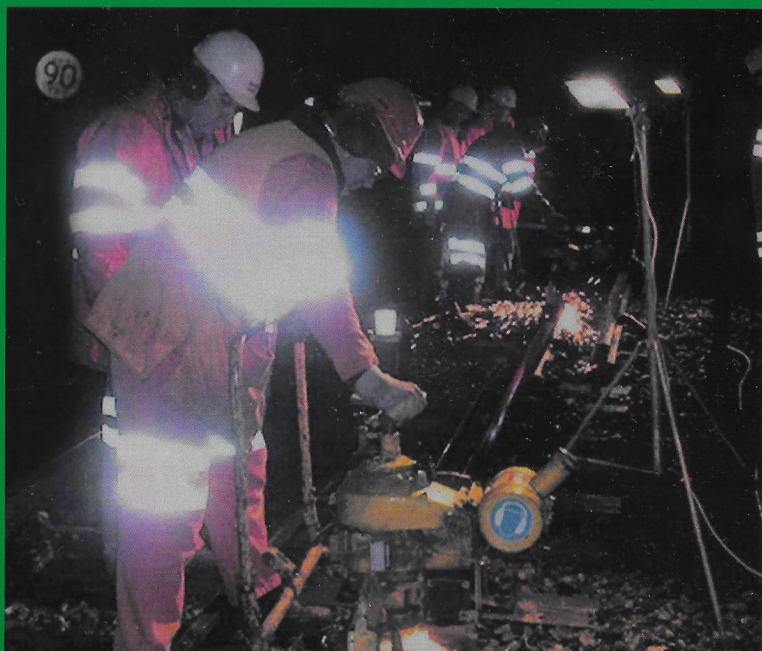


THE TREATMENT OF ROLLING CONTACT

FATIGUE BY HAND GRINDING

GOOD PRACTICE GUIDE



Produced by RAILTRACK PLC

RT/PWG/002

Issue 1

July 2001

Note

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This Guide

Although reference is made throughout this guide to the Grinding Supervisory Manager's role in hand grinding, the guidance provided is directed primarily at the grinding operatives actually carrying out the grinding operation.

Approved Training Courses

The guide refers to the Railtrack-approved Rolling Contact Fatigue Hand Grinding Training Courses for Grinding Supervisory Managers and for grinding operatives. Certification from the appropriate course is a pre-requisite for Grinding Supervisory Managers or grinding operatives undertaking rail hand grinding activities to remove rolling contact fatigue.

Glossary

A glossary of terms and abbreviations in use in reference to rolling contact fatigue issues, some of which are used in this guide, is contained in Appendix A.

FOREWORD

The grinding of rails is a basic means of maintaining rails in switches and crossings, being used to remove the lipping that develops on switches and crossing noses.

Recent experience has shown that rail grinding is one of the primary means of removing and managing rolling contact fatigue (RCF) cracks. If carried out in accordance with this Good Practice Guide, hand grinding is an effective means of removing short lengths of RCF and reducing the rate at which it will return.

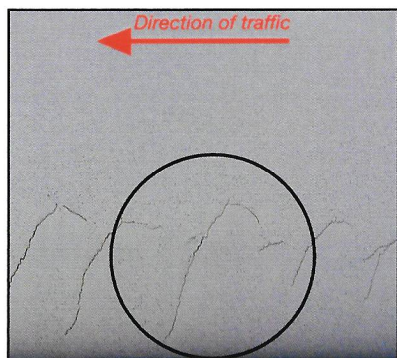
Grinding will also be effective if the general condition of the track is good. Alignment and top faults, dipped welds or joints, and defective or loose components should be rectified before hand grinding is carried out to ensure a long lasting treatment.

This guide has been prepared by Arup/TTCI for Railtrack, with particular contribution from Bill Garth.

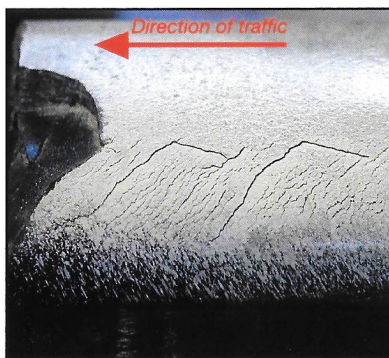
David Ventry B Eng (Hons) CEng FICE FPWI
Head of Track Engineering

ROLLING CONTACT FATIGUE

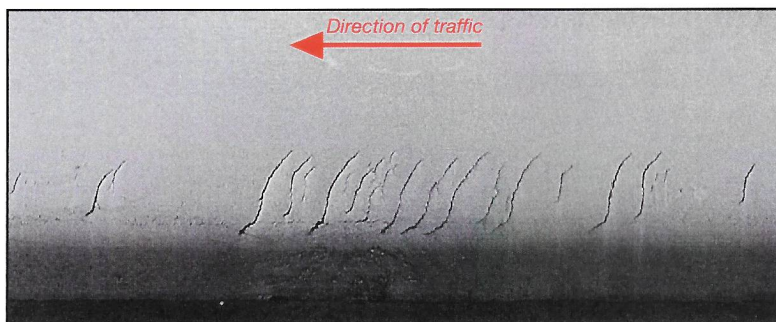
The rolling contact fatigue (RCF) of rails, whether manifested as head checking ('gauge corner cracking' on the gauge corner), squats, or lipping (or the more severe tongue lipping), is a major problem worldwide. Railtrack's 'Rolling Contact Fatigue in Rails; A Guide to Current Understanding and Practice RT/PWG/001', issued in February 2001, documents current understanding of the phenomenon of RCF as seen on its infrastructure.



C - Type Head Checks



V - Type Head Checks



S - Type Head Checks

The principal treatment to control RCF and other rail head irregularities is to grind the rail. There are two reasons for grinding: -

- To remove or reduce the size of cracks.
- To mitigate future crack development by re-profiling the rail head to reposition and reduce contact stresses.

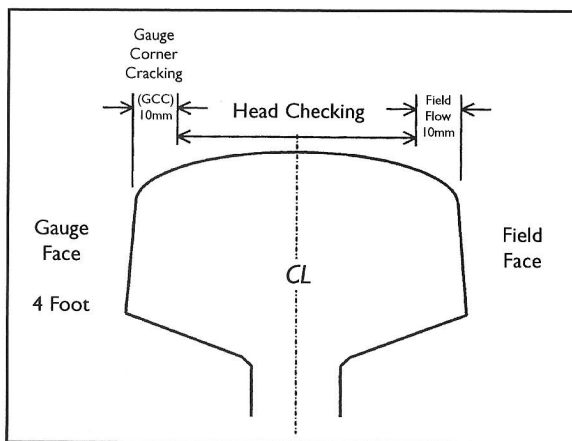
Such grinding can be train-based or manual, using a hand-guided, single stone, frame-mounted grinder.

Whilst hand grinding can be used to treat other forms of RCF, the primary purpose of this guide is to advise hand grinding operatives on the application of

hand grinding to plain line, switches and crossings (S&C) and adjustment switches to remove head checking and lipping.

Head Checking and Gauge Corner Cracking

Head checking can occur on all types of track but is predominantly found on curves and vertical S&C. When a high level of cant deficiency is combined with a curve radius of 1500 m or above, head checking usually occurs near the rail crown. As the curve radius reduces, the position of the head checking tends to move towards the gauge corner, hence the use of the alternative term 'gauge corner cracking'. It may be found on rails less than a year old, right through the age spectrum to rails that have been in track for 30 years and which have previously shown no sign of head checking.



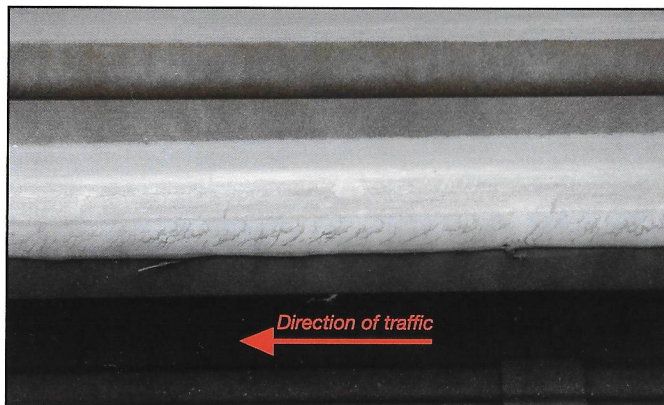
Classification of RCF According to Position on Rail Head

Usually, a substantial length of track is affected (e.g. the highly canted part of a curve), although isolated head checking can occur. The head checking is typically seen as a very fine array of small, closely spaced, nearly parallel cracks, perhaps only 2 – 3 mm apart, but the longer cracks may be more widely spaced (10 – 20 mm).

Head checking is typically found near the centre of the running band. It can be seen at a variety of angles (35° to 60°) to the longitudinal axis of the rail and develops into a variety of shapes; some are nearly straight; some have an elongated S-shape with a slight 'hook' at the end; others become V-shaped or C-shaped.

Lipping

Lipping occurs in components of S&C, such as the switch and stock rails, crossings and expansion switches. An essential part of good practice is to ensure that any such lipping is removed by hand grinding.



Gauge Corner
Cracking

APPLICATION OF THIS GUIDE

The provisions of this guide may be applied to any site on Railtrack's network where RCF exists or has previously existed. A site is defined by S&C number (if appropriate), ELR, track description (up, down etc), rail (6 foot, Cess, etc) and start and finish mileage / yardage.

The guide relates to the hand grinding of all rail grades (including Normal, MHT, Rolled AMS, Grade A and Grade B). It also relates to bainitic steel rails and crossings. It does not apply to cast, austenitic manganese components, which continue to be covered by Railtrack Specification RT/CE/S/054.

APPLICABLE STANDARDS AND SPECIFICATIONS

Railtrack's Company Standards must be complied with when undertaking any hand grinding activities. A brief introduction to the most relevant documents and some of the issues raised that may impact on hand grinding are contained in Appendix B – Applicable Standards and Specifications.

WHERE AND HOW MUCH TO HAND GRIND? WHO DECIDES?

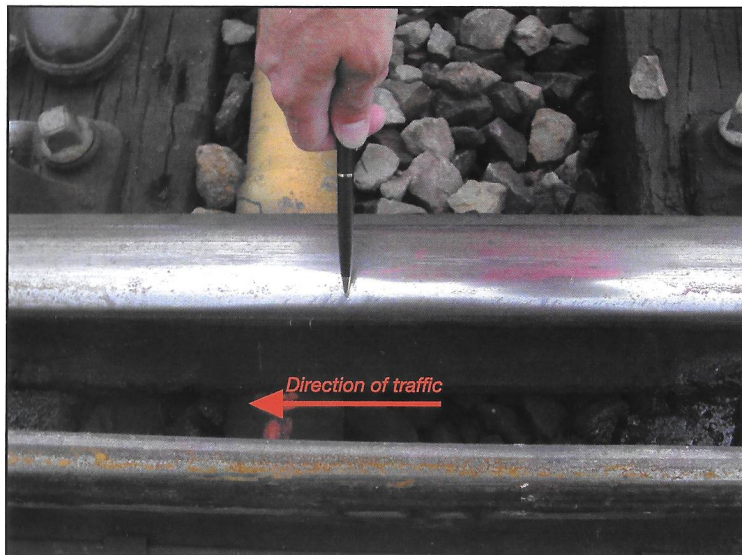
Where and How Much to Hand Grind?

Hand grinding is generally appropriate for removing short lengths of cracking in full cross-section rails. Permanent Way Special Instruction No 4 (PWVSI4 - see Appendix B - Applicable Standards and Specifications) recommends such short lengths should be of the order of 2m in order to ensure hand grinding can be accomplished within a shift. Longer lengths of cracking in either full cross-section or planed switch rails can be ground if adequate possession time is available. All lengths of lipping in full cross-section or planed rails should be removed by hand grinding, whether or not cracking is present.

Standard hand grinding equipment can be used to grind out gauge corner cracks to a depth of up to 5mm (7mm in exceptional circumstances), although

adequate clearance to fishplates must be maintained in accordance with Railtrack Specification RT/CE/S/104. The ground length should be transitioned into the adjacent un-ground rail at either side at a rate of change of no greater than 1 in 600.

Where any grinding is carried out, the rail head should be re-profiled in conjunction with the crack removal to prevent or minimise recurrence.



Gauge Corner Cracking on Switch Rail

Although, initially, work will almost certainly be prioritised on the basis of crack removal, grinding is a preventative and long-term maintenance activity.

Who Decides the Extent of Hand Grinding?

(A flow diagram indicating the sequence of activities following the discovery of a defect is given in Appendix C – Flowchart of Activities.)

Grinding Supervisory Manager

Track inspection, using visual and then ultrasonic or electro-magnetic array techniques, will identify a site affected by RCF. If the cracking is categorised as being other than 'Severe' and of short length (see PWSI 4), hand grinding should be considered to remove cracks.

The Grinding Supervisory Manager will be a person holding certificates in Personal Track Safety and from the Railtrack-approved Rolling Contact Fatigue Grinding Supervisory Manager's Training Course. For supervisory purposes it is necessary for the Grinding Supervisory Manager to have been instructed and deemed competent in S/053 inspections. He will be notified of the hand grinding requirement via Form HGI (see Appendix D).

It is the Grinding Supervisory Manager's role to assess the extent of hand grinding. In particular, he will inspect the site and complete Form HGI in relation to: -

- any preparatory work required prior to work (e.g. fettling of S&C)
- all relevant information which refers to the worksite (e.g. ultrasonics reports)
- any further investigation deemed necessary
- the extent of grinding work to be carried out (and mark the site accordingly)
- the resources (including safety staff) and time required to carry out the work
- whether there are any special requirements (e.g. S&T attendance is required)
- protection and access arrangements required

The Grinding Supervisory Manager will request the necessary preparatory work to be carried out and for the possession or other appropriate protection to be provided. He will then brief the grinding team using Form HGI on the hand grinding work to be carried out at the site.

BEFORE HAND GRINDING

Safety Precautions

Only persons holding certificates in Personal Track Safety and from the Railtrack-approved Rolling Contact Fatigue Hand Grinding Training Course will be permitted to carry out hand grinding operations. Operatives will be trained in all relevant safety legislation, and be in possession of, and use, appropriate Personal Protective Equipment.

Each site will be provided with the appropriate safety staff (eg. Controller of Site Safety (COSS), Site Warden(s), Lookout(s)).

Grinding Resources

Each grinding gang will normally consist of three grinding operatives including a Gang Leader. The three operatives should rotate on the grinding operation, allowing one to rest whilst the other two grind. Where work on S&C is planned, one member of the gang will be appropriately qualified in the inspection and repair of S&C to Railtrack Line Specification RT/CE/S/053.

Tools and Equipment

The recommended equipment for grinding will consist of: -

- Frame-Mounted Grinder(s)
- Generator Power Plant
- Lighting Units (for night working)

- Hand Held Angle Grinder
- Switch and Crossing Grinder
- Bar Gauge and Templates
(3 Pairs – Straight, Mild Curve and Sharp Curve)
- Other Approved Gauges for S&C Work
- Magnetic Particle Inspection Equipment
- Fire Extinguisher(s)
- Adequate supplies of consumables.

Switches and Crossings

It is essential that, if requested by the Grinding Supervisory Manager on Form HGI following the site inspection, any necessary fettling of S&C, or other works, is done before grinding commences.

The Railtrack-approved Rolling Contact Fatigue Hand Grinding Training Course provides grinding operatives with familiarisation on the components that make up S&C and their functions.

DURING HAND GRINDING

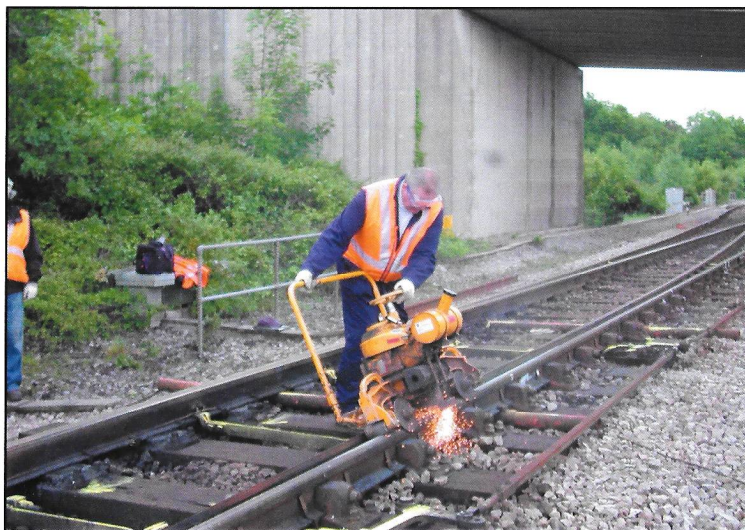
Use of Bar Gauge and Templates

Bar Gauge and Templates

A bar gauge, with accompanying templates, is a device intended to assist grinding operatives in re-profiling rail heads and for checking the final ground profiles. The bar gauge consists of an insulated central bar which spans between the rails and onto which an appropriate set of profile templates can be accurately mounted by hand tightened screw fixings. Templates not in use are also attached to the gauge for safekeeping. The template at one end of the bar gauge is fixed, whilst that at the other end is free to slide in the plane of the gauge to take up differences in the track gauge. A central carrying handle is provided.



Bar Gauge and Templates

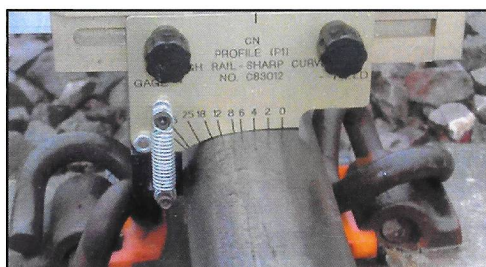


Frame Mounted Grinder In Use

There are three pairs of templates for straight or varying degrees of track curvature.

Template Pair No	Template Pair Marked	Template Pair Applicable To
1	Straight Track	Any straight track or any uncanted track, including that in S&C
2	High Rail - Mild Curve Low Rail – Mild & Sharp Curve *	Curves of radius of 440 m (22 chains) or more and including curved sections of S&C
3	High Rail - Sharp Curve Low Rail – Mild & Sharp Curve *	Curves of radius of 440 m (22 chains) or less, or with greater than 100 mm cant

* Note. The Low Rail templates (i.e. “Low Rail – Mild & Sharp Curve”) for curves of more than 440 m radius and for curves of less than 440 m radius are identical.



Typical Template

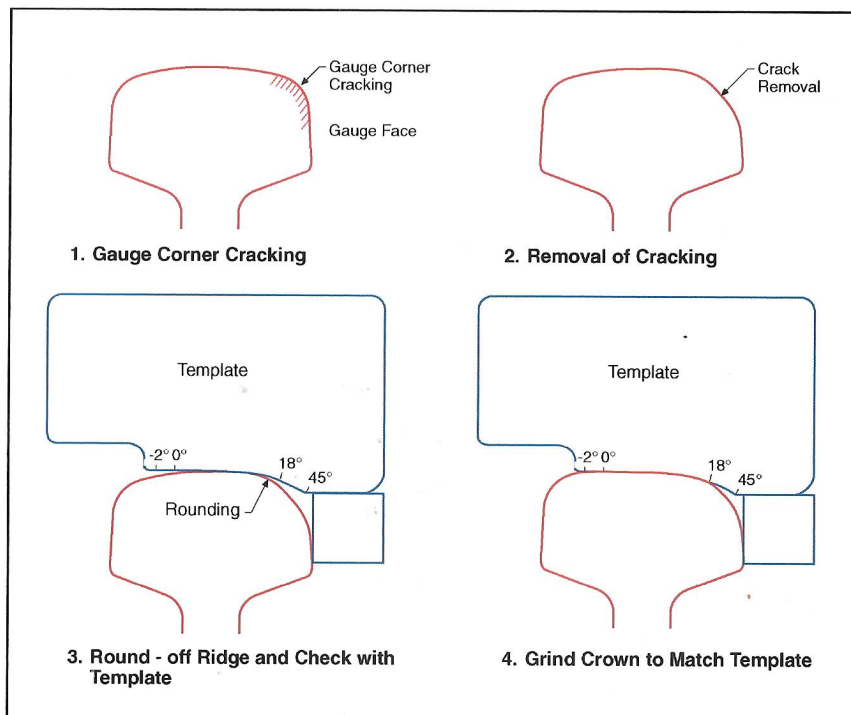
Setting the Bar Gauge

After selecting and fitting the correct templates, the bar gauge should be placed on the track at the location under inspection, taking care that, when used, the “High Rail” / “Low Rail” ends are correctly orientated. The fixed end template should be pushed firmly into the gauge face of the rail, with the sliding end template adjusted to fit snugly against the opposite gauge face.

Assessment of Rail Head Profile During Grinding

In all cases, there should be a good fit between the template and the rail head over the crown (i.e. between the -2° and 18° markings on the template). However, some clearance between the template and the rail head between the 18° and 45° markings on the template is acceptable, although there should be no excess material (i.e. there should be no high points) in this region. Any ‘ridge’ remaining between the ground gauge face and crown (i.e. close to the 18° mark) should be rounded-off by grinding.

In addition, there should be no excess material on the field side of the low rail on curved track between the -2° mark and the field face of the rail.



Grinding And Reprofile Sequence

Frequency of Checking Profile

The finished profile should be checked at every timber / bearer location within the re-profiled area.

Transition to Adjoining Un-ground Rail

The transition from the newly ground rail to the adjoining un-ground rail should be at a maximum rate of change of no greater than 1 in 600 (e.g. over a three metre length for a grinding depth of 5mm). There should also be a gradual transition of the newly-ground rail head profile to the adjacent un-ground rail profiles over this length.

Verification of Crack Removal

Magnetic particle inspection will be used to check that the depth of grinding has been sufficient to remove the cracks.

If further grinding is required and there is sufficient time available, it should be carried out immediately. Once the additional metal has been removed, the rail head should be re-profiled to the template and the ground length transitioned to the adjacent un-ground rail. The magnetic particle inspection should be repeated. This inspection/grinding/re-profiling/transitioning/inspection process should be repeated until the indications are that the cracks have been removed.

Although the planned grinding length(s) should be achievable within a shift, if further grinding is required but there is insufficient time available, the rail head should be re-profiled to the template and the ground length transitioned to the



Template on Closed Switch (Un-ground)

adjacent un-ground rail. The incomplete work should be recorded on Form HGI and the form returned to the Grinding Supervisory Manager who will request a further possession for completion at a later date.

If magnetic particle inspection indicates cracking could continue below 5mm, the Gang Leader should request ultrasonic testing to confirm whether further grinding is appropriate. Action will then be taken in accordance with PWVI 4 (see Appendix B).

Hand Grinding of Switches & Crossings

When grinding S&C, it is important to begin by removing all lipping on the crossing, switchblade, stock and closure rails.

With the switches set appropriately, the visible cracking on the gauge corner should be ground out with multiple passes with the grinding wheel set at approximately 20° – 45° to the gauge corner. During this stage, two grinding gangs working in adjacent areas, each operating a hand grinding machine, is often the most efficient method of working.

Removal of cracks should be verified as described earlier.

For switch and stock rail interfaces, the switches should be inspected to ensure that they are compliant with Railtrack Line Specification RT/CE/S/053, using the S/053 gauges, carrying out remedial grinding as necessary to achieve this.

Occasionally, obstructions such as bonding cables or tight flangeways will preclude the use of the frame-mounted rail grinder. Under these circumstances, the frame-mounted grinder is to be used as far as possible up to the obstruction on each side and the local area remaining then treated using a hand held disc grinder. For this reason, a stock of spare discs should be available, and the profile carefully matched to the template and transitioned into the adjacent rail.

Final re-profiling should be carried out over the whole length of the site, with frequent checks with the templates. A finer grade of grinding stone should be used for the final finishing. Once the cracks are removed and the template profile achieved, the switch rail/stock rail fit should be checked for compliance with standards.

The low rail, even if not affected by the cracking, should also be re-profiled to the appropriate template profile to improve the contact band. On the low rail, this will, generally, involve removal of material from the field side of the rail head. Again, switches should be moved as necessary to check compliance with standards.

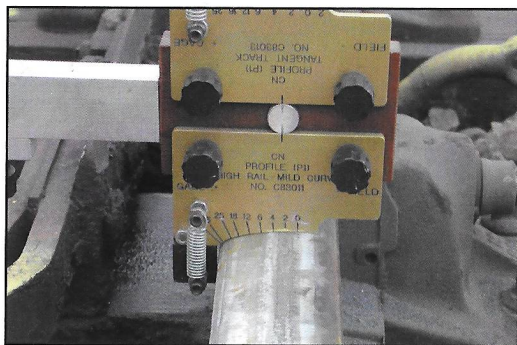
Hand Grinding Plain Line

The principles of grinding and procedure are as for S&C, with particular care being taken to ensure the appropriate template pair is used on the bar gauge.

AFTER HAND GRINDING

Inspections and Testing

After completion of the grinding operation, the Gang Leader should request that the track be re-inspected, with ultrasonic testing, magnetic particle or electro-magnetic array inspection being carried out to determine the adequacy of the grinding operation. If further grinding is necessary, and can be carried out within the same access period or possession, it should be undertaken immediately. If further grinding is required but cannot be completed within the time available, a new possession should be applied for.



Template Check at End of Grinding

If grinding cannot be completed entirely within a single possession, the track must be left in a suitable condition for the passage of traffic until such time as the grinding can be resumed.

When testing indicates sufficient grinding has been done, the Gang Leader should complete Form HGI

and return it to the Grinding Supervisory Manager. It is the Grinding Supervisory Manager's responsibility to pass completed copies of Form HGI to the track inspection personnel and to Railtrack.

After grinding S&C, the flangeways must be examined for obstructions and grinding dust and debris should be cleared away from the baseplates, rollers etc. The signalman should be asked to operate the points and confirm he has detection in normal and reverse directions.



Finished Rail Head

If a detection failure occurs, a signalling inspection of the switches must be made before their return to service at either restricted or full speed.

GOOD PRACTICE REMINDERS

In order to ensure that the hand grinding operation is performed safely and efficiently, it will be necessary: -

- to make sure all grinding operatives are aware of all the hazards
- to ensure that equipment has been maintained and certified in good working order and functioning prior to the possession
- to check that there are adequate supplies of consumables available
- to confirm that any arrangements for any moving of switches are in hand
- to make sure that the site is adequately lit
- to leave the works in a clean and orderly state, ensuring that no waste materials from the grinding process interfere with switch mechanisms or disrupt signalling circuits. (For example, grindings should not be allowed to contaminate roller or slide baseplates, and any insulated rail joints should be thoroughly cleaned on completion.)

Appendix A – Glossary of Terms and Abbreviations

AMS	Austenitic manganese steel, used for cast crossing components.
Bainitic Steel	Heat-treated, harder steel grade with a microstructure of predominantly ferrite and cementite.
Cant Deficiency	The difference between the equilibrium cant for the design speed (at which a passenger would feel no lateral force) and the actual cant provided.
CAT 1A	Category of track based on speed and tonnage.
Decarburised Layer	Softened surface layer caused by the hot rolling of rail.
DPI	Dye penetrant examination for surface crack detection.
ELR	Engineers Line Reference.
EMA	Electro-magnetic Array, technique for surface crack length and depth measurement. (e.g. 'Lizard' equipment)
EMGT(PA)	Equivalent Million Gross Tonnes (per annum)
ESR	Emergency speed restriction.
Field Flow	Rolling contact fatigue in the outer 10mm edge of the rail head on the field side.
GCC	Gauge corner cracking in the outer 10mm edge of the rail on the gauge corner side.
Grade A	Rail grade with a minimum hardness of 260 Brinell used for improved wear resistance.
Grade B	Rail grade used for improved wear resistance.
HC	Head checking, rolling contact fatigue in the central portion of the rail head.
Lipping	A band or line of material, which has been deformed from the rail shoulder forming along the gauge or field face of the rail.
Lizard	Electromagnetic Array equipment used for the sizing of surface breaking defects.

MHT	Mill heat-treated rail grade with a minimum hardness of 350 Brinell used for improved wear resistance.
MPI	Magnetic particle inspection for the detection of surface breaking cracks.
NDT	Non-destructive testing.
Normal Grade	Normal grade of rail with a minimum rail hardness of 220 Brinell.
Planed Rail	Planed rails are the length of switch rails with reduced head section, expansion switches and moveable rails in swing nose crossings.
PWSI	Permanent Way Special Instruction.
RCF	Rolling Contact Fatigue.
RT/PWG/001	Blue book: Rolling Contact Fatigue in Rails; A Guide To Current Understanding and Practice.
S&C	Switch and Crossing
S&T	Signalling and Telecommunications
Spalling	Breaking out of the surface of the rail due to the propagation of shallow sub-surface cracks.
Squat	A form of rolling contact fatigue usually occurring due to a local irregularity in the track or other defect.
Tongue Lipping	A form of severe lipping where metal from the shoulder of the rail is deformed in tongues down the gauge face.
TSR	Temporary speed restriction.
U3	Ultrasonic test procedure using 0° and 70° probes to examine along the rail, which can be offset towards either the gauge or field face of the rail.
UI4	Ultrasonic test procedure using 0° and 70° probes to examine along the rail, offset by 10mm from the centreline of the rail head.
“V” Shaped Crack	Rolling contact fatigue crack which shows a clear branch normally approximately perpendicular to the original crack.

Appendix B – Applicable Standards and Specifications

Background

There are Railtrack Company Standards that must be complied with when undertaking any hand grinding activities. Care must be taken when undertaking hand grinding activities to ensure total compliance. Knowledge of the constraints, adequate preplanning, the proper use of bar gauges, and care in the grinding process as presented in this Good Practice Guide should produce compliant results.

Applicable Specifications

The most important Railtrack documents that should be considered in conjunction with this document are:

- PWSI 4: Permanent Way Special Instruction No. 4 – Instruction on Management of Rails to Control Rolling Contact Fatigue (Gauge Corner Cracking and Head Checking)
- RT/CE/S/053: Inspection and Repair Procedures to Reduce the Risk of Derailment at Switches
- RT/CE/S/054 : Inspection of Cast Crossings and Cast Vees in the Track
- RT/CE/S/103 : Track Inspection Requirements
- RT/CE/S/104: Track Maintenance Requirements

A brief introduction to two of these documents and their possible impacts on grinding work are discussed in this appendix.

Permanent Way Special Instruction No 4 (PWSI 4)

The reader's attention is drawn to Permanent Way Special Instruction No 4 – Instruction on Management of Rails to Control Rolling Contact Fatigue (Gauge Corner Cracking and Head Checking), issued by Railtrack Plc on 27 April 2001. This Special Instruction, which has the status of a Railtrack Line Standard, is due for withdrawal on 1 April 2002, or sooner, when superseded either by a future PWSI or by a future issue of Railtrack Line Standard RT/CE/S/103.

Site Categorisation Under PWSI 4

PWSI 4 categorises each site on the basis of: -

- type of RCF (head checking, gauge corner cracking or field flow)
- surface length of the crack (lengths and shapes of cracks lead to a categorisation of the head checking as 'light', 'moderate', 'heavy' or 'severe')
- length of rail affected (if less than 18m of clean rail between sites of RCF, it is considered continuous)
- full section or planed (S&C and expansion switches) rail

Actions Arising From PWSI 4

PWSI 4 stipulates the actions required following the categorisation of the RCF. Where grinding is necessary, this may be carried out by hand grinding or train-based machine grinding. For shorter lengths of head checking, hand grinding, using a single stone frame-mounted manual machine (for example Stumec MPI2) of the type used to profile new welds, is the most appropriate.

RT/CE/S/053: Inspection and Repair Procedures to Reduce the Risk of Derailment at Switches

This document concentrates on two special aspects of switch wear that can increase the probability of derailment; switchblade shape and plain rail sidewear, with emphasis on the former.

Section 5: Tell Tale Signs of Derailment Risk

This section tabulates geometric conditions of switch rail in the tip region that can increase derailment potential. The section describes five hazards, which are explained in detail in Section 10. Grinding can produce some of these conditions.

Section 10: Inspection Procedures and Actions for Particular Derailment Hazards:

Sections 10.1 to 10.5 describe in detail – including pictures – the five hazard conditions. These sections dictate a shape of blade and a method of blade/stock rail contact. The requirements of this section must be considered before grinding in the vicinity of the switch blade tip, to ensure that the finished profile is compliant.

Section 6: Inspection Gauges and Their Use:

The gauges described in this section (which do not include the bar gauge described in this Good Practice Guide) as well as in Section 10 are depicted in pages 21 through 26. The grinding teams should obtain these gauges and become proficient in their use as described in Section 10.

Appendix B: Risk of Derailment

This section describes overall geometry of the blade and stock rail and contains requirements for the finished shape.

Appendix C – Flowchart of Activities

Visual, ultrasonic or
electromagnetic array track
inspection indicates rolling
contact fatigue

Grinding Supervisory Manager
inspects site and assesses work to
be done (eg fettling) and access
requirements to complete task.

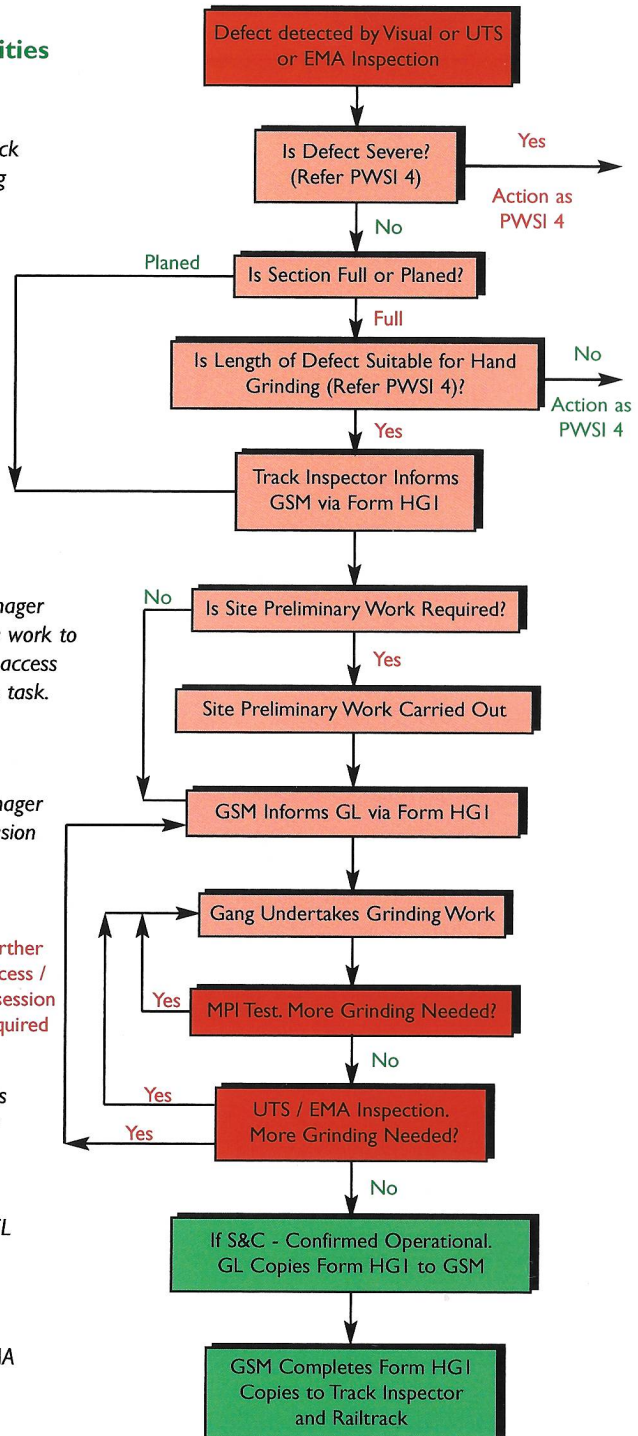
Grinding Supervisory Manager
arranges access or possession
and notifies Gang Leader

Track Inspector re-inspects
site to determine whether
cracks removed.

Following work on S&C, GL
requests signalman to
confirm detection.

Regular Visual / UTS / EMA
Inspection Resumes

Further
Access /
Possession
Required



Appendix D

RAILTRACK PLC HAND GRINDING RECORD – FORM HG1

Track Inspection Report

Inspection Type	Visual	UT	EMA	(Taken from Rail Defect Database)	Defect No	
Location						
ELR		Start		Finish		
Track ID		Mls	Yds	Mls	Yds	
Rail	Left/Right	Curve Radius		metres	S&C	Points No
Track Inspector		Signed		Date		

Grinding Supervisory Manager's Report

Inspection Date

Access to Site

Preparatory Work Required

Special Requirements

Protection and Access Requirements

Grinding Specification

Number of Gangs

Estimated Possession Time Required

Grinding Supervisory Manager

Signed

Date

Grinding Team Leader's Record

Depth of Grinding

Total Length Ground

Work Complete

Yes

No

If yes

mm

metres

Length of Blending

Grinding Time Taken

mm

hrs

Remarks

NDT Test Acceptable

Yes

No

Method

UT

MPI

EMA

Switch Blade Inspection S/053 Compliant

Yes

No

Switch and Crossing Confirmed Operational

Yes

No

Team Leader

Signed

Date

Supervisory Manager's Confirmation

Supervisory Manager

Signed

Date

Original Retained

Copy

Track Inspector

Railtrack

Notes

Notes

Notes

