fitting of gauge ties or tie bars (which must be of the insulated type on track circuited lines) can be undertaken as a temporary measure (up to three months) to return the track to gauge.

**Adzing of Timbers**
Adzing of the timbers under the affected baseplates to provide a level bearing area is not recommended but if this is the only method that can be adopted then the cross-level of the track must be restored by fitting thick base chairs/ baseplates on hardwood packing to compensate for the timber removed. All adzed surfaces of softwood timbers must be treated with creosote but cut surfaces of hardwood timbers should be treated with approved switch lubricant.

### 4.7.6 Chairs, Baseplates and Fastenings

**Chairs**
Chairs must be placed firmly to the foot and web of the rail and held in place by a wood or steel key of either the tapered or self retaining type. Where a tapered key has worn or distorted or the chair jaw has become worn the old key should be driven out, the sleeper and chair held up tight to the rail and the new key driven in with the addition of a maintenance liner if necessary.

Broken chairs, or those incapable of gripping a key and maintenance liner must be replaced. Chairs must not be struck with a hammer because of the possibility of damage to the chair and injury caused by flying splinters of the casting.

**Baseplates**
Flat bottom rail must seat evenly on baseplates with all fastenings correctly tensioned. All broken or defective baseplates must be replaced at the first opportunity with baseplates of compatible types. If there is any doubt about the grip of spike fastenings in the sleepers then maintenance liners should be fitted before the spikes are re-driven and additional spikes can be fitted to holes not in use.

Where attention is given to baseplates and/or fastenings the sleepers must be repacked, the ballast returned to the correct profile and consolidated where necessary. Baseplates must not be struck with a hammer because of the possibility of damage to the baseplate and injury caused by flying splinters of the casting.

**Chair/Baseplate Screws (Coachscrews or Chairscrews)**
Correct hole sizes must be drilled to suit the coachscrew or chairscrew specified. All holes must be drilled vertically and centrally with respect to the chair or baseplate holes. Screws must NOT be driven in the timber or sleeper by the use of a keying or sledge hammer. In softwood the screw can be "started" quite easily by hand prior to being screwed down by means of a "T" spanner or impact wrench. For hardwood one light tap only using a keying hammer is all that is required to "start" the chairscrew. Chairscrews must not be tightened so far that the underside of the head makes contact with the upper surface of the chair or

baseplate but must just contact the top of the ferrule. Chairscrews must be entered vertically into the pre-drilled holes; care must be taken to ensure that the chairscrew remains vertical as it is screwed home.

Chairscrews which are bent, have damaged threads, show signs of corrosion or have damaged square heads should be scrapped.

Prior to any tamping or lining Chairscrews must be checked and tightened where necessary.

When chairscrew holes have become enlarged and the timber or sleeper is no longer capable of gripping the chairscrew then either maintenance "M" screws or maintenance liners or coils should be used.

Where gross elongation of the chairscrew holes has been allowed to develop it is possible that the fitting of the maintenance liners or coils may not be sufficient to restore the grip of the chairscrews. In such cases it will be necessary to either "pull through" the affected timber(s) or sleepers or provide new serviceable timbers.

Chairscrew holes which are not drilled either centrally or vertically with respect to the baseplate or chair holes will result in the chairscrew pulling the chair or baseplate out of position as the screw is tightened down. This will result in variations in track gauge.

For softwood timber two persons using a "T" spanner will exert sufficient torque to tighten chairscrews but the use of an impact wrench is recommended for fitting chairscrews to hardwood timber. In both cases care must be taken to avoid crushing the ferrule.

**Ferrules**

Ferrules are designed to be inserted into the holes in chairs or baseplates such that the top of the ferrule is 6mm ($^1/_4$") above the upper surface of the chair or baseplate.

Ferrules must not be driven fully home into the hole in the casting, unless the ferrules are of the flange type, when the flange must be in contact with the top of the chair or baseplate. Screws must be inserted with care to avoid damage to the ferrules by overtightening. Full contact must be made between the underside of the head of the screw and the ferrule. The screw must not make contact with the chair or the baseplate.

Where ferrules have become distorted or damaged because of incorrect fitting or through the effects of traffic they must be replaced by new ferrules of the correct type. In cases where the ferrule drops into the chair or baseplate without any force being applied to the ferrule, then the chair or baseplate must be renewed.

Where ferrules are prone to crushing, nylon "66" ferrules should be used.

**Bullhead Rail Fastenings**

In through bolted sleepers, the nuts of all chair bolts should be systematically oiled and retightened at least once every two years. Where through bolt nuts cannot be tightened because of deterioration of the underside of the sleeper, the nut can be burnt off and a new chair bolt fitted. Where chairbolts have become seized up they should first be treated with penetrating oil to make them workable and where they have already been tightened to the limit of the thread, mild steel round washers 3mm ($^1/_8$") or 6mm ($^1/_4$") thick may be used under the nuts. The bolt should not be overtightened; 1 person using a standard "T" spanner will provide adequate torque.

Keys must be driven in the direction of traffic, except at joints where the key on each side of the joint is driven towards the fishplate. On single lines keys should be driven either in the direction of the main weight of traffic or in the direction in which there is a tendency to creep or, if traffic is equal in both directions and rail creep is not present, in alternate directions on adjacent sleepers. Each key must be tightly driven but not overdriven and all keys found to be loose or out must be re-driven immediately. When keying up, the chair must be held firmly to the foot of the rail to ensure that the rail is properly bearing on the chair seating and firmly against the inner jaw of the chair.

Wooden keys are slightly tapered, with distinguishing mark "S" at the thin end, and wood or metal packing liners should be used between the web of the rail and the key when the keys are found to be undersized for tight driving but otherwise sound. Wood keys should be used in tunnels. Stocks of keys, packing or liners should be kept under cover until required.

Standard steel keys must not be used in check rails, parallel wing rails or in tunnels nor must they be used in vertical position, Steel keys are suitable for all other locations and must be used with bullhead CWR.

All horizontal bolts must be oiled or greased before being tightened, all blocks firmly gripped and the rails correctly seated in the chairs before they are finally screwed or bolted down on the timbers.

New bolts must be used as replacements in S&C except as a very short term measure when new bolts are not available.

When serviceable S&C is recovered for re-use then the existing bolts may remain in-situ but any which require replacement must be replaced with new items before installation.

Any bolts which have been packed out with washers or packing pieces must be replaced with new items. No more than two washers should be used under any one nut.

**Flat Bottom Rail Fastenings**

Care must be taken that the spikes are not over driven. The spikes should be adjusted as required, defective or broken ones being replaced. Where an effective grip or toe load can no longer be maintained then either fitting maintenance liners to the spikes, fitting spikes to previously unused baseplate holes or fitting maintenance spikes as replacements for the original spikes should be undertaken.

New holes for elastic spikes should be drilled 12mm (1/2") diameter and right through the sleeper taking care not to damage the drill bit. Care must also be taken to avoid any buried cables which may be located under the sleeper.

Normally clips shall be inserted using the manufacturers approved technique. Clips should not be driven with a hammer. Any clips which are broken or have become defective should be replaced. Where clips are tensioned by a nut or screw, care must be taken to ensure that they are correctly tensioned. In the case of CWR, care should be taken in hot or cold weather not to release more than eight consecutive pairs of clips on one rail at the same time, except during stressing operations.

From time to time it will be necessary to undertake maintenance of driven, pulled-in or screw-fastened type clips to regain the toe load on the rail foot. Where nylon insulators have been used they shall be replaced to maintain toe load and gauge.

When fastenings become loose, the designed toe load on the rail is not retained, resistance to rail creep in jointed track is reduced and the resistance to track buckling is reduced.

Vertical vibrations can also be set up which will lead to pad wear and vibration of the sleeper against the ballast. This in turn will lead to wet or slurry spots developing.

Worn and cracked pads contribute to loose fastenings, sleeper damage, formation of wet beds and, in some cases, track circuit failures in signaled sections. They should be replaced as soon as possible. Periodic inspections must be made so that defective pads may be replaced before mechanical damage occurs.

**Correct Fitting of Baseplates**
The outer shoulder of FB baseplates should contact the foot of the rail before fixing to gauge, except at:

| | |
|---|---|
| (i) Crossing noses and wing rail fronts | where the rails must contact both baseplate shoulders; |
| (ii) Crossing V legs | where the crossing legs must be in contact with the baseplate centre section. |

**Locking Devices**
Lock nuts or other locking devices should be used wherever possible. Nuts for bolts with spring clips in FB inclined design switches and crossings must be tightened with a box spanner. Where HT bolts are used the correct torque must be applied with a torque spanner.

**Rail Creep**
There is a tendency for the rails to move gradually through the fastenings in the direction of predominant traffic. On single and bi- directional lines this movement will be in the direction of the most or heaviest traffic. The phenomenon is known as rail creep and can be influenced by:

- braking of trains
- worn or missing fastenings
- shortage of ballast
- inadequate packing of the sleepers
- worn and badly maintained joints
- gradient
- corrugations

The first sign of rail creep will be that the expansion gaps close up (tight joints) and these must be corrected at the first opportunity, particularly before the onset of hot weather, to reduce the risk of buckling. All existing fastenings must be examined and retensioned or retightened and the packing must be checked to ensure that all sleepers are consolidated.

If, after the fastenings and the packing of the track have received attention, rail creep persists one or more of the undernoted remedial actions may need to be undertaken:

(i) fit additional fastenings i.e. fit spike fastenings in unused baseplate holes;

(ii) fit replacement fastenings

(iii) fit fastening maintenance liners;

(iv) fit chairscrew liners and new ferrules;

(v) spot resleeper as necessary, especially at joints;

(vi) square and correctly space all sleepers;

(vii) pull back rails and correct expansion gaps;

(viii) fit approved rail anchors;

(ix) if shimming of the joints has failed to correct the dip, undertake rail joint straightening followed immediately by the fitting of new fishplates and fishplate shims and the packing of sleepers;

(x) remove corrugations using specialist equipment;

(xi) ensure that there is adequate ballast and that it is profiled in accordance with the specification.

**Rail Anchors**

Anchors must not be fitted against any joint sleepers nor should they be fitted to one end only of a sleeper. Anchors must always be fitted tight to the vertical face of the sleeper against which they will bear. Where anchors are loose on the rail they should be replaced. Where anchors have been moved along the rail they should be refitted tight to the face of the sleeper and additional anchors fitted.

**Rail Creep Correction**

Each site must be carefully surveyed noting any additional work required, e.g. packing hanging sleepers, to enable the task to be accurately planned. Wherever possible the cutting of rails should be avoided and both rails should be adjusted. Special attention must be given to flat bottom track tending to creep towards bullhead track or S&C, level crossings, longitudinal timbers, adjustment switches and other similar locations. New track must be monitored in its first year so that any tendency to creep can be detected and rectified. All adjusting should be undertaken using hydraulic rail adjusters. The use of a hammer and set is prohibited, as is the use of slewing bars, to lever the rails apart.

Rail anchors must be removed prior to adjusting rails and then refitted on completion of the work. Anchors must be relocated as necessary after tamping and sleeper squaring.

### 4.7.7 Rails

**Supply and Use of Rails**

Rails are generally supplied from the manufacturer in 18.3m (60 ft) lengths, although shorter lengths, drilled both ends, are available for use on the inner rail of curved, jointed track. All fishbolt holes will have been cold expanded.

When shorter lengths are required the rails must be ordered undrilled or "drilled one end" and cut to the required length and drilled in the depot or on site.

To minimise unnecessary waste of rail, short closure rails should not be cut from 18.3m rails; the appropriate standard short rail closest to the length of the required closure should be selected for the purpose.

Rails drilled for fishbolt holes must not be manipulated by means of a slewing bar or other device inserted into the bolt holes. Only the correct rail turning bar, rail handling beam or rail tongs must be used.

### Storage of Rails

This section is based on the booklet *'Rail Handling—Recommended Procedures'* produced by British Steel Track Products.

Rails are to be stored on an area smooth, level having a firm base. Concrete hardstanding is ideal but well compacted earth is acceptable. Base supports or dunnage should be provided at regular intervals along the length of the rail, with special attention being paid to the supports near the rail ends. The bottom layer of rails in a stack must be aligned such that rail flanges do not overlap. As assembly of a stock pile proceeds the essential features are:

Use rails of the same length. If this is not possible then the shorter rails must be laid nearer to the top.

Keep the ends of rails of the same length vertically above one another.

Do not cross layers without specific advice.

Dunnage or spacers to be in identical positions along the rail length, so that when the stack is completed the dunnage is in good vertical alignmment.

Successive rail layers should be of the same or decreasing width.

### Twist Rails

Twist rails are closure rails which have a designed twist at a predetermined position. They are used to connect vertical design S&C or vertical plain line to inclined design track where the rails are set at an inclination of 1 in 20 towards the centre line of the track. Failure to provide twist rails will result in misaligned running edges.

### Position of Joints

Care should be taken to ensure that the appropriate length rails are used to obtain joints squarely opposite each other, but in any event joints should not be more than 6mm out of square.

### Installation of New or Replacement Rails

When new or replacement rails are laid into existing jointed track, the old rails, where practicable, should be cut back to take the full length of the new rails. Site closure rails in jointed track must not be less than 9m (30 ft) in length between fishplated joints and must be supported by at least 12 sleepers. The minimum length of rail between a weld and a fishplated joint is 4.5m (15 ft).

### Minimum Length of New or Replacement Rails

When new rails are laid in CWR the closure rails must be not less than 4.5m in length and supported by at least six sleepers. If a rail in CWR has a defect which needs to be cut out, the replacement rail must be not less than 4.5m long in straight track or 9m long (and supported on a minimum of 12 sleepers) in transitions and curved track. Where the defect is of a type that may be repeated in the 18.3m length then the whole rail must be cut out.

On any section of CWR where rail has been replaced stress restoration must be carried out in accordance with Railtrack Group Standards.

These dimensions apply irrespective of the type of joint (welded or fishplated) at each end of the closure.

**Use of Worn Rail**

The permissible wear of used rails expressed as a percentage reduction from new in overall height or width of head or width of foot of rail, is as follows:

| | |
|---|---|
| Limit at which rail in place should be renewed | 10% |
| Limit for reuse of partly worn rail | |
| in heavily trafficked depot track | 5% |
| in sidings | 9% |
| in occasionally used running lines | 9% |

These limits apply to rails up to and including 113A FB and 95 BH.

The measurement of wear may be undertaken using an appropriate gauge or by weighing a sample length of rail.

Careful visual inspection of rails will reveal obvious defects such as severe corrosion, buckling and cracks which would make the rail unsatisfactory. Where corrosion is limited to the fishing surfaces but the rail is otherwise sound, it may be possible to salvage the rail by cutting off the ends. The same remedy may be applied to rail with battered ends or cracked fishbolt holes. Wheel burns indicate locations where repeated wheel slips have occurred and are a possible source of rail fracture. Burred and chipped rail edges are undesirable, but re-use of the rail may be feasible, if one edge is still sound, by reversal. Where it is not practicable to examine every length of rail for which re-use is anticipated, a judgment has to be made based on an assessment of the visual and physical conditions of representative samples.

The head of a rail is subject to most wear but the sides and the foot may also wear to varying degrees. The overall height and width of the head are the most critical dimensions and they should be checked with a straight edge and steel rule or with calipers. Web thickness cannot be checked easily as it consists of a curved surface in most rail sections, but it is not subject to wear, except at fishplates, and the extent of any corrosion can be checked by striking with a hammer.

Used rail may be factory re-rolled to restore its profile. The new weight will be less than the original and this must be taken into account when determining maximum axle loadings and sleeper spacing. Re-rolled rail cannot be regarded as equal in quality to that of new rail but will be acceptable for most narrow gauge work. It should not be used in standard gauge running line.

**Depth of New or Replacement Rails**

The greatest difference in rail depth between adjacent rails of the same nominal section which can be welded together economically using pre- formed moulds currently available for the alumino- thermic welding process is 9mm (11/32").

Where it is necessary to introduce into a track a rail which has a depth more than 9mm different from the existing rail then closures of a depth intermediate between existing and new/replacement rail must be provided.

Where it is required to weld together rails of different sections, ie to produce alumino-thermic welds known as "composite welds", then the maximum difference in relative wear of the two rails is 3mm (1/8")- For example, 113A FB worn 5mm (3/16") can be welded to 95 Ib RBS BH having a wear range of 2mm (3/32") to 8mm (5/16").

**Joints**
Each jointed rail end must not have more than two fishbolt holes, except where six hole fishplates are in use. Plain line running rails with more holes than standard within fishplate limits should be replaced at the first opportunity. Bond wire holes in new rails must be outside fishplate limits. Where it is proposed to use the alumino-thermic process to weld together rails previously drilled for fishplates, then the rail ends must be prepared so as to ensure a minimum distance of 30mm from the prepared rail end to the nearest part of the first bolt hole. The minimum dimension of 30mm rail end to nearest part of the first bolt applies equally to fishbolt holes and bond wire holes. The nearest edge of bond attachments and bond attachment scars must not be closer than 100mm from the end of the rail to be welded.

All bolt holes which have not been cold expanded and which are at rail ends which are to be alumino-thermic welded must be ultrasonically tested within two months prior to welding.

**Cutting of Rails**
All rails must be cut by disc or by saw. Any flame cut rails will be rejected and not form part of any track.

**Examination and Testing of Rails**
All rails must be visually examined, during the course of track inspections, for cracks and other defects.

Rails removed because of defects must be clearly marked with paint to prevent their accidental re- use.

Previously bolted rails which are to be welded together in-situ to form low-cost CWR must be ultrasonically examined not more than 7 days prior to welding so that any rails having serious defects can be changed whilst still within jointed track.

**Marking of Defects**
All rail defects should be marked in paint in the web of the rail, recorded and kept under special observation.

**Broken and Defective Rails**
When a broken rail or a defective rail is discovered in the running line, the first and immediate duty is to take the necessary action to protect traffic and to advise the local operating staff. The action to be taken is described in Figure 4.3.

**Figure 4.3** Minimum action to be taken on discovery of a broken rail

| TYPE OF BREAK | BLOCK THE LINE | IMPOSE 5mph ESR | IMPOSE 10mph ESR |
|---|---|---|---|
| | If ALL conditions apply | If ANY conditions applies | If ANY conditions applies |
| Transverse break through a plain rail or at a weld | 1 The break passes though a bolthole<br>2 The gap is wider than 50mm (2") and bridging pieces cannot be fitted<br>3 The break is more than 50mm (2") out of vertical<br>4 The break is at or is within 3m (10") of a joint, weld or S&C rail. | 1 The break passes though a bolthole<br>2 The gap is up to 50mm (2") wide and bridging pieces cannot be fitted or the gap is between 50mm (2") and 165mm (6½") and bridging pieces cannot be fitted<br>3 The break is less than 50mm (2") out of vertical<br>4 The break is more than 3m (10") from a joint weld or S&C rail. | 1 The break passes though a bolthole<br>2 The gap is less than 50mm (2") and emergency clmped fishplates can be fitted.<br>3 The break is less than 50mm (2") out of vertical<br>4 The break is more than 3m (10") from a joint weld or S&C rail. |
| Any part of the railhead broken away | 1 The break passes though a bolthole<br>2 If the break is at or is within 3m (10") of a joint, weld or S&C rail.<br>3 The gap is more than 50mm (2") wide and bridging pieces cannot be fitted<br>4 There are any crack extending into the web | 1 The break does not pass though a bolthole<br>2 Less than 50mm (2") of the railhead is missing and bridging pieces cannot be fitted or between 50mm (2") and 165mm (6½") of the railhead is missing and bridging pieces can be fitted.<br>3 The break is more than 3m (10") from a joint weld or S&C rail<br>4 There are no cracks extending into the web | 1 The break does not pass though a bolthole<br>2 Less than 50mm (2") of the railhead is missing and emergency clamped fishplates can be fitted<br>3 The break simore than 3m (10") from a joint weld of S&C rail<br>4 There are no cracks extending into the web |
| Lower part of the rail broken away | 1 The break passes though a bolthole<br>2 If the break is at or is within 3m (10") of a joint, weld or S&C rail<br>3 More than 50mm (2") of the rail foot on wach side of tbe rails is missing<br>4 There are any cracks extending into the web | 1 The break does not pass though a bolthole<br>2 Less than 50mm (2") of the rail foot on each side of the rail is missing and emergency clamped fishplates can be fitted<br>3 The break is more than 3m (10") from a joint weld of S&C rail<br>4 There are no cracks extending into the web | 1 The break does not pass though a bolthole<br>2 Less than 50mm (2") of the rail foot on one side of the rail is missing and emergency clamped fishplates can be fitted<br>3 The break is more than 3m (10") from a joint weld or S&C rail<br>4 There are no cracks extending into the web |
| Longitudinal split | 1 Any part of the side of the railhead on the running edge side (gauge face) breaks away | 1 Any part of the non-running edge (back edge) of the railhead breaks away | Not permitted |
| Railhead damage | 1 The railhead is damaged or distorted either vertically or laterally by more than 25mm (1") as determined by visual examination | 1 The railhead is damaged or distored wither vertically or laterally by between 25mm (1") and 10mm (1/2") as determined by visual examination | 1 The railhead is damaged or distorted either vertically or laterally no more than between more than 12.5mm (1/2") as determined by visual examination |
| Switches and crossings | 1 It is not possible to fit emergency clamped fishplates the tail is free to move (ie a switch rail) the break is not supported by the S&C blocks and bolts or MGL pins or it is not possible to provide any other form of support to the rail. | 1 It is not possible to fit emergency clamped fishplates but the rail is free to move and it is possible to provide some other form of support to the rail.<br>2 The break is supported by the S&C blocks and bolts or MGL pins | 1 Emergency clamped fishplates can be fitted to the break and the rail supported by the S&C blocks and bolts or MGL pins |

**Notes to accompany Figure 4.3**

1 Where bridging pieces are used then they should be fitted in pairs, ie one on each rail so as to minimise the risk of introducing a twist fault.

2 Bridging pieces must normally be secured by four G clamps; however in exceptional circumstances the use of three clamps is permitted. Where it is possible to fit only three G clamps then two must be on the "running-on" side of the break. Where four G clamps can be fitted then there must be two on each side of the break.

3 Emergency clamped fishplates must be secured by four G clamps, two on either side of the break.

4 Assessment of "out of vertical" should be made over the full depth of the rail.

5 Localised breaking away of lipping on either the running edge or back edge of a rail is usually of insufficient severity to warrant classification as rail head damage.

6 Sleepers and fastenings on either side of the break must be complete.

**Loading and Unloading of Rails**

Instructions for the loading and unloading of rails are available from British Steel and the correct tools and lifting appliances must be used. Notwithstanding British Steels' recommendations fork lift trucks must not be used to handle rail. When rails are being unloaded, the utmost care must be taken to ensure that they are not damaged, particularly at the rail ends and that damage is not caused to anything in the vicinity, eg. sleepers and signal equipment and cables. Cables and other equipment must be protected to prevent rails resting directly upon them.

Where it is necessary to unload rails in the "fourfoot" of a line open to traffic then the rails must be positioned so that the maximum height of the rail above the plane of the running surfaces of the running rails is not greater than 25mm. This dimension is the maximum permitted irrespective of the need to insert packing pieces to lift the materials clear.

Rails for re-use must be suitably marked to show serviceability.

**Rail Corrugations and Minor Rolling Contact Flaws**

During the passage of trains rails tend to develop corrugations on the running surface especially along the wheel/rail contact band. On certain lines the development of corrugations is accompanied by a fattening of the running surface.

Corrugations are detectable by the increased wheel noise or "roaring". In extreme cases the vibrations induced into the rail will lead to premature failure of pads, insulators, clips and ultimately the cast in housings in concrete sleepers.

Loss of rail head profile is detected by visual observation and profile measurement and by the poor riding of vehicles on track which is otherwise within maintenance tolerances. Where loss of profile is detected the EWC shall measure that loss and report it to the Property Manager and Railway Operating Manager. Minor rolling contact rail flaws, ie small squats, small wheelburns, gauge corner cracking and micro- cracking of the bright running band on the rail head can be removed using rail rectification machines.

Details of corrugations, loss of head profile and minor rolling contact flaws should be assembled by the EWC as part of the inspection schedule into a programme of work for rail profile rectification and submitted to the Property Manager.

### 4.7.8 Fishplated Rail Joints

**Joint Sleepers**
It is particularly important to keep joint sleepers firmly packed. Sleepers should be kept square and correctly spaced. The rail joint should be central + 60mm ($2^3/_8$") between the joint sleepers, with the correct expansion gap. The sleeper on each side of a fishplated rail joint must be of the same material and compatibility, ie both timber, both concrete of the same design or both steel. Joints with different sleepers on each side are not permitted. The rail to sleeper fastening must be kept tight and the correct gauge maintained.

**Fishbolts**
Fishbolts must be kept tight but not so tight as to prevent the proper expansion and contraction of the rails in jointed track. Black (non-high tensile steel) fishbolts and high tensile steel (HTS) "V" quality fishbolts fitted with "R" quality steel nuts and insulated and tight joints should be tensioned, using the approved torque spanner, to:

| | |
|---|---|
| Black fishbolts | 475 N m (350 lbs ft) |
| HTS fishbolts 25mm (1") diameter | 881 N m (650 lbs ft) |
| HTS fishbolts 28.5mm ($1\ ^1/_8$") diameter | 1017 N m (750 lbs ft) |

If black fishbolts or threads are rusty or dirty they must be cleaned and greased before being tightened.

**Bolt Holes**
Special care is required when drilling holes for fishbolts. The holes must be accurately located and true in shape to prevent overstressing rail ends, fishplates or fishbolts. Each fishbolt hole in non AMS rail should be cold expanded using special equipment where this is available. Cold expanded holes can be checked by inserting a finger into the hole and feeling for a 'joint line' which is quite detectable. Metal particles must be removed from the rail ends, particularly at insulated joints where they may cause electrical current leakage.

**Bolt Hole Dimensions**
When the rail ends have been drilled for fishplates the principal dimensions shown in Figure 4.4 apply.

**Figure 4.4** Rail drilling

| | BH 95RBS | FB 75lb | FB 110A 113A | FB 98lb | FB 109lb |
|---|---|---|---|---|---|
| End of rail to centre of first hole | 60.3mm ($2^3/_8$") | 47.6mm ($1^7/_8$") | 60mm ($2^{23}/_{64}$") | 60.3mm ($2^3/_8$") | 60.3mm ($2^3/_8$") |
| Centre of first and second holes | 114.3mm ($4^1/_2$") | 101.6mm (4") | 127mm (5") | 127mm (5") | 127mm (5") |
| Diameter of drill | 30mm ($1^3/_{16}$") | 30mm ($1^3/_{16}$") | 30mm ($1^3/_{16}$") | 30mm ($1^3/_{16}$") | 30mm ($1^3/_{16}$") |
| Finished diameter of holes (after cold expanding) | 30.7mm ($1^{13}/_{64}$") | 30.7mm ($1^{13}/_{64}$") | 30.7mm ($1^{13}/_{64}$") | 30.7mm ($1^{13}/_{64}$") | 30.7mm ($1^{13}/_{64}$") |
| Diameter of bolts for ordinary joints | 23.8mm ($^{15}/_{16}$") | 25.4mm (1") | 25.4mm (1") | 25.4mm (1") | 25.4mm (1") |
| Diameter of bolts for insulated and tight joints | 25.4mm (1") | 28.6mm ($1^1/_8$") | 28.6mm ($1^1/_8$") | 25.4mm (1") | 25.4mm (1") |
| Height of hole centres from underside of rail | 64.3mm ($2^{35}/_{64}$") (mid-web) | 54mm ($2^1/_8$") | 65mm ($2^9/_{16}$") | 59.5mm ($2^{11}/_{32}$") | 65mm ($2^9/_{16}$") |

Note:

With the bolts located centrally in the rail and fishplate holes, the dimensions shown in the above table give a 6mm gap between the rail ends. Where a tight joint is required (ie. no expansion gap) special tight joint (TJ) fishplates must be used.

### Drilling of Fishbolt Holes

All rails which are to be drilled must be firmly supported so that there is no tendency for the rail to tip or vibrate off its support when the drilling machine is working. When drilling for fishbolt holes the machine must be accurately positioned relative to the rail end using the distance gauge provided. The drilled hole must be at right angles to the longitudinal axis of the rail, and the correct height from and at right angles to the vertical axis of the rail.

The holes should be cold expanded after drilling.

### Cold Expanding of Bolt Holes

Accepted policy is for all rail end bolt holes in pearlitic rail steels used in jointed track to be cold expanded using the special equipment provided. All rails drilled at the rail manufacturers premises or supplied by S&C manufacturers are delivered with the fishbolt holes cold expanded and retreatment must not be undertaken. Manufacturers cold expand all fishbolt holes in both plain rail and S&C but the rails are not specially marked.

Cold expanded bolt holes can be identified (once fishplates and bolts have been removed or before they are fitted) by the presence of a slight nib at either 9 o'clock position. The "nib" is caused by the rail steel being squeezed into the small gap or split in the mandrel sleeve. Mandrel sleeves must not be left in the boltholes. A detailed record of all fishbolt holes treated must be maintained.

Holes in rails, other than fishbolt holes, need not be cold expanded.

### Cutting of Rails by Reciprocating Saw

Rails to be cut by means of a reciprocating saw must be firmly supported so that there is no tendency for the rail to move during the cutting operation. The rail to be cut must be accurately measured and marked and the saw carefully aligned to the cutting mark. All sawcut ends should be cut square, ie at right angles to the longitudinal axis of the rail and the cut must be vertical.

The saw must not be forced through the cut but be allowed to cut at its designed speed. As the saw blade approaches the tip of the rail foot it is essential to check that the weight of the length of rail being cut off does not cause the rail end to sag, twist or trap the saw blade. Rail offcuts must not be left on site but collected up for scrap.

### Cutting of Rails by Disc Cutter

Rails to be cut by means of an abrasive saw or disc cutter must be supported as noted in the previous section, the rail carefully measured and marked and the disc cutter support arm positioned relative to the cutting mark by means of the distance gauge. The abrasive wheel must be carefully checked before use and if any doubts exist about its suitability for cutting steel, its general condition or its safe operating speed, then it must be replaced by a new wheel of the correct type.

An abrasive saw must not be forced through the cut but be allowed to cut at its designed speed. It may be necessary to partially cut the rail from one side, reverse the machine on the support arm and cut the remainder of the rail from the other side, depending upon the type of abrasive saw in use and the diameter of the wheel.

### Expansion Gaps

Expansion gaps for 18m (60') and 36.6m (120') rails must be provided and maintained in accordance with Figure 4.5.

**Figure 4.5 Rail joint expansion gaps**

| Rail Temperature | Nature of Weather | Expansion Gap 36ft (11m) Rails | Expansion Gap 60ft (18m) Rails | Expansion Gap 120ft (36m) Rails |
|---|---|---|---|---|
| Below 10 degrees C | Cold | Expansion gaps for 36ft rails will be as for 60 ft rails due to the tolerances between the fishplate holes and the bolts | 10mm ($^3/_8$") | Expansion gaps 120 ft rails will be as for 60 ft rails due to the tolerances between the fishplate holes and the bolts |
| 10 degrees Cand below 24 degrees C | Cold to warm | | 6mm ($^1/_4$") | |
| 24 degrees C and below 38 degrees C | Warm to hot | | 3mm ($^1/_8$") | |
| 38 degrees C and over | Very hot | | Nil | |

In periods of high rail temperature it may be necessary to slacken off fishbolts at joints in jointed track and top the fishplates where the expansion gap has not closed ("frozen joints") to permit the rails to expand. Once the rails have expanded the fishbolts should be correctly tightened and at the first opportunity the joints should be lubricated.

### Joints on Underbridges

It is undesirable for fishplated joints to be located on underbridges or in level crossings. If, however, rail joints are unavoidable, eg on long viaducts, consideration must be given to the welding up of fishplated joints, without increasing the length of the rails between fishplated joints to more than 36.6m.

### Adjustment Switches at Long Underbridges

Where adjustment switches are provided at the ends of underbridges longer than 30m, particular attention needs to be given to their maintenance owing to the movements of the bridge deck that can take place.

Bolted or welded joints in the ballasted track at each end of an underbridge carrying non-ballasted track must not be located within 4.5m of the point of transition from one trackform to another.

### Assembly of Joints

All fishplates, bolts and fishing surfaces at the rail ends must be lubricated before any rail joint is assembled. Fishbolts must be fitted with the nuts on the outside of the track.

### Rail Joint Lubrication

Rail joint lubrication will be carried out by taking off both fishplates, wire brushing and lubricating plates, rail bearing flanges and bolts, plates will be turned (except junction) and all plates refixed. Before retightening the bolts any shims must be reset or, if badly worn, replaced with the correct size shim.

### Shimming of Joints

Fishplates that are worn so that they do not give adequate support should be either shimmed or renewed.

Failure to keep fishplates correctly tightened will lead to accelerated component wear. It is possible to compensate for this wear by the insertion of shims between the upper surface of the fishplates and the underside of railhead.

Shimming of joints should take place as part of the routine maintenance of jointed track. Determination of the correct shim size should be carried out by the EWC inspector. Continuity of materials should be maintained on both sides of the joint.

Following the fitting of shims it is important to check that wear has not been overcompensated. In addition two sleepers either side of the joint must be repacked.

### Special Fishplates

A special junction dropped forged fishplate must be used to join rails of different sections, e.g FB rails to BH rails.

### Tight Joints

The only type of joint in CWR, usually at the junction between plain line and S&C, is the tight joint fitted with high tensile fishbolts. This joint is dry installed and must not be lubricated. The high tensile bolts must be kept correctly torqued at all times.

### Emergency Clamped Fishplates

These are temporary plates used to effect an emergency repair to a broken rail or defective joint. They should be secured with 4 G-clamps and every effort must be made to carry out a permanent repair as soon as possible.

### 4.7.9 Switches

**Flangeway Clearances**
The space between switch rail and stock rail must always be kept clear of obstructions and a minimum flangeway clearance of 50mm (2") must be maintained. The minimum clearance between the stock rail and switch rail at the toes of the switches should be 102-120mm (4"- $4^{3}/_{4}$").

**Gauge Measurement**
Gauge at the switch should be checked at each inspection 100mm (4") in front of the switch toes and at all drive points and fixed heel blocks.

**Facing Switches**
Switches should be checked for switch and stock rail wear during the course of normal inspections. This is particularly important on facing switches and on trailing switches which are occasionally used in the facing direction.

All switches must be examined in both normal and reverse positions.

**Bolts in Switches**
The stock rail bolts must be kept tight and the exposed thread periodically greased. Where black bolts exist they should be tightened to 475 Nm (350 lbs ft) using a torque spanner. High tensile bolts must be tightened to 881 Nm (650 lbs ft) using a torque spanner.

**Multiple Grooved Locking Fastenings in Switches**
Where these studs have been used in lieu of stock rail bolts then the complete half set of switches should be so fitted at the same time. Fitting should be undertaken sequentially commencing from one end. The studs should be tensioned in two stages.

The studs are slightly larger than the bolts that they replace. It is therefore essential that timbers and baseplates are lifted tight to the underside of the stock rail and correctly packed prior to the fitting of studs.

**Replacing Switches**
Changing of one rail in a half set of switches is not permitted except in an emergency. Only complete half sets should be changed to ensure that the switch rail fits correctly to the stock rail.

Where a new half set of switches is being installed all slide baseplate bolts must be slackened before the switches are fixed to the timbers. Once the switches are set to correct line and level the slide baseplate bolts should be tightened to the correct torque and timbers packed.

The rail seating on slide baseplates must be kept clean and lubricated regularly.

**Indentation of Slide Surfaces**
The indentation of a slide baseplate in the seating under the switch rail will require renewal of the baseplate.

**Stretcher Bars**
Failure of one or more stretcher bars will result in an incorrect flangeway gap, leading to (in the worst case) derailment. Any cracked, broken or bent stretcher bars should be replaced as soon as possible. In the interim the turnout must be removed from use.

### Hand Lever Operated Switches

All hand lever operated switches must open and close to correct positions with equal pull in both directions. If this is not the case it may be as a result of one or more of the following:

- incorrectly adjusted switch lever
- weakened or broken spring
- connecting rod incorrectly adjusted
- connecting rod not at right angles to the track
- damaged switch rail
- poor installation

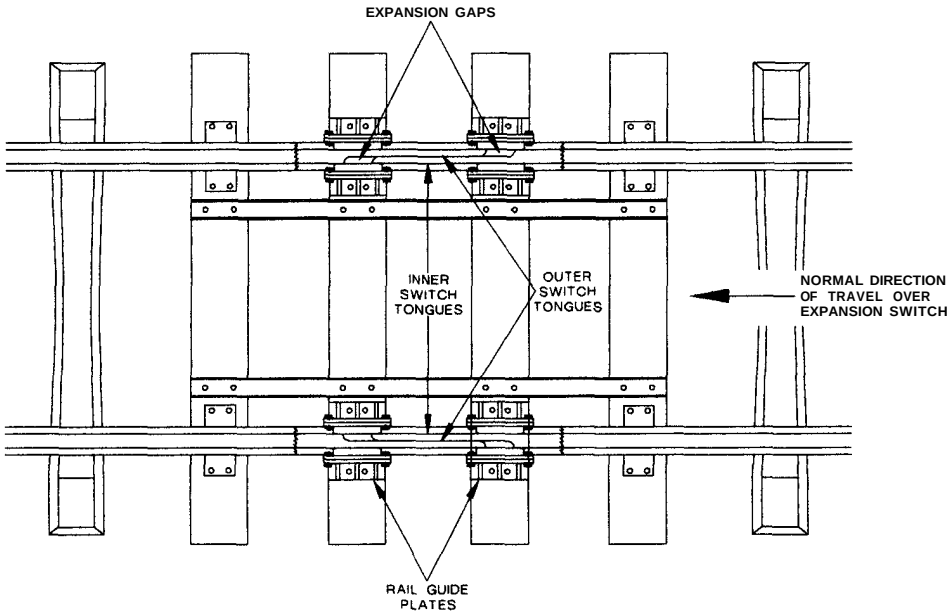
### Switch Toes

Switch toes, other than in single or double slips and switch diamonds must always be kept square to each other.

## 4.7.10 Adjustment Switches

An adjustment switch allows longitudinal movement of rail as a result of thermal movement in the last 100m (328 ft) of CWR track. A typical adjustment switch is shown in Figure 4.6.

**Figure 4.6** Typical adjustment switch




### FB Adjustment Switches

The setting of the standard adjustment switch according to ambient rail temperature is shown in Figure 4.7.

**Figure 4.7** Adjustment switch settings

| Rail Temperature | Overlap of Switch Rails | Gap Opening |
|---|---|---|
| - 4 to 2 deg.C | 635mm (25") | 125mm ($4^{29}/_{32}$") |
| 2 to 7 deg.C | 641mm ($25^{1}/_{4}$") | 119mm ($4^{11}/_{16}$") |
| 7 to 13 deg.C | 648mm ($25^{1}/_{2}$") | 112mm ($4^{13}/_{32}$") |
| 13 to 18 deg.C | 654mm ($25^{3}/_{4}$") | 106mm ($4^{3}/_{16}$") |
| 18 to 27 deg.C | 660mm ($25^{31}/_{32}$") | 100mm ($3^{15}/_{16}$") |

**Timber Spacing Straps**
If timber spacing straps are located in the fourfoot they must be fastened to the timber by means of coachscrews.

### 4.7.11 Common Crossings

Crossings may be of a built-up bolted (fully fabricated), semi-welded (part fabricated) or cast in inclined or vertical design.

**Track Gauge at Crossings**
The gauge through common crossings should be checked every 3 months. The crossing bolts should always be kept tight and the exposed threads greased. For inclined standard gauge crossings the gauge should be 1435mm (4′8$^{1}/_{2}$″) with a flangeway gap of 44mm (1$^{3}/_{4}$″). For vertical standard gauge crossings the gauge should be 1432mm (4′8$^{3}/_{8}$″) with a flangeway gap of 41mm (1$^{5}/_{8}$").

**Flangeways**
The distance between the inside edge of a standard check rail and the running edge of the opposite rail must be maintained at 1391mm (4′6$^{3}/_{4}$″). The maximum permitted wear on check rails and wing rails is 3mm ($^{1}/_{8}$″). Flangeways should be kept clear of dirt and other obstructions.

**Check Rails**
The position of the crossing nose should be checked to ascertain that the nose is covered by a check rail.

**Defective Crossings and Their Replacement**
When a broken crossing is found it should be replaced as quickly as possible and in the meantime consideration given to the rerouting of traffic or the temporary substitution of a plain rail to maintain through running only and the switches clipped out of use.

### 4.7.12 Maintenance Of Gauge

Gauge is measured between the running edges of the rails 14mm ($^{9}/_{16}$") below the crown of the rail (when new).

Gauge irregularities give rise to sidewear of the rail and could lead to derailment. In checking gauge particular attention should be given to any visible movement of baseplates or chairs on the surface of the sleeper, or any worn fastenings.

To avoid gauge irregularities any change of component should be compatible with those remaining.

Correction of gauge in concrete sleepered track may be carried out by sleeper replacement, provision of new clip insulators or gluing in clip housings. The actual correction method will depend on the type of failure and sleeper type.

Correction of gauge in timbered track may be carried out by moving the sleeper perpendicular to the track and refastening the baseplates or chairs.

**Gauge Widening**
On very sharp curves (below 200m (656 ft) radius for standard gauge railways) it may be necessary to increase the track gauge to ease the movement of vehicles round curves. In addition check rails should be fitted. The Railway Operating Manager and Railway Staff Office must always be consulted

concerning the level of gauge widening. Figure 4.8 should be used as a guide to ascertain the amount of gauge widening and the resulting flangeway dimension between the running rail and check rail.

**Figure 4.8** Gauge widening

| Curve Radius | Gauge Widening | Flangeway Dimension |
|---|---|---|
| 200-140m | 6mm ($^1/_4$") | 50mm (2") |
| 140-110m | 12mm ($^1/_2$") | 57mm ($2^1/_4$") |
| below 110m | 19mm ($^3/_4$") | 63.5mm ($2^1/_2$") |

To achieve the widened gauge the inner or low rail should be moved at a rate of 3mm ($^1/_8$") per sleeper space.

### 4.7.13 Sidewear

Sidewear takes place as a result of the wheel flange making contact with the gauge face of the rail. As sidewear increases the railhead is worn to the profile of the wheel flanges. Sidewear may be reduced by the installation of lubricators to the affected running rail.

Sidewear is measured using a recognised sidewear gauge. Rails should be replaced when the sidewear or a combination of sidewear and a reduction in overall height has caused a loss of head area greater than 10%. Rails may be turned or transposed before the following limits are reached:

Limits for turning or transposing rail

| | |
|---|---|
| in heavily trafficked track | 5% |
| in sidings | 5-7.5% |
| in occasionally used track | 5-7.5% |

The locations of sidewear must be monitored monthly, ensuring that readings are taken at the same point on the curve. This may be carried out by painting the web of the rail with a unique identifier.

After 4 readings the EWC shall examine the records and estimate the rate of wear to when a rail will require turning, transposing or replacing.

### 4.7.14 Rail Lubrication

Rail lubricators should be considered for curves with a radius of 200m or less, but only if recommended by the EWC as a result of detailed inspection.

If rail lubricators are installed they should be correctly adjusted so that grease is not allowed to contaminate the running surfaces of the rails.

#### 4.7.15 Twist

Twist is defined as a track condition where there is a difference in cross levels over a short distance which induces one or more wheels of a vehicle to lose contact with the running surface of the rail.

Twist may be detected by measuring the cant or cross levels every 3 metres. The difference in adjacent readings will give the twist value. A twist fault for standard gauge track is a twist gradient of 1 in 200 or steeper.

If the twist gradient is such that track repair has to be carried out the repair should be executed to give a twist of not less than 1 in 400.

### 4.7.16 Lifting and Packing

Lifting and packing of the track should be carried out after first ensuring that all fastenings are correctly tensioned, rails are seated and defective components replaced. Adequate ballast should be provided and the profiles made good upon completion of the work.

Where lifting and packing work is to be carried out during normal running only the obstructionless type of jack shall be used. Jacks shall be used in a upright position and must never be used under a rail joint.

Lifting should always be carried out towards on- coming traffic except on single lines when it should be carried out in the direction of the rising gradient.

Where tracks are subject to subsidence or other major earthworks are required, remedial work should be designed by the WSM unless the estimated cost of the work exceeds the Property Manager's limit.

Whenever lifting or packing is carried out the track must be checked for alignment and corrected as necessary.

Voids under sleepers should form part of the EWC inspection. Where identified they should receive a high priority for correction.

Where sleepers are identified as being only reinforced and not prestressed, these sleepers shall not be packed at their centres.

### 4.7.17 Rail End Straightening

Rail ends at joints develop a vertical deformation under traffic which is correctable using a hydraulically driven Rail End Straightening (RES) machine.

The practice of rail end straightening must not be carried out when the rail temperature is 0 deg C or less. When undertaking straightening the following precautions must be taken:

All joints should be inspected ultrasonically by an approved procedure.

No insulated joints should be straightened.

Packing is to be carried out to the four joint sleepers at the time of straightening. Where ballast is frozen preventing packing, straightening should not be attempted.

Any shimming required should be carried out at the time of straightening.

All fastenings including fishbolts must be tightened.

Replacement fishplates must be kept at hand in case of failure of the joint plate during the straightening process.

Rails at each side of a joint should be marked each time it is straightened. (Joints straightened more than three times are suspect).

### 4.7.18 Slewing And Lining Of Track

Unless realignment work is of a very minor, local nature a realignment scheme should be prepared by the WSM. The realignment scheme will normally be prepared using the Hallade method.

The alignment scheme must be set out on site using brightly painted pegs of a single colour set clear of any walking routes or work site.

When adjusting tracks at platforms or loading bays arrangements must be made for the adjustment of any structure that may be required.

After any realignment work steps should be taken to reprofile ballast particularly at sleeper ends. In addition all voids should be filled with ballast and properly compacted.

If CWR is to be realigned then the track affected must be restressed.

### 4.7.19 Effects Of Hot Weather

Late spring or early summer are the most vulnerable periods for track buckling. During these times there may be cool nights followed by hot days giving rise to an extreme range of temperature. In general certain locations are more susceptible to buckling than others and these should be monitored at the appropriate time.

- wind sheltered north/south cuttings
- sites of embankment slips
- areas of recently disturbed ballast
- wet spots
- ash ballasted track
- where ballasting of sleeper ends is inadequate

EWC inspection should recognise those lengths of track where there is potential for buckle and should recommend those works required to mitigate the threat. Where works are recommended they should be carried out before periods of hot weather.

**Track Buckle**
If a buckle occurs the severity should be assessed by the EWC and if necessary the track closed until remedial work can be carried out. Emergency remedial work may consist of:

- slewing the track
- cutting rails
- adjusting rails

### 4.7.20 Effects Of Cold Weather

Typical permanent way problems associated with cold weather are fishbolt failures, joints pulling apart, frost heave and excessive icicle formation causing reduced clearances.

Local personnel should keep the following clear of snow and ice:

- speed restriction signs
- point rodding
- signal operating wires

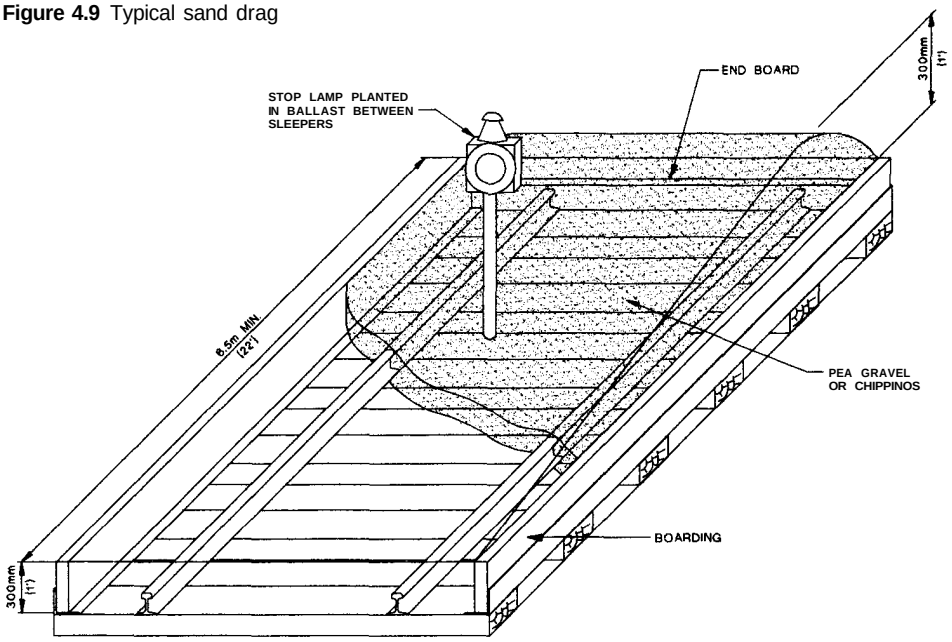
- authorised walkways
- level crossing signs

Work that affects the stability of the track should not be carried out at temperatures below minus 7deg.C.

### 4.7.21 Sand Drags

At some locations a sand drag may be provided instead of buffer stops. The maintenance requirements are to ensure that the level of sand is maintained to the top of the boarding, that any defective boards are replaced and that the boarding is at the correct spacing either side of the track. A typical sand drag is shown in Figure 4.9.

**Figure 4.9** Typical sand drag



# 5 Construction

## 5.1 PROCUREMENT

### Contractors

With the privatisation and fragmentation of British Rail there are now many more permanent way contractors than used to be the case. This has led to a more competitive market thus reducing the cost of constructing and maintaining permanent way.

The procurement of permanent way contractors must follow MOD guidelines. However, it is important that contractors are selected to tender based upon their expertise in permanent way and their previous record with either the MOD or other organisations.

Whilst most construction and maintenance works will be procured on a plant, labour and materials basis there may be some benefits in the advance procurement of materials to obviate long lead times for some specialist materials.

It is recommended that every opportunity is taken to amalgamate works and undertake these as a distinct project under the control of a separate project manager for the work above the property management limit.

Notwithstanding the above, it is important that the most appropriate method is adopted for the procurement of works and to this end the EWC or project manager should advise.

No permanent way work should be let without the preparation of suitable contract documentation. This documentation will vary in content depending on the type of work to be carried out.

### Work by other than WSM or Project Manager

Any proposed work carried out on the track must first be advised to the Property Manager who seeks advice from the EWC and WSM. Unauthorised work carried out by others within the MOD may invalidate contractual maintenance agreements.

## 5.2 SUPERVISION

Any work carried out on the railway track shall be supervised by a competent person.

The completion of any work carried out on the track, no matter how minor, must be authorised as safe by a competent person. This person will normally be the Railway Operating Manager.

## 5.3 PLANT AND EQUIPMENT

No matter what plant and equipment is used to construct and maintain the track, users must be competent in its use. Most manufacturers will provide training in the use of specialist plant and equipment. Larger items can be hired complete with properly trained operatives.

Typical plant used in the construction and maintenance of railway track is as follows:

**On-Track Plant**
Tampers and liners Material handlers with road and rail capability

**Specialist Machinery**
Rail jacks, rail grinders, sleeper dogs, cranes, excavators, rollers, rail dogs,

**Small Tools**
Compaction hammers, shovels, forks, bars, drills, torque wrenches

## 5.4 USE OF SECONDHAND MATERIALS

The rising cost of permanent way materials has led to an increased use of secondhand materials for the renewal and maintenance of track. The use of these materials is particularly desirable in low speed/ low traffic tracks where a decreased rate of wear may be expected. Accordingly, railways within MOD establishments are ideally suited to secondhand materials.

Although permanent way materials may be advertised *as* secondhand they may not be of any value to a railway as they do not have any serviceable life. The WSM should therefore specify the maximum acceptable level of wear allowed for each component. Guidance concerning acceptable levels of wear is given in Chapter 4 Maintenance.

Where secondhand materials are procured they may only be used if accompanied by appropriate certification.

Designs should accommodate secondhand serviceable items wherever possible, consistent with the requirement to obtain the best value for money for the MOD.

# 6 Standard Gauge Railways

## 6.1 DESIGN STANDARD

### 6.1.1 Purpose

This Standard provides guidance to which all alignments for the MOD standard gauge (1432mm & 1435mm) track must conform. Notwithstanding the contents of this Standard designers must be proactive, considering all the issues that may affect their design.

The contents of this section does not absolve the Project Manager, WSM and designer from discharging his professional duties.

### 6.1.2 Application

The maximum design speed to be adopted for MOD standard gauge railways shall be 40 km/h (25mph) unless agreed otherwise with the Railway Operating Manager.

Lower design speeds may be adopted for certain sections where rolling stock characteristics will limit achievable speed or where a line speed of 40 km/h would result in unacceptable construction costs or where operational constraints limit the speed.

Where possible alignments shall be straight line and constant grade.

Designs shall be prepared using desirable values. If it is found in certain locations that the use of desirable values has unacceptable cost implications, values between desirable and absolute may be adopted, although the absolute values may not be exceeded.

### 6.1.3 Symbols

The following symbols have been used in this document:

R = Horizontal curve radius (m)
Vm = Maximum speed (km/h)
Ve = Equilibrium speed (km/h)
E = Applied cant (mm)
D = Deficiency of cant (mm)
g = Acceleration due to gravity (m/s2)
s = Distance between contact points of wheels on rails (mm)
$\frac{dE}{dt}$ = Rate of change of cant (mm/s)
$\frac{dD}{dt}$ = Rate of change of deficiency (mm/s)

1 in N = Cant gradient
L = Length of transition (m)
G = Limiting gradient on straight track (%)
Gc = Limiting gradient on curved track (%)
Av = Vertical acceleration (m/s2)
Rv = Vertical curve radius (m)
Ch = Chord length (m)
E = Change in cant over a transition
D = Change in deficiency over a transition

## 6.2 HORIZONTAL ALIGNMENT

### 6.2.1 Circular Curves

**Relationship between Cant, Deficiency, Radius and Speed**
The relationship between cant, deficiency, radius and maximum speed is defined by the equation

$$E = 11.82 \frac{V_m^2}{R}$$

The relationship between cant, deficiency, radius and equilibrium speed (i.e. when D=0) is defined by the equation

$$E = 11.82 \frac{V_e^2}{R}$$

**Cant and Deficiency Limits in Plain Line**

**Figure 6.1** Desirable and absolute limits

| Desirable Limits | |
|---|---|
| Cant | :100 mm (4") |
| Deficiency | :100 mm (4") |
| **Absolute Limits** | |
| Cant | :150mm(6") |
| Deficiency | :100 mm (4") |

**Cant to be Applied**
Usually the cant to be applied will be given by the lesser of :

$$E = \frac{2}{3}(E + D)$$

or

E = 100 mm

This recognises that some deficiency is beneficial, to assist the steering of the bogies and yet prevent slow running traffic from experiencing excess cant.

However, in some circumstances the cant will have to represent a smaller than ideal proportion of the total cant plus deficiency—for example in the case of some reverse curves or in the vicinity of S&C.

**Maximum Radius**
The maximum permitted horizontal radius is 10,000m (32808 ft). It is not possible to effectively apply and maintain flatter curves.

**Minimum Radius—Speed Related**
The minimum permitted horizontal radius for a given speed can be calculated using the limits defined above.

For example, minimum radius for 40 km/h:

$$150 + 100 = E + D = \frac{11.82 \times 40 \times 40}{R}$$

$$\text{i.e.} \quad R = \frac{11.82 \times 40 \times 40}{150 + 100} = 75\text{m}$$

**Minimum Radius—Rolling Stock Related**
An absolute minimum radius of 75m (256 ft) may be permitted if operating restrictions are accepted but only with written agreement of the Railway Operating Manager. This figure has been derived from the requirements of modern long wheelbase wagons.

**Radii through Platforms and in Tunnels**
Where possible platforms should be located on a straight length of track. If this is not possible they should be located on a curve with as large a radius as possible. This is to ensure that acceptable stepping distances are maintained.

**Length of Straight or Circular Curve between Transitions**
It is undesirable to have very short lengths of straight or circular curve between transitions as vehicles do not have enough time to stabilise between leaving one transition and entering another. A direct reverse is preferable to a very short element. The minimum length of element should allow a vehicle 2 seconds before reaching the next transition, at the maximum speed being considered for the line.

A useful rule of thumb is:

$$\text{minimum element} = \frac{V_m}{2} \text{ metres}$$

### 6.2.2 Transition Curves

**Form of Transition Curves**
The form of transition curve to be used is a section of clothoid spiral.

For the purpose of manual calculations a very close approximation to the curve can be obtained by using a cubic parabola.

**Relationship between Transition Length, Maximum Speed, Cant or Deficiency and Rate of Change of Cant or Deficiency.**

These relationships are defined by the equations:

$$\frac{dE}{dt} = \frac{\Delta E V_m}{3.6L}$$

$$\frac{dD}{dt} = \frac{\Delta D V_m}{3.6L}$$

Where $\Delta E$ and $\Delta D$ are the change in Cant or Deficiency over the length of transition.

## Rate of Change of Cant and Deficiency Limits in Plain Line

**Figure 6.2** Desirable and Absolute Limits

| | |
|---|---|
| **Desirable limits** | |
| Rate of Change of Cant | 35 mm/s |
| Cant gradient no flatter than 1 in 1500 or steeper than 1 in 600 | |
| Rate of Change of Deficiency | 35 mm/s |
| **Absolute limits** | |
| Rate of Change of Cant | 55 mm/s |
| Cant gradient no flatter than 1 in 1500 or steeper than 1 in 400 | |
| Rate of Change of Deficiency | 55 mm/s |

If cant gradient = 1 in N, the rate of change of cant is given by

$$\frac{dE}{dt} = \frac{1000V_m}{3.6N}$$

Cant gradients flatter than 1 in 1500 are unacceptable, as they are difficult to apply and maintain.

### Lengths of Transitions

The required transition length for a given speed can be calculated using the equations above

If cant is applied in accordance with the above, cant will always exceed deficiency, and therefore transition lengths will always be governed by a consideration of rate of change of cant rather than rate of change of deficiency. However, where the applied cant is restricted for any reason (e.g. in the vicinity of S&C), the rate of change of deficiency may govern.

It is necessary to choose a rate of change within the limits given and to decide on the cants to be applied to the circular curves, before a transition length can be arrived at.

Taking in to account the requirement to maintain the geometry of the transition the minimum practical length for a transition should be 15m (42'2"). Where the calculated length of transition equates to a length of below 15m an instantaneous transition may be assumed. For calculation purposes when checking the rates of change a transition length of 11.25m (36'11") may be assumed. This figure is derived from the shortest distance between bogie centres on BR LWB wagons.

Application of superelevation on virtual transitions is to take place $^2/_3$on the straight and $^1/_3$ on the curve.

### Transitions between Reverse Curves

The term "reverse curve" is used to denote the situation where a curve of one hand is followed by another of the opposite hand, with either no intervening length of straight, or a length of straight which is less than the distance between the axles or bogies of a given vehicle.

To prevent buffer locking a length of straight or transition curve must be provided between reverse curves equal to at least the length of the longest wagon used, eg. LWB Wagon 11.25m (37 ft), Freightliner Containers 13.5m (44 ft), MOD Warwell Wagon 14.3m (47 ft).

The transitions between reverse curves must be designed with the same rates of change on both sides of the reverse, to give a constant rate of change of curvature and, within the limits of rounding, cant and deficiency through the transition. To obtain this condition the equilibrium speeds for the curves either side of the reverse must be equal. If one of the curves is designed to the limits, this may only be achieved by accepting "unnecessary" deficiency on the other curve.

## 6.3 VERTICAL ALIGNMENT

### 6.3.1 Gradients

**Limiting Gradients**

The ruling or maximum gradients on running lines are a function of the tractive and braking effort available from the locomotive and the weight of the train being drawn. Starting effort, curves and turnouts will reduce the power available for motion on inclines. The Railway Operating Manager should be consulted to ascertain the capabilities of the locomotives and hence to determine the ruling gradient. Figure 6.3 provides a series of values applicable to the main line network.

**Figure 6.3** Limiting gradient values

| Gradient Value | Application |
|---|---|
| 0% | Acceptable anywhere, but see paragraph **Gradients in Tunnels** for tunnels where 1 in 200 minimum gradient is required. |
| 0.20% (1 in 500) | Maximum gradient to be used in platforms and siding layouts |
| 0.20% to 1.50% | May be applied anywhere subject to above provisions. As gradients become steeper train performance can be affected and hence steeper vertical alignments should only be adopted where construction economies can be achieved by so doing. |
| 2.50% (1 in 40) | Absolute maximum gradient. |

**Instantaneous Changes In Gradient**

At a vertical intersection point when the change in gradient is less than 0.15% it may be assumed that a vertical curve is not required and the gradient may be allowed to change instantaneously.

**Compensation of Gradient on Horizontally Curved Track**

The gradients quoted in the paragraph above refer to straight track. If a gradient is on a horizontal curve, it must be further limited to compensate for the additional resistance due to curvature.

In practice, the compensation need only be applied when the horizontal curve radius is small, say 500m or less.

An estimate of the limiting gradient on curved track can be obtained from:

$$Gc = G - \frac{70}{R}$$

**Gradients in Tunnels**
Ideally tunnels should have gradients of no flatter than 0.5% (1 in 200), to facilitate free drainage.

If the geology or other factors make this difficult to achieve, flatter gradients may be used, down to a limit of 0.2% (1 in 500).

Every effort should be made to avoid locating a sump or low point in the vertical alignment in a tunnel.

**Limiting Gradients Through Platforms and Loading Bays**
The HM Railway Inspectorate's Railway Safety Principles and Guidance require a gradient not steeper than 0.20%(1 in 500) through a station, where there is a likelihood that trains will be terminated, turned back, have portions attached or detached, have crews changed or stand without brakes applied.

If it does not prove possible to limit the gradient to 0.2%(1 in 500) or flatter through any station platforms an application for dispensation must be applied for from the HSE(Railway Inspectorate).

### 6.3.2 Vertical Curves

**Form of Vertical Curve**
The form of vertical curve to be used is a parabola.

**The Relationship Between Radius, Maximum Speed and Vertical Acceleration**
The relationship is defined by the equation:

$$A_v = \frac{V_m^2}{12.96R_V}$$

**Figure 6.4** Vertical acceleration limits

| | |
|---|---|
| **Desirable limit** | 1.0%g = 0.098m/s2 |
| **Normal maximum** | 3.0%g = 0.294m/s2 |
| **Absolute maximum** | 5.0%g = 0.490m/s2 |

Every attempt should be made not to exceed the desirable limit. The absolute maximum value will only be used in exceptional circumstances. Where rolling stock speed is slow, determining the minimum vertical radius will be based on the following.

**Minimum Radius — Rolling Stock Related**
The minimum permitted radius of vertical curve will be limited where a three axle rigid wheelbase vehicle is to be used. The limiting factor will be the spring travel of the suspension of the vehicle.

For example if the rigid wheelbase (Ch) is 3m long, and the maximum allowable spring travel (V) is 40mm. The minimum allowable radius will be given by:

$$R = \frac{Ch_2}{8V}$$

Where Ch=3.0 and V=0.020, ie. R=56.25

If the positive and negative spring travels, measured about the horizontal axis, are the same, this figure applies to either hog or sag curves.

**Minimum Radius—Clearance Related**
If the maximum allowable loss of under-clearance of a vehicle is likely to affect the selection of vertical hogging curve radius then this should be evaluated using the formula provided in the section **Minimum Radius—Rolling Stock Related** substituting the maximum allowable loss of under- clearance for the spring travel. Similarly this can also be applied to loss of overhead clearance on a sagging curve.

**Minimum Radius—Rail Related**
The minimum permitted radius of vertical curve will be limited to the minimum radius to which the rail section to be used can be bent in the vertical plane as specified by the rail manufacturer.

**Maximum Radius**
Vertical curve radii must not be greater than 40 000m, as it is difficult to apply and maintain larger radii.

**Interaction of Vertical Curves and Horizontal Alignment**
Vertical curves, for reason of both safety and track maintenance, should not coincide with horizontal transitions, switch and crossing units or other special track features. If this is found to be unavoidable, every effort should be made to obtain a very large radius of vertical curve.

## 6.4 SIDINGS

**Horizontal Alignment**
The absolute minimum radius for slow speed sidings is 75m. To prevent buffer locking a length of straight or transition curve must be provided between reverse curves equal to at least the length of the longest wagon used, eg. LWB Wagon 11.25m, Freightliner Containers 13.5m, MOD Warwell Wagon 14.3m.

**Vertical Alignment**
Sidings should be on level track or where this is not possible on a gradient not steeper than 1 in 500

## 6.5 GAUGE WIDENING

**Application**
On curves of radius less than 200m (656 ft) gauge widening will be necessary to ease the movement of the vehicle round the curve. Gauge widened curves are to be constructed with the rail on baseplates supported by timber sleepers. The amounts of gauge widening prescribed are shown in Figure 6.5.

**Figure 6.5** Gauge widening for new design

| Curve Radius | Gauge Widening | Flangeway |
|---|---|---|
| 200-140m (656-459 ft) | 6 (V) | 50 ($1^{31}/_{32}$″) |
| 140-110m (459-361 ft) | 12 ($^{15}/_{32}$″) | 57 ($2^{1}/_{4}$″) |
| Below 11 Om (361 ft) | 19 ($^{3}/_{4}$″) | 63.5 ($2^{1}/_{2}$″) |

Gauge widening is to be achieved by moving the inner or lower rail of the curve. Gauge widening is not to be employed through switch and crossing work.

## 6.6 CONTINUOUS CHECK RAILS

On running lines where the radius is less than 120m (394 ft) a check rail is required on the inside of the curve. The check rail will be installed to the flangeways indicated in the table above. The check rail must be continued for at least 10m (33 ft) beyond the limit of the curve being protected, and must not finish closer than 5m from a running rail joint. Check rails are not required in sidings.

## 6.7 WHEEL STOPS

Where wheel stops are to be permanently or temporarily installed the following requirements must be fulfilled.

Where permanent wheel stops are to be installed they must be fitted to both rails of the track to protect personnel, property, (and wheels themselves) wherever personnel or property could be in danger from slow moving runaway vehicle in a railway yard as follows.

a. They should be provided in the vicinity of store houses, freight loading sidings, locomotive sheds, washing platforms, repair yards and other such places.

b Every wheel stop should be designed for its particular location, and requirements for its particular location and use on the track should be determined by the Railway Operating Manager.

c The stops should be correctly installed in pairs and in such positions that both wheels on the leading axle of a vehicle simultaneously contact the stops.

d Where used to protect locomotive sheds or other buildings where men work in or under rolling stock, they should be hinged and locked to the 'on' position at all times whether the shed doors are open or closed, except when rail movements in or out are required, in which case they may be locked after obtaining the approval of the shed master.

e Wheel stops are suitable only to hold a rail vehicle which is moving with minimum momentum and are NOT an alternative safety device to a buffer, sand drag or catch points.

f Details of permanent wheel stops for rail vehicles are shown in Figures 6.6 and 6.7.

## 6.8 SWITCHES AND CROSSINGS

### 6.8.1 Selection of Turnouts

The switch and crossing units available for use on MOD standard gauge railways are circular curve turnouts in the range between AV7-DV10$^{3}/_{4}$. These are currently in use on the majority of standard gauge railways within the British Isles. A typical turnout arrangement is shown in Figure 6.8 and a table of the leading dimensions is shown in Figure 6.9.

**Figure 6.6** Typical hinged wheelstop for use in paved areas

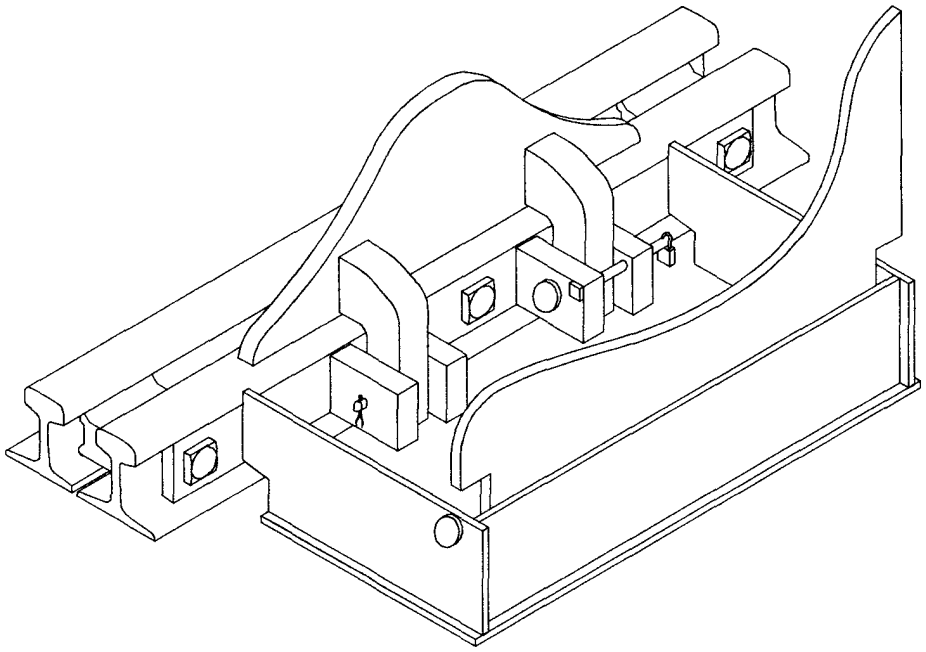


**Figure 6.7** Typical hinged wheelstop for use on ordinary plain track

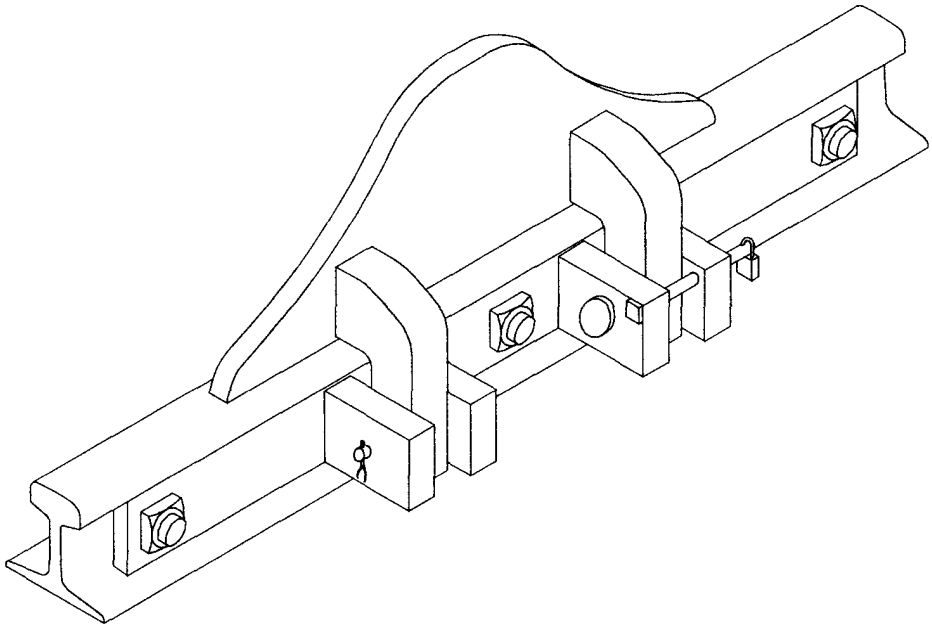


**Figure 6.8** Typical turnout arrangement

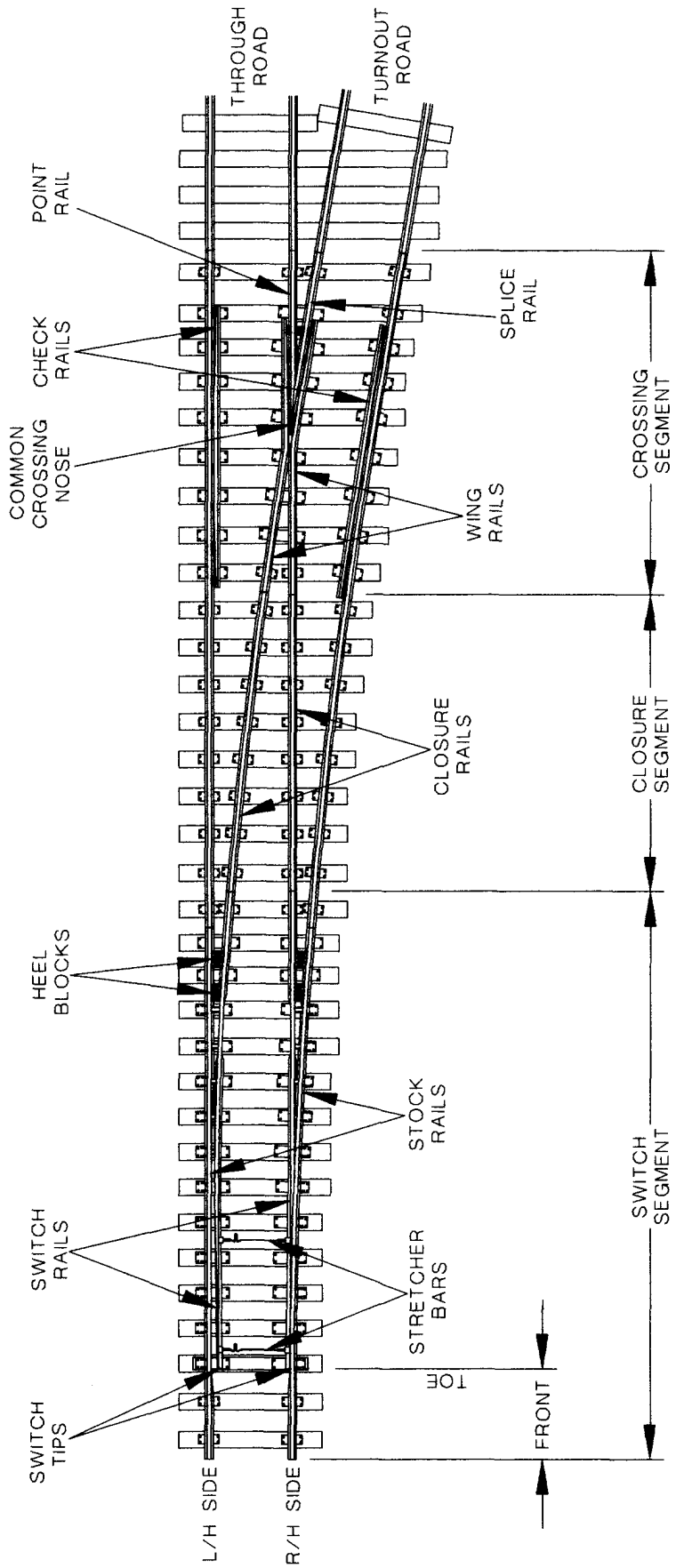


**Figure 6.9** BS 113A vertical s&c—circular curve turnouts—leads and radii

| Switch | Crossing 1 in | Lead Toe-Nose | Planing Radius | Switch Radius | Turnout Radius | Toe to Heel | Heel Offset |
|---|---|---|---|---|---|---|---|
| AV | 7 | 18617 | 196750 | 141052 | 141052 | 7317 | 279 |
| BV | 8 | 21465 | 230725 | 184012 | 184012 | 8737 | 289 |
| CV | 9.25 | 25025 | 287251 | 245767 | 245767 | 11920 | 373 |
| DV | 10.75 | 29346 | 367038 | 331687 | 331687 | 12440 | 298 |

**NOTES**

1. All dimensions in millimetres
2. Gauge is 1435 mm
3. All switches to be provided with 3070 mm fronts
4. Leads are given from toes of switches to nose of common crossing
5. All leads shown are natural angle turnouts.

### 6.8.2 Common Crossings

Figure 6.10 provides the leading dimensions of the common crossings associated with the specified 113A FB circular curve turnouts.

**Figure 6.10** Common crossing dimensions

| Crossing Angle 1 in | Nose to IP | Wing Rail Fronts | Vee Rail | Wing Rail |
|---|---|---|---|---|
| 7 | 112 | 3070 | 5450 | 5720 |
| 8 | 128 | 3070 | 5590 | 5720 |
| 9.25 | 148 | 3070 | 4110 | 5720 |
| 10.75 | 172 | 3070 | 4880 | 5720 |

### 6.8.3 Twist Rails

Twist rails are to be used to connect vertical design S&C or vertical plain line to inclined design track where the rails are set at an inclination of 1 in 20 towards the centre line of the track. Twist rails are closure rails which have a designed twist at a predetermined position. The twists in the rail must be located opposite each other and not closer than 1420 mm to the nearest joint in the rail.

## 6.9 SPECIFICATION

### 6.9.1 General

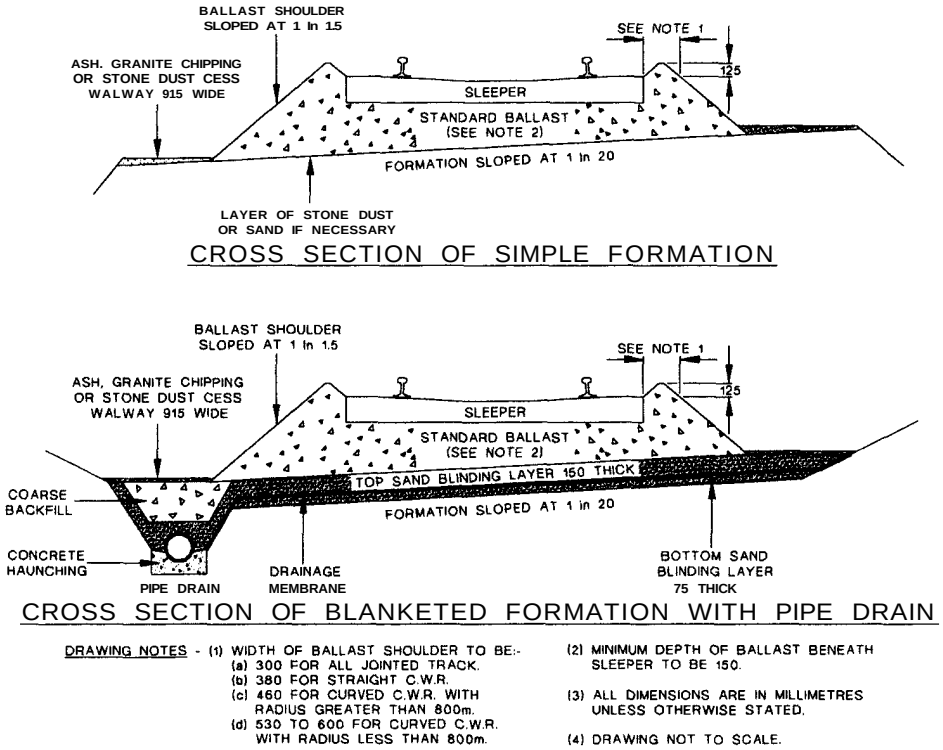
It is the responsibility of the Property Manager to task the WSM to ensure that the relevant standards are used. The WSM is to ensure that the specification for the works is of no lesser standard than indicated in the subsequent paragraphs.

### 6.9.2 Subgrade

**Preparation of Subgrade for Blanketing or Ballasting**

No ballast shall be spread upon the subgrade until the latter has been prepared in accordance with the approved design.

**Figure 6.11** Typical track cross sections




The subgrade shall be profiled in accordance with the typical track cross sections shown in Figure 6.11.

Where new tracks are to be laid on a site which has previously been used to support trackwork, any spent or fouled ballast or other material shall be excavated and removed from site before spreading any new ballast or blanketing material.

### 6.9.3 Granular Blanketing For Track

Granular blanketing (blinding) material shall be a sand grading which falls within the particle size distribution limits specified in Figure 6.12, when determined by sampling and sifting in accordance with BS 812: Parts 101 and 103.1.

Materials with more than 4% passing the 75 micron sieve shall have a Plasticity Index of zero when tested in accordance with the requirements of BS 1377: Part 4.

Where a granular blanket is placed within 230 mm of the bottom of sleeper level the material shall have a Uniformity Coefficient of not less than 2.

**Figure 6.12** Granular blanketing grading

| BS Test Sieve | Cumulative % by weight passing BS Sieve |
|---|---|
| 14 mm | 100 |
| 2.36 mm | 80*-100 |
| 1.18 mm | 70 - 90* |
| 600 micron | 48 - 76 |
| 300 micron | 24 - 60 |
| 150 micron | 5 - 4 2 |
| 75 micron | 0 - 1 0 |

* A tolerance of up to 4% may be applied to these percentages, distributed between the two sieves.

Sampling shall be in accordance with BS 812: Parts 101 and 102 with the defined bulk quantity which the sample represents taken as one lorry load on the stock-pile where present.

Test certificates on the granular material shall be provide for approval. Testing shall be undertaken by an approved independent company.

A 10 kg sample of the granular blanketing material shall accompany the test results.

**Laying of Granular Blanketing**

Granular blanketing shall be laid and spread upon the graded sub-grade by means which do not disturb the surface of the sub-grade. Pneumatic wheeled vehicles shall not run over the surface of the sub-grade during placing of blanketing.

Granular blanketing shall be laid, spread and compacted in layers not exceeding 150 mm thick. Each layer shall be compacted evenly by the use of approved plate compactors.

The final layer shall be regulated to a tolerance of +0 to —15 mm of a datum line parallel to the specified finished levels.

### 6.9.4 Geotextiles

If in the opinion of the WSM's design engineer the subgrade condition is such that movement of fines between the ballast and the subgrade is likely to occur then a suitable geotextile shall be provided. The geotextile shall be laid in accordance with the manufacturer's instructions and every precaution shall be taken to prevent the puncturing of the material by ballast. In particular, care shall be taken to ensure that geotextiles are laid correct side upwards.

### 6.9.5 Track Ballast

**Material**

Ballast shall normally be of crushed stone extracted from non-friable unweathered igneous or metamorphic rock. Other materials may be used subject to the approval of the WSM's design engineer. The ballast shall be angular in shape with all dimensions nearly equal and free of dust and deleterious substances. Samples shall be taken in accordance with BS 812: 1984 'Methods of sampling and testing'.

Grading of ballast shall fall within the limits shown in Figure 6.13 and have even grading between 50 and 28mm.

**Figure 6.13** Ballast grading

| Square mesh size (mm) | Percentage of weight passing |
|---|---|
| 63 | 100 |
| 50 | 97-100 |
| 28 | 0- 20 |
| 14 | 0- 2 |
| 1.18 | 0- 0.3 |

The ballast shall have the physical characteristics shown in Figure 6.14 which are derived from tests carried out in accordance with the procedures detailed in BS812:1984.

**Figure 6.14** Ballast characteristics

| Property | Not exceeding |
|---|---|
| Impact value | 25% |
| Crushing value | 30% |
| Wet attrition value | 6% |
| Flakiness index | 40% |
| Elongation index | 35% |
| Abrasion value | 25% |

In interpreting the requirements of this specification, reference shall be made to BS63 Part 2: 1987 and BS812 1984.

In the past, ash has been used for ballast. However, it is unsuitable because it crushes to dust and drains poorly.

Laying and consolidation of track ballast Bottom ballast shall be laid and spread upon the graded surface of the sub-grade or blanketing layer by means which do not disturb the surface. Only pneumatic wheeled vehicles with low ground pressure, or tracked vehicles shall be permitted to run over the graded surface after the initial layer of track ballast has been spread. No vehicle shall be permitted to run over the blanketing or subgrade until the initial track ballast layer has been provided.

Track ballast shall be laid, spread and compacted in layers not exceeding 150 mm thick up to 25 mm below bottom of sleeper level.

Each layer shall be spread to an even thickness, within a tolerance of +25 mm of a datum line parallel to the specified finished levels.

Each layer when spread to within the above tolerances shall be compacted evenly with two passes of an 8/10 tonne static smooth roller or equivalent.

The final layer shall be regulated to a tolerance after compaction within +0 to —15 mm of a datum line parallel to the specified finished levels.

### 6.9.6 Sleepers

**Timber Sleepers**

Timber sleepers shall be Douglas Fir, Baltic Redwood, Scots Fir or similar. They must be seasoned and impregnated with preservative. If the sleeper is machined in any way after receipt, the exposed area shall be treated with creosote to prevent the onset of decay in this area.

Sleepers shall be free from decay, heart (pith), unsound knots and live borers. They shall also be free from shakes, splits, hollow knots, compression failures or other defects which would render it unsuitable for use as a sleeper.

Sleeper size shall generally be 250mm (10") x 125mm (5") x 2600mm (8'6").

Maximum dimension tolerance at the time of inspection shall be:

| | |
|---|---|
| Width | +12mm / -0mm ($+^{15}/_{32}''/-0''$) |
| Thickness | +llmm / -0mm ($+^{14}/_{32}''/-0''$) |
| Length | +12mm / -0mm ($+^{15}/_{32}''/-0''$) |

The suppliers mark shall be impressed on the sleepers before delivery. Sleepers without the suppliers mark will not be accepted. The maximum variation in thickness (excluding wane) between the thinnest and the thickest points on a sleeper shall not exceed 12mm.

Deviations from straightness shall not exceed the following:

Spring (Curvature in the plane of its wide face)

A string, stretched from the mid point on one end to the mid point of the other end of the sleeper on the wide face, shall be wholly within that sleeper.

Cup (Curvature across the width)

A straight edge laid across the wide face of the sleeper shall not be more than 6mm from the deepest part of the cup.

Twist (Spiral distortion)

A spring stretched diagonally on either wide face shall not be more than 6mm from any point on that face.

Bow (Curvature in the direction of its length)

A string, stretched between the mid point of one end of the sleeper and the mid point of the other end on the edge (narrow face) should not deviate from the centre line of this face by more than 9mm.

Sleepers containing included phloem which runs from one end of the sleeper to the other, and is less than 30° to the vertical will be rejected. Sleepers containing included phloem through part of the sleeper and inclined at an angle of more than 30° may be accepted. The aggregate length of the longest splits at each end of the sleeper shall not exceed 150mm. Any single split whose length exceed 75mm shall be adequately clamped with galvanised steel anti-splitting plates of an approved type.

**Concrete Sleepers**

Concrete sleepers shall be of prestressed concrete and shall be capable of carrying 25 tonnes axle load and installed at 710mm centres. They shall be purchased from approved suppliers who shall provide certification as to their design loading.

Concrete sleepers readily available from manufacturers which fulfil these criteria are F40 grade or when available serviceable F27 grade.

**Steel Sleepers**

Steel sleepers are available to a number of different patterns the most current in main line use is to the BS 500 design. This pattern is of rolled steel construction with pressed up lugs and Pandrol brand rail fastenings which allow for full insulation for track circuiting. The sleeper is 12.7 mm thick under the rail seat and 280 mm wide overall with the legs 9 mm thick, a length of 2515

mm and finished weight of 81.9 kg. These sleepers are capable of carrying 25 tonne axle loads at moderate speed and achieving a service life of up to 25 years in the right conditions. Steel sleepers are difficult to pack without stone blowing machinery to insert ballast into the sleeper.

### 6.9.7 Rail

The selection of a suitable section of rail will be dependent upon the usage and envisaged annual tonnage a track will have to carry.

For new works and extensions 113A FB rail to BS11 should be used. However, if readily available, serviceable 75, 98, 109 or 110 Ib rail may be proposed.

On sites where there is sufficient length of continuous relaying or new works, Continuous Welded Rail may be used. Rails for use in continuously welded track shall contain no holes within the usable length. The minimum length of rail to be used shall be 4.5m.

For locations where rails shall be drilled for fishplates the minimum length of rail to be used shall be 4.5m on straight and 9m on curves.

### 6.9.8 Continuously Welded Rail

Where the use of Continously Welded Rail can be financially justified this is to be installed and maintained to the relevant Railtrack Group Standards.

### 6.9.9 Joints

In jointed track the running rails shall be connected end to end by fish plates requiring not less than four fishbolts and nuts for each pair of plates. Both fishplates and bolts shall be installed lubricated. Fish plates shall be forged and not machined or otherwise fabricated.

Rail joints shall be square across gauge on straight track but may be allowed to stagger by up to 60 mm ($2^3/_8$") on curved track. Appropriate short rails shall be provided on the inside rail of curved track to maintain the rail joints within this limit.

The running table of new rails at joints shall not be stepped or present angul ar discontinuity in any plane.

Joints between worn or different section rails shall be made with junction fishplates selected to minimise any step and shall, if necessary, incorporate approved shims to eliminate angular discontinuity in the horizontal plane. The requirement for and thickness of any shims to be fitted shall be determined from a 1.0 metre long straight edge and shim gauges. Shims shall eliminate dips without causing joints to hog.

**Expansion Gaps**

Expansion gaps for 18.3m (60 ft) and 36.6m (120 ft) rails must be provided and maintained in accordance with Figure 6.15.

**Figure 6.15** Rail joint expansion gaps

| Rail Temperature | Nature of Weather | Expansion Gap for 18 and 36 m rails |
|---|---|---|
| Below 10 degrees C | Cold | 10mm ($^{13}/_{32}$") |
| 10 degrees C and below 24 degrees C | Cold to warm | 6mm ($^{1}/_{4}$") |
| 24 degrees C and below 38 degrees C | Warm to hot | 3mm ($^{1}/_{8}$") |
| 38 degrees C and over | Very hot | Nil |

**Cutting Closure Rails**
When butting up new track to existing track, the final rail or rails shall be accurately measured and cut to match the length of the gap. Site closure rails in jointed and continuously welded track must not be less than 4.5m in length on the straight and 9m on curves.

**Drilling Fishbolt Holes**
All holes in rails shall be produced by drilling or trepanning. All personnel who are required to undertake the site drilling of rails shall be examined, passed proficient, and issued with a Certificate of Competency.

**Cold Expansion Bolt Holes**
All fishbolt holes in pearlitic rail steels shall be cold expanded.

### 6.9.10 Fastenings

Rail fastenings shall be of the spring clip type selected to provide the appropriate toe load to suit the axle load, type of rail, type of rail support and environmental conditions.

### 6.9.11 Baseplates

Baseplates for timber sleepers shall be manufactured from spheroidal graphite cast iron to BS 2789 or shall be an approved rolled steel section and shall be designed to suit the rail fastening system.
Baseplates shall show the following markings:

Manufacturer's Identification
Last two digits of the year of manufacture
Rail section
Plate type

### 6.9.12 Switch and Crossing Work

**Switch Rail Profile**
The vertical chamfered switch profile should be used; this provides additional thickness to the switch rail and also a continuity for wheels travelling from the stock rail to the switch rail. This is the most widely adopted profile and is the standard profile of full depth switch in the UK.

**Timbering For Switches**
Switch timbers are generally positioned at 710 mm centres throughout except at the rail joints. On the stock rail fronts, the spacing is 640 mm, and at the heel joints it is 660 mm. The centreline of the timber supporting the switch toe is 90 mm towards the crossing. The timbers are to be positioned at right angles to the main line—eg. for a right hand turnout the timbers are at right angles to the left hand track when looking toward the crossing.

### Common Crossings
Standard vertical BS113A built up crossings are to be used comprising a point rail, a splice rail, and two wings.

### Check Rails
Check rails are to be provided opposite all fixed common crossings, and form part of the construction of any obtuse crossing proposed. The check rail must control the path of the wheelset so that it is not possible for the wheel moving across the gap in the throat of the crossing, to strike the nose of the point rail. The ends of check rails are to be painted white as a trip hazard warning.

### Flangeway Width
The standard flangeway width in vertical switch and crossing work is 41 mm *(1¾")*. The critical dimension to be maintained is the distance between the running edge on the crossing side, and the working face of the opposite check rail (check gauge).This dimension must be maintained as nearly as possible at 1392 mm.

Flangeways of similar widths are to be provided between the vee rails and wing rails of common crossings, and between the wing and point rails of obtuse crossings.

### Timbering of Crossings
Timbers to be used are to be of Jarrah hardwood (supplied from a certified renewable source) of 307 mm x 127 mm (12" x 5") section, or an approved softwood of 307 mm x 154 mm (12" x 6") section, in lengths varying in 150 mm steps from 2450 mm to 6350 mm, and then in 300 mm steps up to 10250 mm.

On crossover roads, through timbers are used throughout the crossing portion (5900 mm long with a standard six-foot of 1970 mm).

Separate timbers are to be used where tracks opening out exceed 900 mm (3 ft) between running edges. This figure has to be increased to 1200 mm (4 ft) when concrete sleepers support the separate tracks.

### Orientation of Timbering
Timbers of common crossings are to be placed at right angles to the main line to avoid problems when tamping the alignment. It is essential that the longer baseplates should sit on the timber without overhanging the edge. If this is likely to occur the bearer must be rotated so that it lies closer to the theoretical optimum position, which is at right angles to the axis of symmetry of the crossing.

### Fouling Points
Fouling points must be marked in a manner agreed with the Railway Operating Manager.

# 7 Narrow Gauge Railways

## 7.1 DESIGN STANDARD

### 7.1.1 Purpose

This standard provides guidance to which all narrow gauge and range railway alignments for the MOD must conform. Notwithstanding the contents of this Standard designers must be proactive, considering all the issues that may affect their design.

The contents of this section does not absolve the Project Manager, WSM and designer from discharging his professional duties.

### 7.1.2 Application

The maximum design speed to be adopted for MOD narrow gauge railways shall be 15 km/h (10 mph) unless agreed otherwise with the Railway Operating Manager.

Lower design speeds may be adopted for certain sections where rolling stock characteristics will limit achievable speed or where a line speed of 15 km/h would result in unacceptable construction costs or in the case of range railways where the requirements for the target dictate the speed.

Where possible alignments shall be straight line and constant grade.

### 7.1.3 Symbols

The following symbols have been used in this document:

R = Horizontal curve radius (m)
Vm = Maximum speed (km/h)
E = Applied cant (mm)
D = Deficiency of cant (mm)
g = Acceleration due to gravity (m/s2)
s = Distance between contact points of wheels on rails (mm)
1 in N = Cant gradient
L = Length of transition (m)
G = Limiting gradient on straight track (%)
Gc = Limiting gradient on curved track (%)
Av = Vertical acceleration (m/s2)
Rv = Vertical curve radius (m)
V =Versine (m)
Ch =Chord Line Length (m)

## 7.2 HORIZONTAL ALIGNMENT

### 7.2.1 Circular Curves

**Relationship between Cant, Deficiency, Radius and Speed**

The relationship between cant, deficiency, radius and maximum speed is defined by the equation where D=0

$$E = \frac{sV_m^2}{gR} \text{ where D=0}$$

Where s = gauge + width of rail and g= 9.80665

For narrow gauge railways assume the use of 35M rail section for new works which has a head width of 42.86mm.

therefore Constant $K = \frac{s}{12.96g}$

Figure 7.1 provides the required K values for the variety of narrow gauge railways used by the MOD.

**Figure 7.1** K values for narrow gauge railways

| Gauge (mm) | Constant K |
|---|---|
| 600/610 | 5.17 |
| 762 | 6.33 |
| 1000 | 8.21 |

Therefore the relationship between cant, deficiency, radius and maximum speed for a 610 mm gauge railway is defined by the equation

$$E + D = 5.17\frac{V_m^2}{R}$$

The relationship between cant, deficiency, radius and equilibrium speed (i.e. when D=0) for a 610 mm gauge railway is defined by the equation

$$E = 5.17\frac{V_e^2}{R}$$

**Cant and Deficiency Limits in Plain Line**

The limiting values for cant and deficiency for narrow gauge railways are derived by proportioning those values applying to standard gauge railways.

**Figure 7.2** Cant and deficiency limits

| Gauge (mm) | Desirable Limits | | Absolute Limits | |
|---|---|---|---|---|
| | Cant | Deficiency | Cant | Deficiency |
| 600/610 | 45mm ($1^3/_4$″) | 45mm ($1^3/_4$") | 60mm ($2^3/_8$") | 45mm ($1^3/_4$") |
| 762 | 55mm ($2^3/_{16}$") | 55mm ($2^3/_{16}$") | 75mm ($2^{15}/_{16}$") | 55mm ($2^3/_{16}$") |
| 1000 | 75mm ($2^{15}/_{16}$") | 75mm ($2^{15}/_{16}$") | 100mm ($3^{15}/_{16}$") | 75mm ($2^{15}/_{16}$") |

### Cant to be Applied

Usually the cant to be applied will be given by the lesser of:

$$E = \frac{2}{3}(E + D)$$

or

E = Absolute maximum cant

This recognises that some deficiency is beneficial, assisting the steering of the bogies and avoids slow running traffic from experiencing excess cant. However, in some circumstances the cant will have to represent a smaller than ideal proportion of the total cant plus deficiency — for example in the case of some reverse curves or in the vicinity of S&C.

### Maximum Radius

The maximum permitted horizontal radius is 10000m (32808 ft). It is not possible to effectively apply and maintain flatter curves.

### Minimum Radius — Speed Related

The minimum permitted horizontal radius for a given speed can be calculated using the limits defined above for a 610 mm gauge railway. For example, minimum radius for 15 km/h:

$$65 + 45 = E + D = \frac{5.16 \times 15 \times 15}{R}$$

i.e. $$R = \frac{5.16 \times 15 \times 15}{65 + 45} = 10.6 \text{ m}$$

### Minimum Radius — Rolling Stock Related

The minimum radius of curve should be agreed with the Railway Operating Manager. Where space permits, curves greater than minimum should be specified. Figure 7.3 should be used as a guide.

**Figure 7.3** Minimum curve radii

| Max Wheelbase of Rolling Stock W(m) | Recommended Minimum Radius of Curves | Absolute Minimum Radius of Curves |
|---|---|---|
| 1.830 (6.0ft) | 37m (121 ft) | 22m (72 ft) |
| 1.525 (5.0ft) | 31m (102ft) | 18m (59ft) |
| 1.375 (4.5ft) | 28m (92 ft) | 17m (56ft) |
| 1.220 (4.0ft) | 25m (82 ft) | 15m (49ft) |
| 1.070 (3.5ft) | 21m (69ft) | 13m (43ft) |
| 0.920 (3.0ft) | 18m (59ft) | 11m (36ft) |
| 0.770 (2.5ft) | 15m (49ft) | 9m (30 ft) |

For wheelbases other than those shown above, the recommended and absolute minimums may be taken as 20 and 12 times W respectively. The use of a radius less than the recommended minimum (but not less than the absolute minimum) must be sanctioned by the Railway Operating Manager.

### Radii through Platforms

Where possible platforms should be located on a straight length of track. If this is not possible they should be located on a curve with as large a radius as possible. This is to ensure that acceptable stepping distances are maintained.

### Length of Straight or Circular Curve between Transitions

It is undesirable to have very short lengths of straight or circular curve between transitions as vehicles do not have enough time to stabilise between leaving one transition and entering another. A direct reverse is preferable to a very short element. The minimum length of element should allow a vehicle 2 seconds before reaching the next transition, at the maximum speed being considered for the line.

A useful rule of thumb is:

$$\text{minimum element} = \frac{V_m}{2} \text{ m}$$

## 7.2.2 Transition Curves

### Form of Transition Curves

The form of transition curve to be used is a section of clothoid spiral.

### Relationship between Transition Length, Cant and Cant Gradient

The application of cant to a curve over the transition is governed by the rate at which it is applied, the cant gradient.

### Rate of Cant Application Limits

**Figure 7.4** Rate of cant application limits

| **Desirable limits** | |
|---|---|
| Flattest Limit | 1 in 1500 |
| Steepest Limit | 1 in 400 |

| **Absolute limits** | |
|---|---|
| Flattest Limit | 1 in 1500 |
| Steepest Limit | 1 in 250 |

If cant gradient = 1 in N, the length of transition is given by the formula

$$L = \frac{(NxE)}{1000} \text{ m}$$

### Lengths of Transitions

The required transition length for a given cant gradient can be calculated using the equations above. If cant is applied in accordance with the above, cant will always exceed deficiency, and therefore transition lengths will always be governed by a consideration of rate of application of cant rather than rate of change of deficiency. However, where the application of cant is restricted for any reason (e.g. in the vicinity of S&C or the track being cast into concrete), the rate of change of deficiency may govern. When this situation occurs the formulae and limiting values for standard gauge track will apply. It is necessary to choose a cant gradient within the limits given and to decide on the cants to be applied to the circular curves, before a transition length can be arrived at. Taking into account the requirement to maintain the geometry of the transition the minimum practical

length for a transition should be 5 m (16'5"). Where the calculated length of transition equates to a length of below 5 m an instantaneous transition may be assumed; for calculation purposes when checking the rates of change a transition length of 1 m may be assumed. This figure is derived from the shortest practical distance between wagons axles. Application of superelevation on virtual transitions is to take place $^{2}/3$ on the straight and $^{1}/s$ on the curve.

**Transitions between Reverse Curves**
The term "reverse curve" is used to denote the situation where a curve of one hand is followed by another of the opposite hand, with no intervening length of straight. The transitions between reverse curves must be designed with the same rates of cant application on both sides of the reverse point and when deficiency is the ruling factor the same rates of change of deficiency must be achieved. To prevent buffer locking a length of straight or transition curve must be provided between reverse curves equal to at least the length of the longest wagon used on the system.

## 7.3 VERTICAL ALIGNMENT

### 7.3.1 Gradients

**Limiting Gradients**
The ruling or maximum gradients on running lines are a function of the tractive effort available from the locomotive and the weight of the train being drawn. Starting effort, curves and turnouts will reduce the power available for motion on inclines. The Railway Operating Manager should be consulted to ascertain the capabilities of the locomotives and hence to determine the ruling gradient.

**Instantaneous Changes In Gradient**
At a vertical intersection point when the change in gradient is less than 0.15% it may be assumed that a vertical curve is not required and the gradient may be allowed to change instantaneously.

**Compensation of Gradient on Horizontally Curved Track**
Limiting gradients usually refer to straight track. If a gradient is on a horizontal curve, it must be further limited to compensate for the additional resistance due to curvature. In practice, the compensation need only be applied when the horizontal curve radius is small, say 500m or less. An estimate of the limiting gradient on curved track can be obtained from:

$$G_c = G - \frac{70}{R}$$

**Gradients in Tunnels**
Ideally tunnels should have gradients of no flatter than 0.5% (1 in 200), to facilitate free drainage. If the geology or other factors make this difficult to achieve, flatter gradients may be used, down to a limit of 0.2% ( 1 in 500). Every effort should be made to avoid locating a sump or low point in the vertical alignment in a tunnel.

**Limiting Gradients Through Platforms and Loading Bays**
The HMRI's Railway Safety Principles and Guidance require a gradient not steeper than 0.20%(1 in 500) through a platform, where there is a likelihood that trains will be terminated, turned back, have portions attached or detached, have crews changed or stand without brakes applied. If it does not prove possible to limit the gradient to 0.2%(1 in 500) or flatter through any platform an application for dispensation must be applied for from the HMRI.

### 7.3.2 Vertical Curves

**Form of Vertical Curve**
The form of vertical curve to be used is a vertical parabola.

**Minimum Radius—Rolling Stock Related**
The minimum permitted radius of vertical curve will be limited where a three axle rigid wheelbase vehicle is to be used. The limiting factor will be the spring travel of the suspension of the vehicle. For example if the rigid wheelbase is 3m (10 ft) long, and the maximum allowable spring travel is 40mm ($1^{9}/_{16}''$). The minimum allowable radius will be given by:

$$R = \frac{Ch^2}{8V}$$

Where Ch=3.0 and V=0.020, ie R=56.25

If the positive and negative spring travels are the same, this figure applies to either hog or sag curves.

**Minimum Radius—Clearance Related**
If the maximum allowable loss of under-clearance of a vehicle is likely to affect the selection of vertical hogging curve radius then this should be evaluated using the formula provided in the section **Minimum Radius—Rolling Stock Related** substituting the maximum allowable loss of under-clearance for the spring travel. Similarly this can also be applied to loss of overhead clearance on a sagging curve.

**Minimum Radius—Rail Related**
The minimum permitted radius of vertical curve will be limited to the minimum radius to which the rail section to be used can be bent in the vertical plane as specified by the rail manufacturer.

**Interaction of Vertical Curves and Horizontal Alignment**
Vertical curves, for reason of both safety and track maintenance, should not coincide with horizontal transitions, switch and crossing units or other special track features. If this is found to be unavoidable, every effort should be made to obtain a very large radius of vertical curve.

## 7.4 SIDINGS

**Horizontal Alignment**
The absolute minimum radius for slow speed sidings is dependent on the rolling stock to be used. Reference should be made to the table within the **Minimum Radius—Rolling Stock Related** section above. To prevent buffer locking a length of straight or transition curve must be provided between reverse curves equal to at least the length of the longest wagon used.

**Vertical Alignment**
Sidings should be on level track or where this is not possible on a gradient not steeper than 1 in 500.

## 7.5 SWITCHES AND CROSSINGS

The minimum angle of turnout will be determined by the sharpest curve within the turnout which can be traversed comfortably by the rolling stock (refer to **Minimum Radius—Rolling Stock Related** above). Superelevation is not applied on turnouts. For a given angle of turnout there is only one radius of curve applicable to the gauge being used. Figure 7.5 is given as a guide so that a suitable angle of turnout can be chosen for a particular wheelbase and should be read in conjunction with the preceding paragraph referring to **Minimum Radius—Rolling Stock Related.**

**Figure 7.5** Typical turnout geometry (1)

| Gauge (mm) | Angle of Turnout (1 in N) | Approx. Centre Line Radius of Curve |
|---|---|---|
| 600/610 | 3 | 9.5m (31 ft) |
| 600/610 | 4 | 17m (56ft) |
| 600/610 | 4.5 | 21.5m (71 ft) |
| 600/610 | 5 | 27m (89 ft) |
| 762 | 2.5 | 9m (30 ft) |
| 762 | 3 | 12.5m (41 ft) |
| 762 | 3.5 | 17m (56ft) |
| 762 | 4 | 22m (72 ft) |
| 762 | 5 | 35.5m (116ft) |

Track fastenings for narrow gauge switch and crossing work will be similar to those used on flat bottomed standard gauge, scaled down as appropriate.

## 7.6 GAUGE WIDENING

The gauge must be widened by 7 mm ($^{9}/_{32}$") in all cases where the radius of curvature is less than 20 times the maximum rigid wheelbase of the rolling stock.

## 7.7 CHECK AND GUARD RAILS

At level crossings and hard standings, guard rails are required to maintain the flangeways required for the passage of vehicles. The flangeway formed by the guard rails shall be 35 mm wide. This should be increased by the same amount as any gauge widening which may be required. On curved track, provision of a check rail should be considered on the inside rail where the radius of curvature is less than 20 times the maximum rigid wheelbase.

## 7.8 SPECIFICATION

### 7.8.1 General

It is the responsibility of the Property Manager to task the WSM to ensure that the relevant standards are used. The WSM is to ensure that the specification for the works is of no lesser standard than indicated in the subsequent paragraphs.

### 7.8.2 Subgrade

Axle loading on narrow gauge track will be less than with standard gauge, but problems such as mud pumping may nevertheless occur on clay soils. With these subgrades consideration should be given to the provision of some form of blanketing eg fabric membrane. The subgrade should be sloped away from the centre line of the track at about 1 in 20.

### 7.8.3 Ballast

Thickness of ballast will depend on the type of subgrade and the use of the track. On narrow gauge track the ballast thickness is usually the same for sidings and running lines. The grading of the ballast for new works and maintenance should be within the ranges shown in Figure 7.6.

**Figure 7.6** Ballast grading

| BS Sieves | Percentage Passing (mm) (by weight) |
|---|---|
| 28 | 100 |
| 20 | 85-100 |
| 14 | 0–35 |
| 10 | 0–7 |
| 2.36 | 0–2 |

The ballast shall have the physical characteristics shown in Figure 7.7 which are derived from tests carried out in accordance with the procedures detailed in BS812: 1984.

**Figure 7.7** Ballast characteristics

| Property | Not exceeding |
|---|---|
| Impact value | 25% |
| Crushing value | 30% |
| Wet attrition value | 6% |
| Flakiness index | 40% |
| Elongation index | 35% |
| Abrasion value | 25% |

In interpreting the requirements of this specification, reference shall be made to BS63 Part 2: 1987 and BS812 1984.

### 7.8.4 Sleepers

Steel or wood sleepers of various sizes, depending on the weight of the rail and the gauge, are used in narrow gauge work including turnouts. Steel sleepers in particular may be found in many sections; usually they are an inverted U shape with plain or spade ends, the latter providing increased lateral resistance to movement in the ballast. Typical dimensions for wood and steel sleepers are given in Figure 7.8.

**Figure 7.8** Typical steel and wood sleeper dimensions

| RAIL (lb/yd) | GAUGE (mm) | WOOD (mm) | STEEL (mm) |
|---|---|---|---|
| 35 | 600/610/762 | 1220x150x100 | 1220x102x51 |
| 45,50 | 762/1000 | 1520x230x100 | 1520x102x51 |

### 7.8.5 Rail

Only flat-bottomed rail is recommended for narrow gauge railway work. On future narrow gauge track construction projects the BS 35M section of rail should be preferred. In the past 25R, 30R and 35R BS rail sections have been frequently used. Their use should continue when extending or relaying existing track layouts to maintain continuity, when the rail is readily available. Re-rolled rail may be considered for use where offered by a Contractor. The use of serviceable 751b rail on narrow gauge railway work requires a detailed evaluation of the interaction of the wheel profile with the gauge corner of the

rail for the particular types of rolling stock being used on individual sites. The standard rail sections and sleeper spacing used with various axle loadings are as shown in Figure 7.9.

**Figure 7.9** Rail loading capacities

| RAIL WEIGHT lb/yard (BS 'R') | GAUGE (mm) | MAX AXLE LOADING (Tonnes) | SLEEPER SPACING |
|---|---|---|---|
| 35 | 610/762 | 5.5 | 750mm (2'51/2") |
| 45 | 762 | 8.5 | 750mm (2'51/2") |
| 50 | 762 | 10.0 | 750mm (2'51/2") |

For new works it is recommended that a rail weight of 35 Ib/yard minimum is used.

### 7.8.6 Fastenings

On wood sleepers, rails are fastened by coachscrews and spring clips or by dogspikes. However for new construction the selection of fastening should be made on a balanced judgment taking into account system characteristics and economy of use. On steel sleepers spring clips used with a hook-on, welded on or punched out shoulder are preferred. In hardstandings, the rail may be fixed to a concrete base by means of rail clips and bolts or cast into the slab.

### 7.8.7 Switch and Crossing Work

Switch and crossing work is to be produced by manufacturers to the angle desired. The angle of the turnout will be governed by the minimum radius which can be traversed by the rolling stock. Where space permits, radii greater than the minimum should be provided.

# 8 Signs and Level Crossings

## 8.1 SIGNS

### 8.1.1 General

Appropriate signs shall be provided in accordance with current legislation and where local management may deem appropriate to satisfy Health and Safety requirements. Signs will be required at the following locations:

(1) The permanent way itself

(2) Level crossings

(3) Road entrances to a rail served depot—at all controlled entrances for pedestrian and vehicular traffic.

(4) Railway entrances to a depot at the point of demarcation between MOD and Railtrack property.

(5) Open Areas i.e. those areas in a rail served depot which are traversed by the permanent way and where official or public pedestrian and vehicular traffic is allowed freely to cross the permanent way. Such areas are frequently, but not necessarily, in hardstanding.

### 8.1.2 Standards For Signs

Railway traffic associated signs at MOD establishments in the UK shall be in accordance with the relevant sections of *The Traffic Signs Regulations and General Directions, 1994* wherever an appropriate sign is included therein. When a particular sign is required which is not included in the Regulations, signs contained within the Railtrack Group Standard *GK/RT0033—Lineside Signs* shall be used. Signs additional to those shown in the aforementioned documents are shown in Figure 8.1.

Signs shall be manufactured in accordance with BS 873.

### 8.1.3 Permanent Way Signs

Signs governing the movement and control of rail traffic must be authorised and sited by the Railway Operating Manager in consultation with HMRI. Temporary engineering signs shall be provided to give warning of permanent way maintenance or other works in progress which necessitate a restriction on speed of rail traffic.

**Figure 8.1** Additional road traffic signs

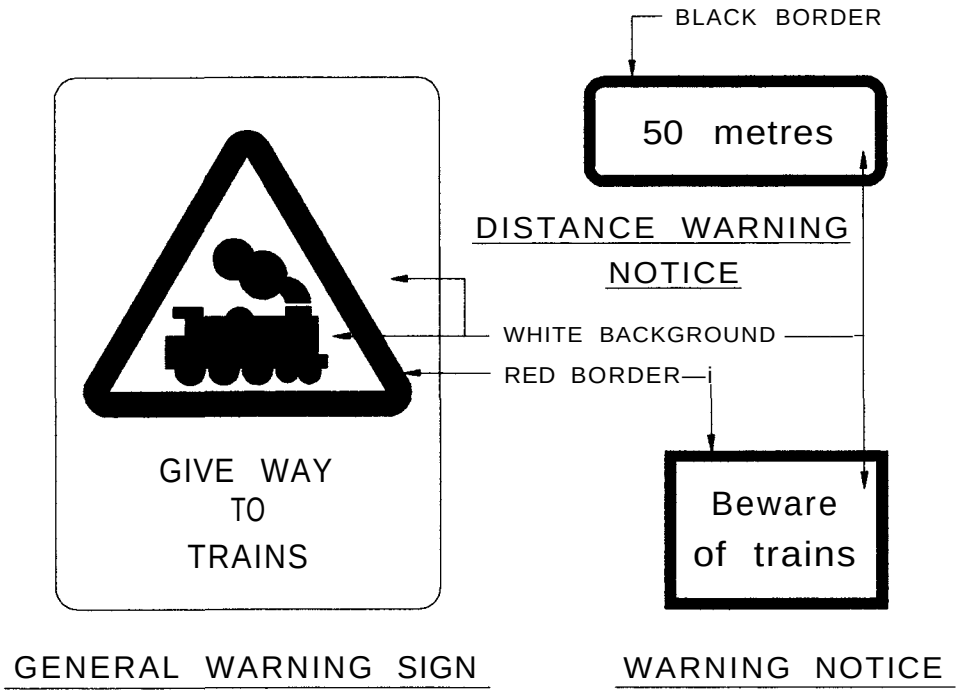
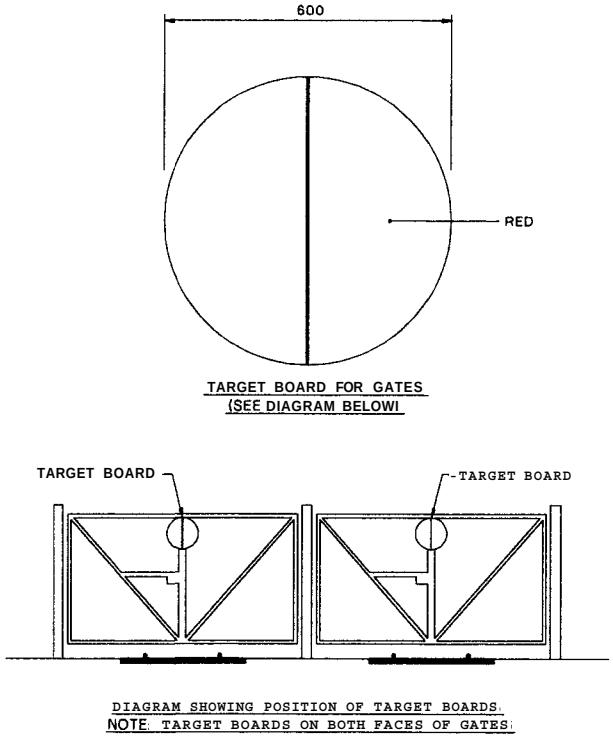



**Figure 8.2** Gates with target boards



### 8.1.4 Road Entrance To A Rail Served Depot

A General Warning Sign must be displayed at the road entrance to all rail served establishments and repeated within the establishment where considered necessary.

### 8.1.5 Rail Entrance To A Depot

Gates with target boards shall be provided at the railway entrance to the depot, as indicated on Figure 8.2. The Railway Operating Manager must be consulted on the railway entrance signing, and Stop Board, Restriction Sign etc. provided to suit the requirements and local arrangements with Railtrack.

## 8.2 LEVEL CROSSINGS

### 8.2.1 Crossing Types

**Within Government Establishments**
Railway Operating Managers' are responsible for controlling all movements of rail vehicles and for signalling within their areas of jurisdiction and must be consulted prior to the erection of signs. Open Crossings as defined in *Railway Safety Principles and Guidance- Level Crossings* should normally be provided.

**At an Intersection with a Public Road**
For the purpose of signing MOD railway crossings shall have a statutory position equal to that of level crossings operated on Railtrack property with public roads. In all cases and in co- operation with the Railway Operating Manager, the Department of Transport shall be consulted through the Local Highway Authority on the most suitable form of road and permanent way protection for the particular circumstances. The final arrangements must be approved by HMRI before proceeding with the installation. An Automatic Open Crossing, Locally Monitored, is normally installed and should be designed by a specialist level crossing consultant.

**Alternative Types of Crossing Protection**
Alternative types of crossing protection such as manually or automatically controlled gated and barrier crossings may sometimes be used after appropriate consultation, and should be in accordance with the *Railway Safety Principles and Guidance—Level Crossings.*

**Signs and Markings**
Appropriate signs shall be provided in accordance with the guidelines set out below at all level crossings within Government establishments and where a MOD maintained track intersects with a public road at a level crossing. The character of signposting and protection required at a crossing is dependent on prevailing circumstances such as the volume and frequency of road and rail traffic and topography of the area. Authorised types of level crossing protection for crossings of statutory railways are described in *Railway Safety Principles and Guidance—Level Crossings.*

**Highway Profile and Visibility**
Surfaces of level crossings and of their approaches, sight lines, lay-bys and other requirements should be provided and maintained to a standard which, in conjunction with signs and crossing protection used, provide the maximum possible safety to road and railway users. Steep road gradients and sudden changes in level should be avoided.

**Roadworks at or near level crossings**

The local Railway Operating Manager and Property Manager must be informed of the intention to carry out roadworks at or near a level crossing. All works at this location must be carried out in accordance with the MOD General Railway Rulebook and associated appendices.

## 8.3 OPEN AREAS

Open areas by their nature require careful control and in the interests of safety, all non- rail traffic (pedestrian and vehicular) must be encouraged, and where possible, channelled, to cross the permanent way at selected points. This will not only limit the number of signs required but it will also enhance the usefulness of the signs used. In cases of restricted visibility it is essential to establish crossings which provide the maximum practicable visibility for users of both the roadway and the railway. Where channelling of traffic and signing as for the Open Crossing layout is not feasible, strategic use may be made of the General Warning Sign for road traffic approaching the open area.

# 9 Loading and Structure Gauge

## 9.1 GENERAL

The dimensional limits of rolling stock and structures are known as loading and structure gauges. The minimum clearance for straight, level track is obtained by comparison of a loading gauge with the appropriate structure gauge. This clearance could be reduced to such an extent as to be dangerous, by one or more of the following:

- overhang of rolling stock due to cant
- centre throw and/or end throw of rolling stock due to track curvature
- loading of stock exceeding the recommended load gauge
- infringements of structure gauge.

## 9.2 LOADING GAUGE

The loading gauge is the maximum profile inside which all wagon loads must be contained. The loading gauge is line specific and will vary according to the minimum clearances to structures and other trains. In special circumstances wagons with loads protruding outside the loading gauge may be allowed but this will be at the discretion of the local management.

Whilst the loading gauge is related to static clearances, these clearances must be enlarged when considering moving rolling stock. The increased profile will be as a result of the effects of dynamic sway and vertical movement caused by speed, track curvature and cant, track positional tolerances, rail wear, rail/wheel tolerances, vehicle wear and suspension performance. The resulting new profile is known as the kinematic swept envelope.

Where an MOD establishment is connected to the Railtrack network the load gauge shall be at least W6A or as defined by Railtrack. However, where rail traffic is expected via the Channel Tunnel the load gauge shall be to UIC GB+. Details of these gauges are published in Railtrack Group Standard *GCIRT5204—Structure Gauging & Clearances* and UIC Code *506OR—Rules Governing application of the enlarged GA, GB & GC Gauges.* If loaded rolling stock has a greater profile than that allowed within an MOD establishment and is to be a regular feature, consideration must be given to making structural alterations to accommodate the new loading gauge. Such alterations may include widening shed door openings, adjusting platforms, raising overhead services etc.

## 9.3 STRUCTURAL CLEARANCES—STANDARD GAUGE RAILWAYS

### Clearances To Structures

The clearances to be used in determining the structure gauge should ensure the safe passage of trains including the additional clearance where vehicles have windows from which staff may lean out.

The derived structure gauge (see Railtrack Group Standard *GC/RT5204—Structure Gauging & Clearances* and UIC Code *506OR—Rules Governing application of the enlarged GA, GB & GC Gauges)* should be used to determine dimensions from a fixed datum preferably the running edge of the nearest running rail.

The lateral clearances between the structure gauge and the swept envelope should be at least 450 mm. This dimension may be reduced to 250 mm on lines where the rolling stock does not permit people to lean out. The dimension may be further reduced to 150 mm where there are no windows from which either passengers or staff can lean out and adequate measures are taken to positively fix the position of the track.

The vertical clearance between the swept path and the structure gauge should be not less than 250 mm. This may be reduced to 100 mm where the level of the track is permanently fixed in relation to the structure.

All wires, cables and conductors and any stay wires, which cross over the railway in the open, should be at least 6000 mm above rail level after allowance for wind and temperature effects.

In the case of electric cables the height may need to be increased to ensure adequate electrical clearances. This height will be determined by the type of electricity carried by the cable and advice should be sought from the cable owners concerning this matter.

Structures such as bridge girders, ground signals and similar railway operational equipment below platform level may encroach within the structure gauge. There should be a minimum clearance of 50 mm from the swept envelope. This clearance may be reduced to 25 mm where the swept envelope includes the maximum displacements combined with an allowance for serious rolling stock suspension fault.

Platforms should have a clearance of at least 50 mm to the swept envelope. The platform level should be determined taking into account all rolling stock using the platform but desirably should be 75 mm below the floor of an unloaded wagon.

### Clearances Between Trains

The clearance between swept paths of trains on adjacent tracks should not be less than the clearance between the swept paths of trains and a structure.

A reduced clearance of 380 mm between adjacent swept envelopes may be used on existing railways where this is the current standard clearance.

Where there are more than two running lines or there are sidings adjacent to running lines wider intervals may be necessary between pairs of running lines and between running lines and sidings to ensure safety of trains and staff.

Where the place of safety for staff is between two running lines or between a running line and a siding, its width should be 900 mm to allow for the possible effects of staff disorientation.

Where work being carried out involves side access for entry or for simple tasks such as examination of rolling stock, train preparation or coupling of vehicles the total clearance between adjacent siding swept envelopes must be 1130 mm.

### 9.4 STRUCTURAL CLEARANCES—NARROW GAUGE RAILWAYS

Due to the variations in rolling stock and rail gauge found between the various MOD Establishments, it is not possible to set a universal structure gauge for narrow gauge railways and the requirements for each site must be considered on their own account in consultation with the Railway Operating Manager. As a guide the clearances defined for standard gauge railways may be used with appropriate allowances for the swept path of the vehicle.

### 9.5 INFRINGEMENTS AND OUT OF GAUGE LOADS

When designing new works or alterations to existing structures the structure gauge must be taken into account. Where infringements exist they must be specially checked for rolling stock using the route and a record kept so that changes of rolling stock or out of gauge loads can be assessed.

On maintenance work care should be taken to ensure that the work carried out does not worsen clearances to structures. Every effort should be made to improve tight clearances by slewing or lowering of track.

Where the Railway Operating Manager wishes to carry out of gauge loads, the required kinematic profile must be checked against the structure gauge and particularly any infringements on the route.

# 10 Crane Track

## 10.1 GENERAL

Track laid down for the use of cranes is of necessity a different construction to that which is used for trains. In general crane track should be supplied, installed and maintained in accordance with the manufacturer's recommendations. However, the following information gives guidance on what may be expected in terms of design, installation and maintenance.

## 10.2 MATERIALS FOR CRANE TRACK AND THEIR USE

### 10.2.1 Foundations

Foundations to crane rail may be reinforced concrete ground beams or continuously supported beams within a harbour wall or on a jetty. Reinforcement in beams should be designed such that it avoids conflict with fixing anchor bolts where they are drilled after the beam is cast. Bolt fixings cast in with beams are preferable, and when used with a slotted rail clip, small adjustments in positioning the rail can be made.

### 10.2.2 Baseplates and Fastenings

Baseplates for rails may consist of a flat steel plate or a channel laid continuously beneath the rail. Where a grout bed is used for baseplates a non shrink grout is recommended. Tie bars fixed or welded to the plates may be laid transversely at 1200 mm centres to maintain gauge during construction. Bolts with fixings cast or drilled into the concrete foundation pass through the plates and rail clips secure the base of the rail. For frequently used track, elastic rail clips are preferred as fatigue induced in the bolts is less than with rigid clips. Where rails will be encased in concrete elastic clips must not be used.

### 10.2.3 Rails

Cranes may run on pairs of single rails, pairs of twin rails (duplex rail) or proprietary bridge rails. A guard rail should be provided where crane rail is located in hardstanding, but high wheel loads may dictate the use of a duplex rail. Cranes which run on duplex rail have a double tyred wheel with a central flange—see Figure 10.1. It is important that duplex rail is laid with the two rails as nearly level as practicable transversely to prevent eccentric loading on the wheel tyres and wheel bearings; hence a steel base plate is essential. Double headed bridge rail which acts in a similar fashion to duplex rail, will retain adjacent levels better. Single railway rails of a suitable section may be travelled by wheels having a central running tyre with straddling flanges on either side of

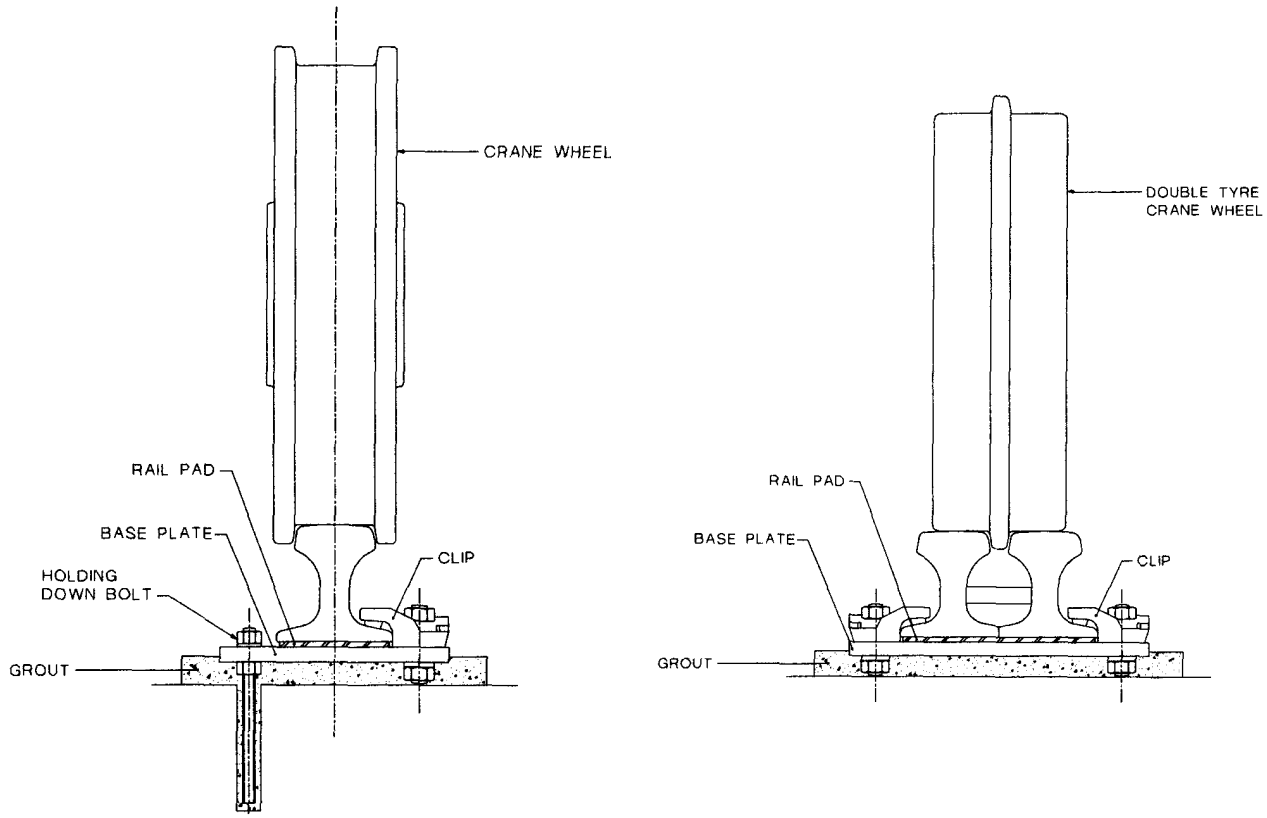



**Figure 10.1** Typical detail of double flange and double tyred crane rails

the rail head, or by a normal railway wheel with a single tyre and inner flange. For the latter, a flangeway width of 50 mm between the running rail and the guard rail is acceptable. For wheels with double tyres or double flanges, the flangeway width is determined by the wheel dimensions and axle span between wheel flanges. Where gauge widening is required on curves, the flangeways should be widened by the same amount that the gauge is widened.

### 10.3 NEW WORKS AND ALTERATIONS

The gauge to be provided should be checked against crane manufacturer's recommendations. The appropriate system of fixing rails should be chosen for the method of construction and the type of usage. Because of the impracticability of maintaining fishplated rail joints in hardstanding, welding of joints by an approved process is preferred. Stressing of the rail to allow for expansion is not necessary as gaps can be allowed at the rail ends for this purpose, or fishplated joints included at intervals in long runs. For tracks where the flangeway width is not governed by wheel dimensions, cleaning may be made easier by providing a wider than normal flangeway, say 100 mm. If there is a possibility of small wheeled vehicles being trapped, the gap should be filled with a sand asphalt mixture to within 50 mm of the rail head, depending on the wheel flange configuration. Expansion and contraction joints must be provided in concrete hardstandings. If parallel to the track and immediately adjacent to a dock edge, contraction or butt joints only need be provided in concrete. See DWS Drawing SD/020/4 for typical joint details in concrete hardstanding. Crane track should normally be laid flat and with no superelevation on curves. Where practicable, buffer systems should be installed not less than 1 metre from the

ends of sections of track as a safety measure. Such arrangements are not suitable for limiting travel under normal operating conditions. Rails should be bonded electrically to a suitable earth, where recommended by the crane manufacturers.

## 10.4 INSPECTION AND MAINTENANCE

### 10.4.1 General

Maintenance is limited to the components in the flangeway, as with any rail in hardstanding. The flangeway itself should be kept free of debris and all drainage holes kept functioning, as standing water will accelerate corrosion of the rail and fittings. Rusting of the web of the rail can be particularly severe at fishplates, which cannot be removed periodically for lubricating, possibly leading to collapse of the web. Regular flangeway cleaning is made easier by mechanical sweeping, but gaiters must be fitted to the apparatus to prevent debris flying outwards. Some cranes have steel bars fitted to their wheel guards, to act as ploughs for removing rubbish from their path. These bars can be used only where the track is straight. Irregularities of line and level can cause dangerous lurching of the crane and in extreme cases render it inoperable. The tolerances for re-laying the rail are set out below. In some cases it may be feasible to modify the crane to operate on out-of-true track by increasing its power to work on gradients, changing to wider tyres or putting more float on the axle to account for wide gauge. These modifications would have to be measured against alterations to the track and the amount of down time this entails. It is also possible to incorporate automatic self leveling devices in the crane design, but not as a remedial measure.

### 10.4.2 Inspection

Inspection of crane track shall be carried out quarterly by the EWC. A detailed report should be prepared following this inspection giving recommendations for maintenance and renewal of the track. If deemed necessary by the Property Manager the inspection interval may be varied but only after full consideration of past and predicted crane usage.

### 10.4.3 Tolerances for Crane Track

Tolerances for new rail and the limits for relaying the rail have been agreed between the MOD and various crane manufacturers as follows:-

New or relaid rails shall be such that when they are correctly laid they shall provide tolerances as shown below:

(a) Single Rail

| | | |
|---|---|---|
| (i) | Level | ± 3 mm about the specified level for each line separately. |
| (ii) | Gradient | 1 in 2000 over the crane base. |
| (iii) | Gauge | ± 5 mm about the specified gauge. |
| (iv) | Straightness | ± 3 mm about a median and a maximum rate of change of 1 in 5000 |

(b) Duplex Rails

As for single rail, but also

(i) Adjacent rails to be within 2 mm of each other vertically.

(ii) Flangeway gap must be compatible with all other tolerances for newly laid rail but a combination of permitted tolerances shall not alter the gap by more than + 6 mm from the specified gap.

Limits of Variation before remedial work is required are as follows:

(a) Single Rail:

| | | |
|---|---|---|
| (i) | Level | Variation must not exceed 3 mm/metre within the crane base measured across the track or along the track or across the diagonal of the crane base. |
| (ii) | Gauge | ± 10 mm about the specified gauge. |
| (iii) | Straightness | ± 6 mm about a median and a maximum rate of change of 1 in 1000 over the crane base. |

(b) Duplex Rail:

As for single rail, but also:

Adjacent rails to be within 2 mm of each other vertically.

Where crane manufacturer's requirements differ from the above, the manufacturers requirements should be used.

### 10.5 SAFETY ON CRANE TRACKS

Safety requirements for working on crane track are different from those relating to railway track. Crane speeds are low and there is normally less signalling equipment and fewer turnouts than with railway track. Maintenance work may be restricted to periods when the crane is not operating in which case normal health and safety at work rules apply. Local working instructions must be followed. Permission to carry out the work must be obtained from the officer in charge named in local working instructions. The crane driver must be informed at the start and end of any work done on the track. Whenever work is done on the track during crane operation a look-out must be posted and members of the maintenance gang must be ready at all times to move themselves and their equipment from the path of the crane. Tidiness of the working area is essential and loose clothing which may catch on obstacles should be avoided. Reflective safety jackets must be worn by the maintenance gang.

# Annexe A
# Inspection Report Format

As a general principle the quarterly defect inspection report (Operation 2) should be an exception report. Only those items which have changed since the last inspection should be reported. However, on an annual basis a full report should be produced (see Section 4.4). Reports should not include a description of the facilities or any superfluous material.

It is recommended that the report contains track inspection record sheets supplemented by inspectors comments. A typical track inspection record sheet follows:

**TRACK INSPECTION RECORD SHEET**

| Inspector: | | Facility:<br><br>Location: | Date: | | |
|---|---|---|---|---|---|
| Track Section/ Turnout No. | Track/ Turnout Type | Faults/Recommendations | Cat<br><br>( ) | Action by | Estimate |
| | | | | | |
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# Annexe B
# List of Common Defects

The following check list is intended to be an aide memoire to those inspecting the permanent way. It does not include every defect that may be found but rather seeks to act as a guide to the more common problems associated with the track.

| Element | Typical Component | Defect | Remedial Action |
|---|---|---|---|
| **Plain Line** | Rail Condition | Broken/Cracked Rail | Worked to be carried to table of minimum action and arrangement made for replacement of rail |
| | | Excessive Rail Water | Locations to be monitored in accordance with Section 4.7.13 and actioned accordingly |
| | | Wheel burns/Squats/ Taches ovales | Remedial action as specified in Section 4.7.7 *Rail Corrugations and Minor Rolling Contact Flaws* |
| | Alignment | Poor Horizontal Line | To be corrected to methods as specified in Section 4.7.18 |
| | | Poor Vertical Line | To be corrected to methods as specified in sections 4.7.16 and 4.7.17 |
| | | Incorrect Cross Level | To be corrected to values specified in Section 4.7.15 by lifting and packing as specified in Section 4.7.16 |
| | | Incorrect runoff | |
| | Gauge | Incorrect Track Gauge | To be corrected in accordance with Section 4.7.12 |
| | Fastenings | Expansion Gaps closed | To be maintained to table included in Section 4.7.8 using maintenance practices as described in Section 4.7.6 *Rail Creep* |
| | | Fishplates—Cracked/Brocken/ Loose/Seized | To be maintained to Section 4.7.8 |
| | | Spikes/Keys/Clips not driven home/Missing | To be maintained to Section 4.7.6 |
| | Sleepers | Incorrect Spacing | To be inspected and adjusted where necessary in accordance with Section 4.7.4 |
| | | Defective Sleepers Rotten/Broken | To be inspected and replaced where necessary in accordance with Section 4.7.4 |
| | Ballast | Deterioration of Quality | Replace sub-standard ballast with that which conforms to specification contained in section 6.9.5 |

| Element | Typical Component | Defect | Remedial Action |
|---|---|---|---|
| **Turnouts** | Switches | Excessive wear on Switch/ Stock Rails | Check gauge at toes (100mm front) and at drive points and heel blocks and adjust accordingly |
| | | Damaged Stetcher Bars | Check opening at switches and flangeway. Adjust/repair stretcher bars to achieve clearance specified in Section 4.7.9 |
| | | Indentation of Slide Baseplate Surface | Replace slide baseplate |
| | | Loose bolts in switches | Tighten to torque as specified in Section 4.7.9 |
| | Crossings | Excessive wear on Crossing Nose/Wing Rail/ Checkrail | Check gauge and flangeways at crossing nose and associated checkrails with reference to those values given in Section 4.7.11 |
| | | Loose blocks and bols in Crossing | Tighten bolts ensuring correct seating of blocks |
| **Wheel Stops and Buffers** | | Not reasonably vertical in the up position | Check clamping mechanism and replace stop when necessary |
| | | Buffer stop unsound | Replace timber buffer beam where necessary |
| **Warning Signs/ Posts and Markers** | Signs/Posts | Not visible | Trim back vegetation where view obstructed Review positioning and relating to the relevant standard should local arrangements have changed since original siting agreed |
| | | Not legible | Replace sign |
| **Level Crossings** | Flangeways | Worn check gauge | Check flangeways and gauge |
| | | Flooding of roadway | Check flangeways capable of draining roadway, clear flangeway of debris where necessary |
| **Drainage** | Formation | Wetspots/Priming | Check track drainage is running Check that debris/spoil has not been deposited on cess restricting run off |
| | Ditches | Overgrown/Blocked | Carry out maintenance/remedial work to bring the drainage ditch to a standard where it is functioning |
| | Catchpits | Blocked | Remove gravel and silts to ensure free running of drain |
| | | Gratings Damaged | Replace grating |
| **Banks/Cuttings** | | Instability of Slopes | Review bank/cut stability and carry out remedial works accordingly |

# Bibliography and other sources of information

## BRITISH STANDARDS


| | |
|---|---|
| BS 11:1985<br>(ISBN 0 580 14171 3) | Specification for railway rails |
| BS 47:1991<br>(ISBN 0 580 18456 0) | Specification for rolled steel fishplates |
| BS 63:1987<br>(ISBN 0 580 15673 7) | Specification for single size aggregate for general purposes |
| BS64 :1992<br>(ISBN 0 580 20981 4) | Specification for normal and high strength steel bolts and nuts for railway rail fishplates |
| BS 500:1956<br>(No ISBN number) | Specification for steel railway sleepers for flat bottom railway rails |
| BS 751:1992<br>(ISBN 0 580 20980 6) | Specification for steel baseplates for flat bottom railway rails |
| BS 4521 | Specification for railway turnouts for private users |
| (ISBN 0 580 06701 7) | Part 1 Section 1.1:1971 Turnouts using bull head rails |
| (ISBN 0 580 06691 6) | Part 1 Section 1.2:1971 Turnouts using flat bottom rail |
| (ISBN 0 580 08407 8) | Part 2:1975 Light grade turnouts over which British Rail locomotives do not operate for axles not exceeding 10 tons, using flat bottom rails |
| (ISBN 0 580 08173 7) | Part 3 Section 3.1:1974 Medium grade bullhead turnouts for axle loads not exceeding 25 tons over which British Rail locomotives do not operate |
| (ISBN 0 580 08186 9) | Part 3 Section 3.2: 1975 Medium grade flat bottom turnouts for axle loads not exceeding 25 tons over which British Rail locomotives do not operate |
| (ISBN 0 580 08196 6) | Part 4:1975 Heavy grade flat bottom turnouts for axle loads exceeding 25 tons over which British Rail locomotives do not operate |


## UIC CODES

UIC (Union Internationale des Chemins de fer) codes are available from DIG Headquarters, Publications Division, 16, rue Jean Rey, 75015 Paris, Tel: +331 44492185 Ext.2187 Fax: +331 44492029


| | |
|---|---|
| UIC 505-3 | Kinematic gauge used for wagon on international services |
| UIC 506 | Rules governing application of enlarged GA, GB & GC gauges |
| UIC 710 | Slacking of track gauge on curves |

| | |
|---|---|
| UIC 712 | Rail defects |
| UIC 715 | Factors affecting track maintenance costs |
| UIC 716 | Maximum permissible wear profiles for switches |
| UIC 717 | Laying of track on ballast on steel and reinforced concrete decks |
| UIC 719 | Earthworks and trackbed construction for railway lines |
| UIC 720 | Laying and maintenance of track made up of continuous welded rails |

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# Glossary of terms

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| **accommodation crossing/bridge** | | a private level crossing/bridge provided for the use of a land owner or his tenants to provide access to property or land when this has been severed by the construction of a railway. |
| **adjustment switch** | | a device installed either between continuously welded rail (CWR) and jointed track, or between CWR and switch & crossing units to permit thermal movement of the end of the CWR. |
| **adze** | | a cutting tool used for shaping timber, consisting of a long handle with a broad blade set at right angles, used in an underarm manner by a standing man. |
| **AHB level crossing** | | Automatic Half Barrier level crossing: a level crossing where barriers are provided only to the nearside of the road to either side of the crossing, whose opening and closing sequences are initiated automatically by the passage of trains. |
| **air brake** | | a type of brake in which the brake is held off by air pressure. |
| **alignment** | (1) | right of way of railway. |
| | (2) | longitudinal direction of track in horizontal and/or vertical plane, either as designed or as a result of traffic effects. |
| **alumino-thermic weld** | | a butt weld used to join rails, using a process causing a thermo-chemical reaction, normally undertaken in-situ. |
| **AMS** | | austenitic manganese steel. |
| **anchor** | | fitting attached to the foot of a rail, in contact with a sleeper or chair, to prevent longitudinal movement (creep) of the rail. |
| **AOCL level crossing** | | Automatic Open Crossing, Locally monitored: a level crossing without barriers, protected by automatic warning lights and sounds for road traffic activated by the approach of trains, the function of the automatic warnings being monitored by train drivers. |
| **AOCR level crossing** | | Automatic Open Crossing, Remotely monitored: a level crossing without barriers, protected by automatic warning lights and sounds for road traffic activated by the approach of trains, the function of the automatic warnings being at a manned location remote from the crossing (normally at a signal box). |
| **ATA** | | Automatic Track Alignment: A computer system fitted to track tampling and alignment machines, which accurately measures and realigns track during tamping. |

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| **ATTA** | | a version of ATA which acurately measures and realigns the track top as well as the alignment, during tamping. |
| **austentite** | | a type of steel consisting of a solid solution of carbon and iron with a smooth grain structure. |
| **back edge (of rail)** | | the outside edge of a rail (as opposed to the gauge face). |
| **back rail** | (1) | see stock rail. |
| | (2) | strengthening rail in a switch diamond. |
| **ballast** | | stone layer used to support and restrain sleepers, timbers and rail bearers; commonly graded, crushed, angular limestone or granite (see also bottom ballast and top ballast). |
| **ballast cleaner** | | a machine for ballast cleaning, with the track in-situ. |
| **ballast cleaner screenings** | | ballast fines after removal from ballast. |
| **ballast cleaning** | | the process of removing fines (which clog drainage) from ballast |
| **ballast fines** | | small particles of ballast broken off though ballast abrasion. |
| **ballast shoulder** | | ballast heaped at sleeper ends to provide lateral restraint to the track. |
| **ballast tray** | | a metal plate attached between S&C timbers or bearers where switch actuation or signalling equipment prevents correct packing of ballast around the timbers or bearers. |
| **baseplate** | | a cast iron, cast steel or pressed steel bearing plate used to support flat bottomed rail, fastened to the top of the sleeper. |
| **baseplate pad** | | a piece of resilient material between sleeper and baseplate. |
| **batter** | (1) | the slope of earthworks or retaining structures. |
| | (2) | the rounding off of rail ends at joints and of crossing noses caused by the passage of trains (a track defect). |
| **bay** | | see bed. |
| **bearer** | | concrete beam, supporting and connecting the rails of switch and crossing units. |
| **bed** | | the space between adjacent sleepers, timbers or bearers. |
| **belly rail** | | see closure rail. |
| **BH** | | bullhead rail. |
| **blanketing** | | a porous layer placed between the earthworks of the railway formation and the bottom ballast, with the aim of drainage, usually formed of sand and/or a special synthetic membrane. |
| **block joint** | | see IBJ. |
| **bond wire** | | an electrical connection between two rails to provide electrical continuity. |
| **bottom ballast** | | ballast beneath the underside of sleepers, timbers and rail bearers, used for vertical support, placed levelled and compacted before track laying. |

**boxing in** filling beds with ballast and reforming ballast shoulder.

**breather switch** see adjustment switch.

**buckle** a severe local distortion in rail alignment, frequently encountered in conjunction with severe increase in local ambient temperature with CWR.

**bullhead rail** a form of rail once used extensively in Britain in which the head and foot were of equal width. Now largely superseded by flat bottom rail.

**cant** superelevation of outer rail above inner rail on a curve.

**cant deficiency** shortfall of cant required for balanced traverse of a curve.

**cant gradient** the rate of change of cant with respect to distance along the track

**care and maintenance** track which has been put out of use for traffic purposes but which is to remain in situ, capable of being used at short notice

**catch pit** a chamber (normally covered) connected to track drains, to trap fines and other deleterious material for periodic removal.

**CCTV level crossing** Closed Circuit Television level crossing: a type of MCB level crossing where the crossing is remotely operated and monitored from a signal box.

**cess** a strip of ground between edge of ballast shoulder and bottom of cutting, top of embankment, bridge abutment or other structure, etc; providing a place of safety or safe walking route for railway staff.

**chair** a cast iron fitting fastened to a sleeper which supports bullhead rail secured in it by a wooden or sprung steel key.

**chair pad** see pad.

**check rail** an additional rail placed inside and parallel to running rails to guide wheel flanges.

**chord line** a short line linking two other lines.

**closure rail** a length of unmachined rail connecting switches and crossings in turnouts or crossings in diamonds.

**clothoid spiral** a type of curve where the curvature (ie. the reciprocal of the instantaneous radius) is proportional to the distance along the curve from its tangent point with the straight.

**compensated gradient** actual gradient plus the gradient equivalent of train curving resistance.

**corrugation** a rail defect: a regular series of peaks and troughs on the running surface of a rail.

**creep** (1) a progressive longitudinal migration of a rail relative to other elements of the track structure or of the entire track structure.

(2) creep control: a device fitted to locomotives either to enable them to haul a train at an exact predetermined (low) speed, activated in loading and unloading freight trains; or, to maximise starting traction.

**crib** see bed.

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| **crossing** | (1) | a piece of trackwork: enabling one track to cross another at an angle. |
| | (2) | a component of a turnout: the element forming the "V" where the tracks leading out of the turnout diverge. |
| | (3) | a right of way crossing a railway line at grade. |
| **cross level** | | the difference in level between a pair of rails, when compared normally to the rail centreline. Also an instrument used for measuring this difference. |
| **crossover** | | a pair of rails leading from one line to another to allow trains to be moved between pairs of tracks. |
| **crow** | | see jim crow. |
| **CWR** | | Continuously Welded Rail: rails joined by a series of butt welds, forming a length greater than 36.5 metres (120'), with adjacent lengths of plain line rail joined by expansion switches rather than fishplated joints. |
| **diamond** | | see crossing (1). |
| **equivalent annual tonnage** | | the total annual tonnage over a section of line with the actual weight of each train adjusted to reflect its "track friendliness". |
| **ESR** | | emergency speed restriction applied for a limited period whilst repairs are being carried out. |
| **exchange siding** | | a siding used to exchange rolling stock between two different railway networks, the exchange siding being connected to both networks. |
| **expansion switch** | | see adjustment switch. |
| **facing** | | facing the direction from which trains normally approach. |
| **facing crossover** | | a crossover which faces the normal direction of movement on the lines connected by the crossover, ie. used by trains travelling in the normal line direction. |
| **facing point lock** | | a mechanical device preventing the movement of points which face the direction of travel, activated when the signal for a train or route is placed in 'off indication. |
| **facing turnout** | | a turnout in which the switches face the normal direction of travel. |
| **fastening** | | a device for securing a rail, either directly to a sleeper or track slab, or to a chair or baseplate. |
| **fishplate** | | a plate used for making a bolted butt connection between two rails. |
| **flangeway** | | a clear way adjacent to the rail along which the wheel flange travels. |
| **FB rail** | | see flat bottom rail. |
| **flat bottom rail** | | a form of rail with a wide foot incorporating a flat bottom enabling it to be fastened direct to the sleeper or baseplate. |
| **foot crossing** | | an at grade crossing of a footpath or other pedestrian route of a railway. |
| **formation** | | the earthworks and trackbed of a railway. |

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| **fouling point** | The position on either of two or more converging tracks beyond which the necessary clearances for trains to safely pass each other is not available. |
| **fourfoot** | the area between a pair of rails forming a track. |
| **freightliner wagon** | a wagon used for carrying ISO type containers. |
| **frog** | a crossing unit (see crossing (2)). |
| **gall** | a defect where the rail has eroded in contact with a chair or baseplate, and/or a baseplate or chair has eroded in contact with rail. |
| **gauge** | the distance between the gauge faces of a pair of rails (see also standard gauge, narrow gauge, and broad gauge). |
| **gauge face (of rail)** | the running edge of a rail (the inside face between a pair of rails), from which the gauge is measured. |
| **gradient post** | a lineside post indicating a change of gradient. |
| **ground frame** | a small mechanical frame set apart from a signal box, often in the open, to control signals. On running lines this is frequently unlocked electrically from the nearest signal box, or by a release key. |
| **guard rail** | an additional rail placed inside or outside running rails and parallel to them, to restrain derailed rail vehicles. |
| **gut rail** | see closure rail. |
| **Hallade** | a mathematical technique for track realignment |
| **HMRI** | Her Majesty's Railway Inspectorate (part of the Health and Safety Executive of HMG) |
| **hunting** | lateral oscillations of a wheelset, bogie or vehicle. |
| **IBJ** | Insulated Block Joint: an insulated rail joint used for separating adjacent track circuits. Sometimes called an IRJ. |
| **interlocking** | either a mechanical or electrical device, or a piece of computer software which prevents signals and turnouts being set in such a manner so as they conflict with the potential to cause accidents. |
| **intersection bridge** | a bridge carrying one railway line over another. |
| **intrados** | soffit of an arch. |
| **jim crow** | a device for inserting or removing sharp bends in rails, shaped somewhat like an archery bow, consisting of clamps to hook round the rail at either end and a plunger on a screw thread in the centre. |
| **jointed rail/track** | rail or track using fishplates for butt connections between rails. |
| **key (as track component)** | timber or steel component used to retain bullhead rail in a chair. |
| **level crossing** | an at grade crossing of a road or other vehicular traffic of a railway line, frequently protected by special equipment and signalling. |
| **line (as permanent way term)** | horizontal alignment of a rail or track. |
| **line speed** | the maximum speed at which the fastest type of train is normally permitted to use the line, subject to PSRs. |

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| **lookout** | a railwayman whose duties are to observe the approach of trains and to warn other authorised persons present on the track of the approach of these trains. |
| **LWR** | Long Weldede Rail: rails joined by a series of butt welds to reduce the number of rail joints, generally forming a length less than 36.5 metres (120'), although this may be exceeded. This is not to be confused with CWR. |
| **longitudinal timbers** | timber rail bearers laid longitudinally to the rails, with chairs or baseplates attached to their upper face. |
| **marker board** | a temporary board placed at the trackside to delineate a particular feature, eg, limits of possession or TSR. |
| **MCB level crossing** | Manually Controlled Barrier level crossings: a level crossing provided with full barriers controlled and monitored by a signalman or crossing keeper. |
| **narrow gauge** | track of less than standard gauge, commonly employed for minor railways, as the normal gauge in Southern Africa, The Far East, and for secondary networks in parts of Europe and India. |
| **nose** | the point at which the running edge of two rails forming a crossing, meet. |
| **occupation crossing/bridge** | a private level crossing/bridge provided for the use of the land owner or his tenants when access to a piece of land or property has been severed by the construction of a railway. |
| **open crossing** | a level crossing where no barriers or warning lights etc are provided, generally confined to lightly used railways and roads. |
| **outside edge (of rail)** | the opposite face to the gauge face or running edge of a rail. |
| **overline bridge (overbridge)** | a bridge carrying a road, canal etc. over the railway. |
| **PACT** | Paved Concrete Track: a ballastless trackform consisting either of a continuous reinforced concrete track slab with baseplates directly attached to it or of special concrete sleepers cast into a continuous concrete slab. |
| **pad** | a piece of resilient non-conductive material between baseplate and rail. |
| **pearlite** | a form of steel made up of alternate laths of ferrite and cementite. |
| **permanent way** | all elements of railway trackwork. |
| **PICOP** | Person In Charge Of Possession during a possession of the line. |
| **PICOW** | Person In Charge Of Work at an engineering site. |
| **plain line** | a piece of track unencumbered by turnouts or crossings. |
| **point machine** | an electric motor providing power worked turnout actuation. |
| **point rail** | one of a pair of rails forming a crossing nose. |
| **possession** | an occupation of the line in which normal train services are suspended, normally for engineering purposes. |

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| **PSR** | Permanent Speed Restriction: applied to particular locations on a track (eg. curves) where the speed restriction required for safety, comfort, etc is less than the line speed. |
| **pumping** | a track defect whereby the sleepers, timbers or bearers depress into voids or soft ground under the passage of trains. |
| **rail bonding** | electrical interconnection of running rails to provide a minimum of resistance for traction return current. |
| **rail seat** | the area of a baseplate, chair, sleeper, timber or bearer which directly supports a rail. |
| **reception siding** | a siding into which an arriving non-passenger train arrives and is held clear of the running times. |
| **route availability** | the classification of locomotives and rolling stock based upon the load which they impose on structures, the numerical value of which must not exceed the Route Availability code for which a line has been passed, unless dispensation has been given. |
| **runround** | the process of releasing a locomotive from the front of a train at the completion of a journey and moving it to the other end of the train ready for the return run, or a track provided to facilitate this movement. |
| **sabot** | rail mounted friction wheel stop. |
| **S&C** | switches and crossings: all elements of the turnouts and crossings under consideration. |
| **S&C unit** | one complete item of S&C, eg. a turnout. |
| **sixfoot** | the space between the inner rails of a pair of double tracks. |
| **slab track** | see PACT. |
| **sleeper** | softwood, hardwood, concrete or steel beams supporting and connecting a pair of tracks in plain line. |
| **slide baseplate** | a baseplate used to support the moving part of the switch rails in a turnout. |
| **slide chair** | a chair used to support the moving part of the switch rails in a turnout. |
| **slip (as trackwork item)** | a type of S&C unit: resembling a crossing but fitted with switches which enable the unit to function additionally as a turnout, single slips permit this function from one end only, double slips permit it from both ends. |
| **splice rail** | one of a pair of rails forming the crossing nose. |
| **spot re-sleepering** | the replacement of individual sleepers as and when failure occurs. |
| **squat** | a fatigue crack seen at the rail head. |
| **standard gauge** | the normal gauge used in Britain, Europe, The Americas, China, most of Australia and many other parts of the world. In Britain is defined as 1435 mm for flat bottom or early CWR track, and 1432mm for switch & crossing work and modern CWR. |

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| **stock rail** | the fixed rail in a turnout, against which a switch rail bears. |
| **stretcher bar** | a connection between a pair of switches. |
| **switch (switch rail)** | one of a pair of moving blades in a turnout. |
| **tamping** | the process of repacking the ballast using a track mounted machine fitted with vibrating tongs which penetrate the ballast. |
| **tare weight** | the unladen weight of a vehicle. |
| **tenfoot** | the space between the inner rails of two pairs of double tracks on a four track railway line. |
| **tie rod** | a steel tie running between the bottom flanges of a pair of rails, used to maintain the correct gauge. |
| **timber** | softwood or hardwood baulk, supporting and connecting the rails of switch and crossing units. |
| **top** | accuracy of vertical alignment of a rail or track. |
| **top ballast** | ballast above the level of the underside of sleepers, timbers and bearers, providing lateral support for these elements, placed after track laying. |
| **track category** | a definition of the required track standard, based on line speed and equivalent annual tonnage. |
| **track circuit** | an electrical device which reveals the presence of a train on the piece of track connected to the track circuit, to a signalman or to the signalling system. |
| **traction motor** | electric motor used to propel train, used in electric or diesel-electric propulsion. |
| **trailable switch or turnout** | switches or turnouts which are set by the wheelsets of trains passing in the trailing direction. |
| **trailing crossover** | a crossover which does not face the normal direction of movement on the lines connected by the crossover, ie. they are used by trains reversing or travelling against the normal line direction. |
| **TSR** | Temporary Speed Restriction: a speed limit imposed, generally for safety reason to a particular length of track, delineated by marker boards. |
| **turnout** | the total assembly of trackwork involved in 'turning out' one line from another by means of a pair of switches, a crossing and a reverse curve running in the direction of the second line. |
| **twist** | a track defect: an unintended difference in cross levels. |
| **twist rail** | a special rail with a twist about a longitudinal axis, to marry inclined plain line rail to vertical S&C rail. |
| **UIC** | Union International des Chemins de Fer: the international railway standards organisation. |
| **underline bridge (underbridge)** | a bridge carrying the railway over a road, river or another railway. |
| **wet spot** | an area where pumping has caused fines to clog drainage through the ballast. |

# Index

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