UGL REGIONAL LINX

# Rail Grinding

**CRN-MAN-CVL-713026361-973**

**CRN CM 225**

LINKING COMMUNITIES. CONNECTING CUSTOMERS.

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# Document Control

| Function | Position | Name | Date |
|---|---|---|---|
| **Approver** | A&E Manager | Lucio Favotto | 30/01/2022 |

| Revision | Issue Date | Revision Description |
|---|---|---|
| **1.2** | | Baseline Document received from TfNSW |
| **2.0** | 30/01/2022 | UGLRL Template applied & First approved and issued UGLRL version |
| **3.0** | 30/01/2022 | Issued for publish to intranet and webpage |

## Summary of changes made from previous version

| Section | Summary of change |
|---|---|
| **All** | This document is based on the previous rail infrastructure maintainer (RIM). Full revision history is available on request from UGLRL. |

# Chapter 1 General

## C1-1 Purpose

This manual provides requirements, processes and guidelines for technical specification and management of rail grinding in both mainline track and turnouts on the Country Regional Network (CRN).

## C1-2 Context

The manual is part of UGLRL CRN's engineering standards and procedures publications. More specifically, it is part of the Civil Engineering suite that comprises standards, installation and maintenance manuals and specifications.

Manuals contain requirements, process and guidelines for the management of track assets and for carrying out examination, construction, installation and maintenance activities.

The manual is written for the persons undertaking technical supervision of rail grinding activities.

It also contains management requirements for the District Engineer and Superintendents needing to know what they are required to do to manage rail grinding activities on their area, and production managers needing to know what they are required to do to manage the rail grinding activity.

This manual is part of a series of seven (7) rail manuals

- CRN CM 221 - Rail Installation and Repair
- CRN CM 222 - Rail Welding
- CRN CM 223 - Rail Adjustment
- CRN CM 224 - Rail Defects and Testing
- CRN CM 225 - Rail Grinding
- CRN CM 226 - Rail Defects Handbook
- CRN CM 227 - Rail Surface Defects

## C1-3 How to read the Manual

The best way to find information in the manual is to look at the Table of Contents on page 3.

When you read the information, you will not need to refer to CRN Engineering Standards. Any requirements from standards have been included in the sections of the manual and shown like this:

| *The following requirements are extracted from CRN Engineering Standard CRN CS 220 “Rail and Rail Joints”* |
|---|
| The rail profiles to be achieved by rail grinding or milling shall meet the following requirements:<br>– The rail shapes apply to tangent track and curved track (including for high and low rails) in accordance with Table 1.<br>– The same basic shapes apply to 47 kg/m, 50 kg/m, 53 kg/m, 60 kg/m and 60 kg/m head hardened rail.<br>– The rail profiles apply to preventive and defect grinding strategies. |

Reference is however made to other Manuals.

Throughout this manual reference is made to the following levels of Engineering Authority:

- Principal Track and Civil Engineer
- District Engineer
- CRN Rail Engineer CRN Representative
- Grinding Superintendent

- Grinding Supervisor

These are general descriptors only. For an explanation of the positions in the CRN organisation that perform these functions, refer to Engineering Manual CRN CM 001 "Civil Technical Competencies and Engineering Authority"

## C1-4 References

### C1-4.1 Australian and International Standards

Nil

### C1-4.2 CRN Documents

CRN CS 100 – Civil Technical Maintenance Plan

CRN CM 001 – Civil Technical Competencies and Engineering Authority

CRN CS 220 – Rail and Rail Joints

CRN CM 222 – Rail Welding

CRN CM 226 – Rail Defects Handbook

### C1-4.3 Other documents

Nil

# Chapter 2 Management Requirements

## C2-1 District Engineer

The District Engineer is responsible for:

- determining grinding strategies for the CRN (See Chapter 8),
- monitoring rail condition through the Track Inspection System

## C2-2 CRN Rail Engineer

The CRN Rail Engineer is responsible for:

For **plain track** grinding:

- Approve application of templates (See Section C7-1).
- Specify the application requirements for the locating lug on low rail and tangent rail templates (See Section C7-2).
- Specify Gauge Corner Relief for the high rail template outside the feeler gauge tolerances specified. (See Section C7-3).
- Specify additional field side relief when, after the application of the normal templates, there is still evidence of field side contact because of excessive tread hollowing on wheels. (See Section C7-4).
- Specify the metal removal requirements for corrective grinding of transverse profile (See Section C7-6).
- Specify the metal removal requirements for transitional grinding of transverse profile (See Section C7-6).
- Specify the requirements for removal of isolated defects identified prior to grinding (such as dipped or peaked welds, wheel burns or squats) (See Section C5-8.2).
- Authorise variation to the requirement to remove longer pitch corrugations (See Section C7-7).

- Undertake visual inspections of the rails at 60 - 70% of the way through the planned grinding cycle (See Section C5-9.2 Item (2))).
- Carry out spot checks of rail grinding at nominated checking locations as a follow up to the grinding operation (See Section C5-9.2).

Investigate variations to the designed contacts and report major anomalies to the Principal Track and Civil Engineer.

For turnout grinding:

- Approve application of templates (See Section C7-1).
- Specify additional field side relief when, after the application of the normal template, there is still evidence of field side contact because of excessive tread hollowing on wheels (See Section C7-4).
- Specify the metal removal requirements for preventive grinding of transverse profile (See Section C7-5).
- Specify the metal removal requirements for corrective grinding of transverse profile (See Section C7-6).
- Specify the metal removal requirements for transitional grinding of transverse profile (See Section C7-6). Carry out spot checks of rail grinding at nominated checking locations as a follow up to the grinding operation (See Section C6-8.1).

## C2-3 Manager, Project Delivery

The Manager, Project Delivery shall:

- Arrange for the supervision and management of the rail grinder.
- Supply CRN Grinding Supervisors.

## C2-4 CRN Grinding Supervisors

CRN Grinding Supervisors shall:

For plain track grinding:

- Visually assess rail condition before grinding (See Section C5-3.2).
- Establish the monitoring regime for the grinding operation (See Section C5-3.4 and C5-3.5)
- Monitor the grinding operation and measure the quality of the output (See Section C5-9.1).
- Arrange calibration of the templates, gauge bar and other measurement equipment (See Section C9-3).
- Ensure that the information detailed in Section C5-9.3 has been appropriately collected and recorded.
- Specify the application requirements for the locating lug on low rail and tangent rail templates (See Section C7-2).
- Ensure track obstructions that prevent grinding have been removed (See Section C5-3.3.)
- For turnout grinding:
- Establish the monitoring regime for the grinding operation (See Sections C5-3.4 and C5-3.5).
- Monitor the grinding operation and measure the quality of the output (See Section C6-8.1).
- Ensure that the information detailed in Section C6-8.2 has been appropriately collected and recorded.

- Ensure track obstructions that prevent grinding have been removed (See Section C6-2.3).
- For turnout grinding:
- Visually assess rail condition before grinding (See Section C6-2.2).

# Chapter 3 Competencies

## C3-1 Plain track grinding

### C3-1.1 CRN Grinding Supervisors

Grinding supervision may only be undertaken by personnel who have been granted engineering authority by the Principal Track and Civil Engineer following demonstration of the following:

- Competent in the use of rail condition and rail grinding terminology.
- Competent in the use of rail grinding for rail profiling and defect correction.
- Competent in the inspection of rail surface condition and identification of common defect conditions (as discussed in Chapter 7).
- Competent in the inspection of contact bands on rail arising from wheel contacts.
- Competent in the assessment of completed rail grinding work.
- Competent in reading and writing and the compilation of detailed records as specified in this manual.
- Experienced in the operation of rail grinding and rail condition assessment for not less than three months (this can be under the supervision of more experienced personnel).

### C3-1.2 CRN Rail Engineer

The CRN Rail Engineer is a person who has been granted engineering authority by the Principal Track and Civil Engineer for grinding management activities, and have demonstrated competency in the assessment of rail conditions and suitable remedial measures as outlined in this manual.

## C3-2 Turnout grinding

### C3-2.1 CRN Grinding Supervisors

The requirements are as detailed in Section C3-1 but with the addition that CRN Grinding Supervisors must be competent in the specific requirements of grinding turnouts and must be experienced in the operation of rail grinding and rail condition assessment at turnouts for not less than three months (this can be under the supervision of more experienced personnel).

Both CRN Grinding Supervisors and grinding personnel nominated by the contractor shall undergo a suitable training course that includes consideration of grinding at turnouts to obtain appropriate accreditation.

### C3-2.2 CRN Rail Engineer

See Section C3-1.2

# Chapter 4 Common Definitions Applied in Rail Grinding

**Running Surface:** The zone on top of the rail head which makes contact with the wheel tread (refer to Figure 1).

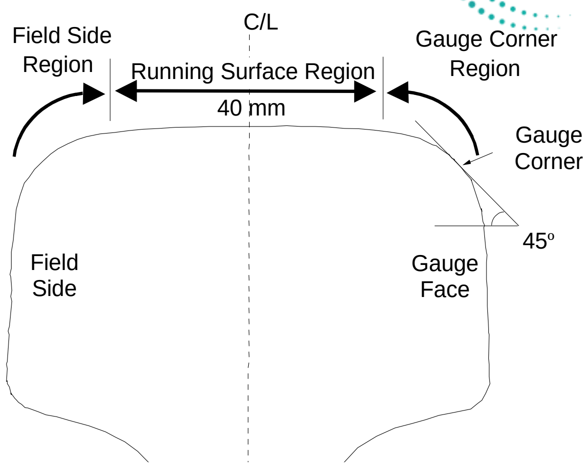


*Figure 1 - Regions in 60 Kg/m Rail*

| | |
|---|---|
| **Gauge Corner:** | The top corner of the rail above the gauge face (refer to Figure 1). The starting angle of the gauge corner is at 60 degrees. |
| **Gauge Corner Region:** | The zone on top of the rail head between the running surface and the gauge face (refer to Figure 1). The region extends from 60 degrees gauge to 6 degrees gauge. |
| **Field Side Region:** | The zone on top of the rail head between the running surface and the field face (refer to Figure 1). The region starts at 2 degrees field and extends to approximately 20 degrees field. |
| **Gauge Face:** | The zone of the rail head facing the inside of the track. In the tighter curves the gauge face may be worn due to contact with the wheel flange (refer to Figure 1). |
| **Field Side:** | The side of the rail opposite the gauge face (refer to Figure 1). |
| **Gauge Corner Relief:** | Clearance between the wheel profile and the rail profile to reduce wheel rail contact in the gauge corner region (refer to Figure 1). |
| **Field Side Relief:** | Clearance between the wheel profile and the rail profile to reduce wheel rail contact on the head of the rail on the far field side (refer to Figure 1). |
| **Contact Band:** | The actual contact position of the wheels on the rail as evidenced by the shiny worn surface. This generally applies to contact occurring on the running surface of the rail. |
| **Gauge Bar:** | A rod or bar section which sits between and normal to the rails to provide a superelevated reference for the application of the template. |
| **Rail Grinding Template:** | A template used to fit over the head of the rail to show the relationship of the ground rail to the defined rail profile. |
| **Cant Bar:** | A flat bar section that sits over the rails to provide a measure of the actual rail cant when taking rail profiles. |
| **Checking Locations:** | Specific points marked on the rail where the achievement of the defined rail profile and/or metal removal is checked and monitored. |
| **Track Segment** | A section of track in which the rail is ground to a uniform profile, for example: a curve from the start TP to the end TP, or a tangent from the start TP of the straight to the end TP of the straight, or the mid point of a short (< 200m) tangent separating two curves. Note grinding of curve and tangent track segments should overlap by nominally 30 metres. |

| | |
|---|---|
| **Preventive or Cyclic Grinding** | Grinding carried out to a regular schedule for the purpose of maintaining the rail profiles, preventing or inhibiting the growth of defects, and maintaining the surface condition of the rail (particularly in terms of corrugations and local vertical irregularities), with a minimum metal removal of 0.2 mm from the rail contact surface each grinding cycle. |
| **Transitional Grinding** | Grinding carried out usually over several cycles to transfer from a corrective/defect to a preventive/cyclic grinding regime. |
| **Corrective or Defect Grinding** | Grinding to remove specific defects in the rail. Such defects may occur over a relatively long track section (for example: rail corrugations or extensive rolling contact fatigue) or over relatively short track sections (for example: wheelburns, squats or isolated rolling contact fatigue defects). |
| **New Rail Grinding:** | Grinding to profile of rails that have been in track for less than 5 Million Gross Tonnes (MGT). |
| **Previously Ground Rail Grinding:** | Grinding of rail to profile which has been profile ground previously but is beyond the specified cycle, noting that the actual rail grinding effort in this case will depend on the tonnage level beyond the specified cycles which the rails have experienced, i.e. more grinding effort will be required as the tonnage beyond the specified limits increases. |
| **Vehicle Mounted Measuring System** | A system mounted on the rail grinding unit or auxiliary vehicle that is capable of measuring the rail head profiles, metal removal and/or surface characteristics. |

# Chapter 5 Plain Track Grinding

## C5-1 Establish grinding locations

Establish the grinding cycle requirements for track sections in accordance with the strategy detailed in Chapter 8 and the profiles to adopted (detailed in Section C5-2 with the following additional guidelines:

1. Some curves or track sections have multiple radii. In these cases, to avoid the need to cover the curve or track section at different cycles and to ensure a continuous rail profile, grind the full curve or track section at the cycle associated with the smallest radius that makes up at least 20% of the total curve length or track section.
2. A limited number of track sections may also require special consideration in relation to the grinding cycles and profiles to be adopted. For example: When two curved track sections are joined by a relatively short (less than 200m) tangent section. In these cases, the short middle segment may be treated the same as the adjoining longer curve segments. On the other hand, if short curved sections (less than 80m) are separated by tangent sections, they may also be treated the same as the adjoining longer tangent segments.
3. Each curve MUST be fully ground to the applicable rail profile, extending into the adjoining tangent past the tangent points (TPs) (nominally 30m) defining that section, as indicated in the appropriate Track Geometry Data Sheets. It is not permissible to grind only a portion of a curve.

## C5-2 Rail profiles

### 1.1.1 C5-2.1 Rail profiles and associated templates

The rail shapes required have been determined for tangent track and curved track (including for high and low rails). They are specified in CRN CS 220 “Rail and Rail Joints”.

*The following requirements have been extracted from CRN Engineering Standard CRN CS 220 "Rail and Rail Joints"*

The rail profiles to be achieved by rail grinding or milling shall meet the following requirements:

- The rail shapes apply to tangent track and curved track (including for high and low rails) in accordance with Table 1.
- The same basic shapes apply to 47 kg/m, 50 kg/m, 53 kg/m, 60 kg/m and 60 kg/m head hardened rail.
- The rail profiles apply to preventive, transitional and corrective rail profiling strategies.
- The rail profiles and their associated templates to be used are summarised in Table 1.
- The details of each template design are given in CRN CS 220.

| Situation | High Rail | | Low Rail | |
|---|---|---|---|---|
| | **Profile** | **Template** | **Profile** | **Template** |
| Tangent track and curves with radius ≥ 1000m | RTG2000 | TGT | RTG2000 | TGT |
| Curved track (< 1000* m radius), mainly freight traffic and >25km/h | RMH2000 | H2 | RML2000 | L2 |
| Curved track (<1000m radius), passenger or exhibiting moderate/severe gauge corner checking or moderate shelling as part of transitional grinding strategy | H3 | H3 | RPL2000 | L1 |
| Curved track (< 1000m radius) and <25km/h | RTG2000 | TGT | RTG2000 | TGT |
| Rails in Turnouts | RTG2000 | TGT | RTG2000 | TGT |

*Table 1 - Rail Profiles*

The rail shapes are designed to suit the wheel profiles and the rolling stock using the track. As part of the design the contact band width and location position is determined.

The profiles provide improved wheel/rail contact characteristics and nominal contact band widths, as follows:

- For passenger traffic - central contact on low and tangent rails with a contact band width of 18mm - 30mm, and conformal gauge corner contact on the high rails of sharper curves extending 0 to 10mm from the centre line towards the field side.
- For mixed passenger/freight traffic - central contact on low and tangent rails with a contact band width of 25mm - 35mm (which depends mainly on the levels of tread hollowing present on freight wheels), and slight gauge corner relief on the gauge corner contact on high rails of sharper curves extending 5mm - 15mm from the centre line towards the field side.

The designed rail shapes required have been converted into matching templates for use with the rail grinding operation.

The templates to be used are detailed in Table 1. Figure 2 provides an illustration of the modified profiles in relation to a new 60kg/m rail. It should be noted that the high rail template H2 contains a run-off section on the gauge side that is not part of the design profile (refer to Figure 2 and CRN CS 220).

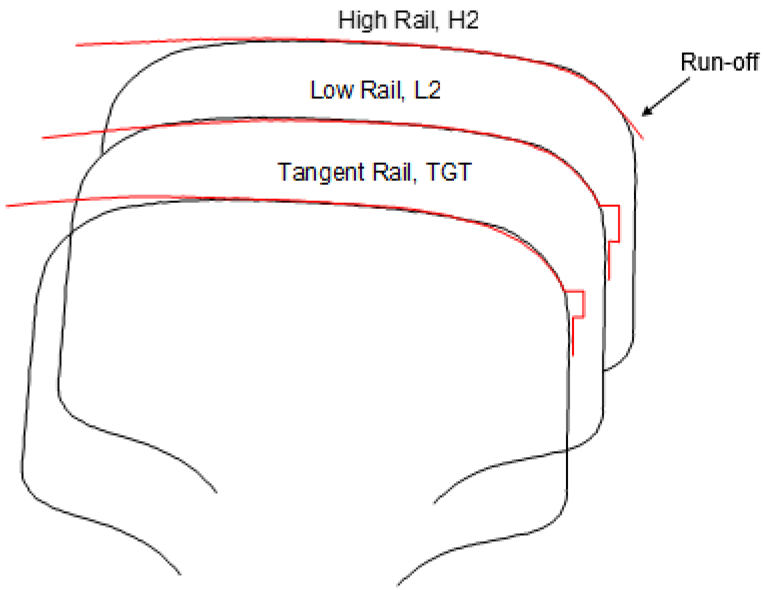


*Figure 2 - New and Modified 60 Kg Rail Profiles*

From Figure 2 the following main variations are evident:

- In the new high rails the H2 profile exhibits a minor undercut in the gauge corner region relative to the new rail, with the aim of reducing the contact stresses in this region.
- In the low rails the L2 profile exhibits very minor undercut relative to the new rails, with the aim of centralising the wheel/rail contact on the running surface.
- In the tangent rail, the TGT profile exhibits an even greater undercut in the gauge corner region, to ensure that wheel/rail contact is made near the centre of the running surface, which enhances vehicle stability at higher operating speeds.

It should be noted, however, that in worn rails or rails that are outside the specified grinding cycles the metal removal requirements could be considerably greater.

In certain cases, there may be a requirement to apply corrective/defect grinding, which will entail the removal of a considerable amount of metal primarily from the running surface of the rail along a certain length of track. In all of these cases, complete the grinding by implementing the relevant rail profiles as specified in Table 1, which shall conform with all of the standards applied to the normal preventive grinding practice. The exception is when the rail profiles before grinding are significantly different to the required profiles (Table 1), due rail plastic flow or excessive gauge corner and/or field side relief applied during previous grinding cycles. In these cases, the rails can be treated as transitional and a relaxation of the required tolerances outside the contact band may be applied at the discretion of the CRN Rail Engineer.

The templates used for tangent and low rails contains a positioning lugs and these should be used for tangent and low rail templates as illustrated schematically in Figure 3. The purpose of this lug is to provide a referencing point for the template relative to the centreline of the rail. The application of the positioning lug is detailed in Section C5-4. It should be noted that due to rail manufacturing tolerances the locating lug may not make contact on the gauge face even in new rails

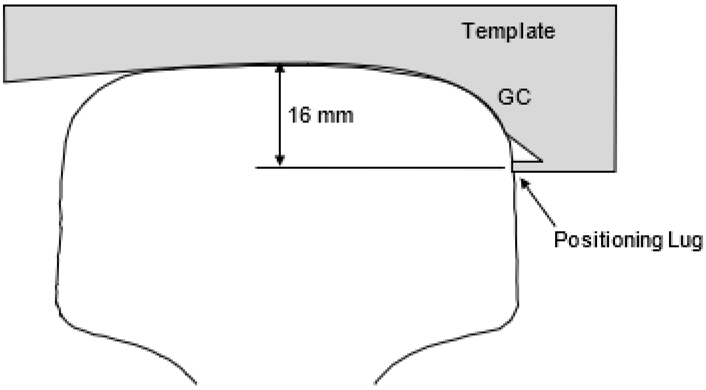


*Figure 3 - Schematic illustration of template and positioning lug*

## C5-3 Preparation for grinding

### C5-3.1 Track geometry

Grinding should be conducted on track that has good top and line, preferably after the track has been surfaced.

### C5-3.2 Rail condition assessment

Visually assess rail condition before grinding.

This assessment will assist in determining the specified requirements for the grinding operation.

### C5-3.3 Remove track obstructions

Remove all track obstructions that prevent grinding within a section (including high ballast, lubricators and wayside monitoring devices) prior to grinding and replace/restore them after grinding.

The Project Manager shall advise the Maintenance Superintendent when arranging for the removal and re-instatement of all components of rail-mounted infrastructure and wayside equipment which may obstruct grinding not more than 7 days before the scheduled grind, and not later than 7 days after grinding.

### C5-3.4 Establish grinding segments

Divide the track into segments as follows:

1. Each segment should have a consistent rail surface shape and condition.
2. A segment cannot be longer than a whole curve, although individual curves can be broken up if required.
3. Adjoining curves with a small tangent in between can be ground as two curves (as detailed in Section C5-1).
4. A track segment should generally be no longer than 500m in curved track with radii up to 1000m, and 1000m in tangent track and shallower curves, or no longer than 300m in the case of corrective/defect grinding.

### C5-3.5 Establish checking locations

1. Each grinding segment is assessed separately.
2. Nominate a set location in each segment as a checking location that will be used for checking the ongoing grinding program.
3. Position the checking location towards the centre of the segment to be ground, avoiding closures, welds or anomalous profile conditions.

4. Paint-mark the rail web and foot and record its location.

# C5-4 Application of templates and associated tolerances

## C5-4.1 Placement

1. Attach the rail template to the gauge bar.
2. With the non-template end of the gauge bar resting on the other rail, place the template onto the rail to be checked and move it down and across to maximise the contact of the template on to the rail. Where the template is provided with a gauge positioning lug, push the lug up against the gauge face of the rail. (for further details refer to Section C5-4.2)

**Note:** DO NOT use excessive force on the template or gauge bar. This may lead to distortion or accelerated wear.

## C5-4.2 Tolerance to template

The rail is to be ground so that the profile matches the template within the following allowable tolerances

*The requirements have been extracted from CRN CS 220*

| Characteristic | Tolerance |
|---|---|
| Conformance to design profile within the contact band (see Figure 4.) | ≤0.20mm |
| Conformance to design profile outside the contact band (see Figure 4.) | ≤0.40mm |

*Table 2 - Rail Template tolerances*

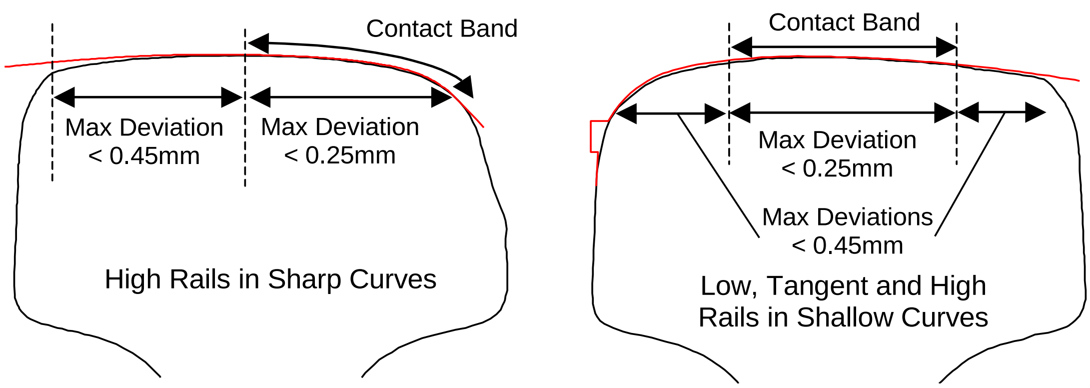


*Figure 4 - Schematic illustration of rail tolerances and templates*

When applying mechanical means, check the tolerance to template by measuring the visible gap between the rail and the template using a feeler gauge approximately 3mm wide at the end.

To provide appropriate referencing for the above measurements, the rail templates should contain scribe marks indicating the position of the contact bands and the contact angles.

When the rail profiles before grinding are significantly different to the required profiles, due to excessive gauge corner and/or field side relief applied during previous grinding cycles or in new 60 kg/m rails (refer to Figure 2), the rails can be treated as being in a transitional regime (C7-7). To reduce the number of grinding passes that may be required to establish the most appropriate profiles, as summarised in Table 1, a relaxation of the required tolerances outside the contact band may be applied at the discretion of the CRN Rail Engineer, as follows:

1. The grinding applied during each cycle must reduce the maximum deviation of the rail profile relative to the template outside the contact band by at least 0.3mm.

2. Within the contact band the tolerances shall remain as specified above.
3. A minimum metal removal of 0.2mm shall still be achieved within the contact band, as specified in Section C5-7).

In such cases, the Contractor shall record the fact that the rails before grinding did exhibit excessive gauge corner and/or field side relief and that a transitional grinding strategy has been applied.

Some rails may exhibit plastic flow lips, which may increase the difficulty of matching the templates with locating lugs. DO NOT use high rail templates and tangent templates with the lug in such cases.

The CRN Rail Engineer will specify the requirements for application of the positioning lugs for the low rail and tangent rail templates, subject to the following:

- If the lug is more than 2 mm away from the gauge face of the original rail, the distance must be reduced to less than 2 mm after grinding. This may require additional grinding passes or the establishment of a transitional grinding strategy, at the discretion of the CRN Rail Engineer.
- The distance of the lug from the gauge face after grinding must be no greater than the distance before grinding.

For example: Figure 5 illustrates rails in tangent track before and after grinding with the templates containing the locating lug.

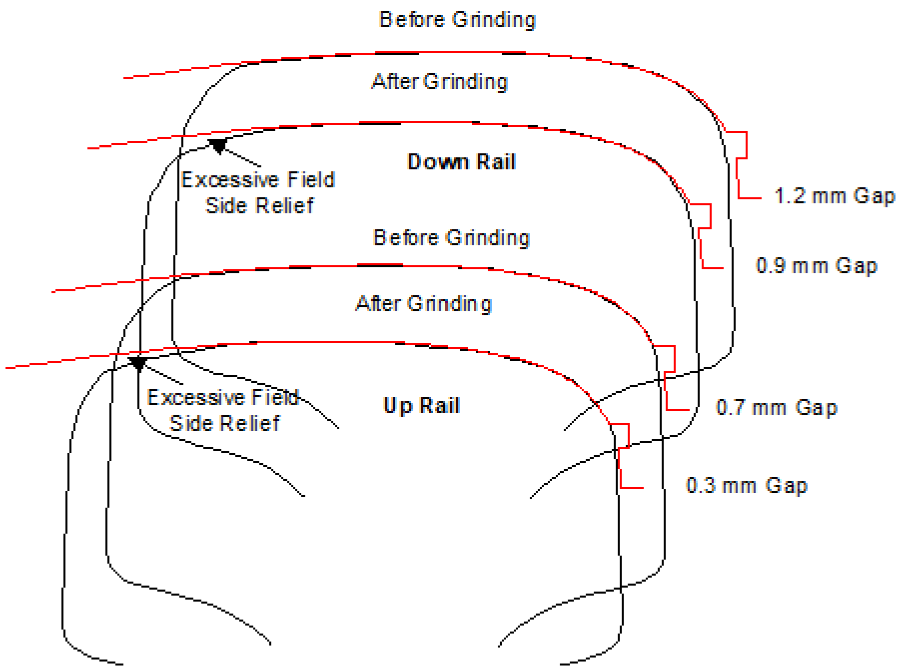


*Figure 5 - Rails in tangent track before and after grinding and tangent templates with positioning lug*

### C5-4.3 Gauge Corner Relief

Gauge corner relief is built into the rail templates.

For the high rail template Gauge corner relief outside the feeler gauge tolerances specified in section C5-4.2 may be specified by the CRN Rail Engineer who can approve an increase in the tolerance to a maximum of 0.6mm).

The grinding facet limits as specified in Section C5-8.1 must still be observed.

Gauge corner undercutting leads to two point wheel/rail contact conditions in the sharper curves as illustrated in Figure 6, which in most cases is not desired.

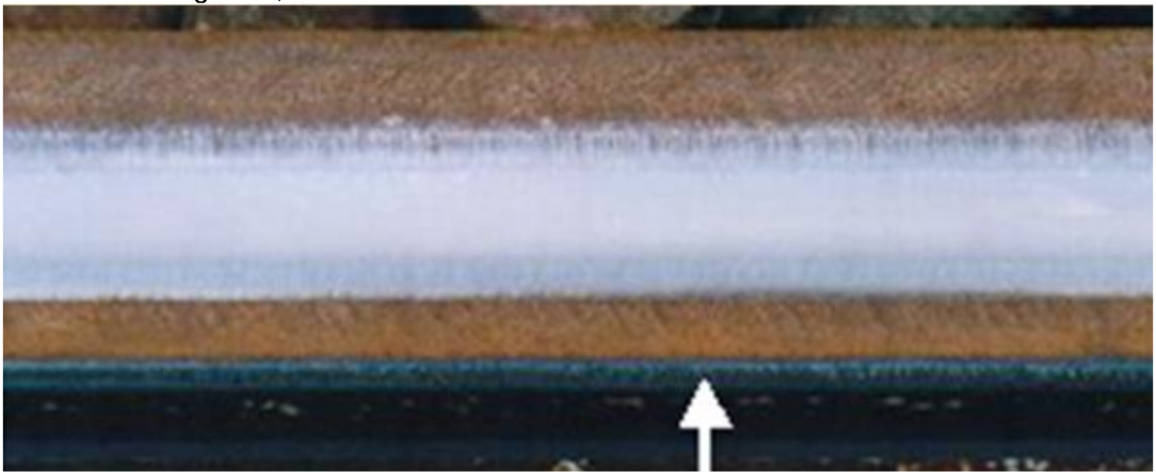

*Figure 6 - Example of unacceptable gauge corner undercutting on high rail in sharp curve (arrow points to gauge corner)*

### C5-4.4 Field Side Relief

Generally any required field side relief is built into the templates.

The CRN Rail Engineer may specify relief requirements but only up to the tolerances specified in Section C5-4.2.

Excessive field side undercutting, as illustrated in Figure 7, leads to a narrowing of the wheel/rail contact band.

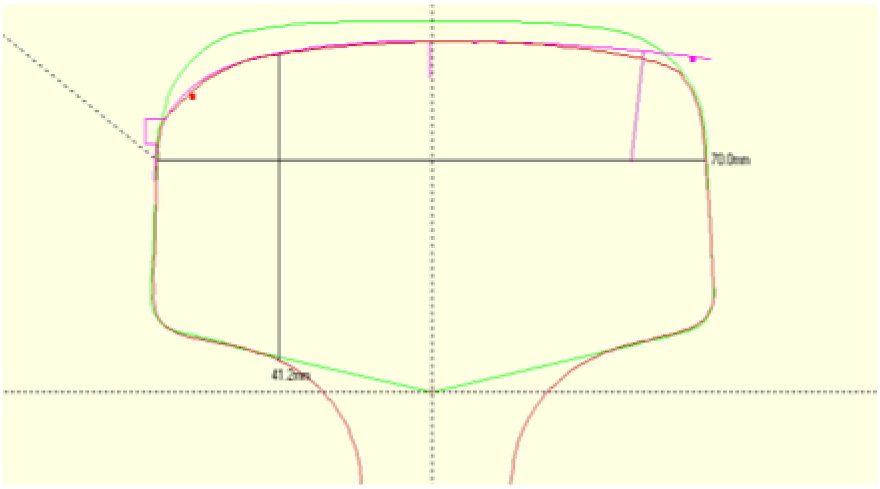


*Figure 7 - Example of unacceptable excessive field side relief in tangent rail*

## C5-5 Vehicle mounted measuring system

A vehicle mounted procedure for monitoring rail profiles before/during/after grinding, based on optical measuring systems, may be utilised to facilitate the grinding process.

All the tolerances specified for the manual measurement system, as specified in Section C5-4, shall apply to the vehicle mounted measurement system.

The measuring system must have a proven accuracy and repeatability of better than □ 0.10mm vertically when comparing actual rail to the target template.

Initially, the vehicle mounted system shall be used in a manner similar to the manual measurements, i.e. at the specific checking locations, each representing a track segment.

Eventually it is envisaged that additional and more detailed rail profile measurements after grinding will be taken using the vehicle mounted system on at least one track segment ground in each grinding shift (or day).

The measurements will be taken at 20m - 25m intervals along the track segment. The profile deviation values will then be used to determine and meet the following maximum allowable deviations from the respective templates:

Within the contact zones (refer to Figure 4):

- 90% of values must be less than 0.25mm
- 95% of values must be less than 0.30mm
- 98% of values must be less than 0.35mm

Outside the contact zones (refer to Figure 4):

- 90% of values must be less than 0.45mm
- 95% of values must be less than 0.50mm
- 98% of values must be less than 0.55mm

Alternatively, no more than one (1) measurement location in the track segment is permitted to be outside the limits.

The vehicle mounted systems shall achieve compliance to template at least equivalent to the manual methods previously described.

In addition, metal removal across the rail head and the total metal removal shall also be measured. This will require rail profile measurements to be taken both before and after grinding.

## C5-6 Minimum metal removal for corrective/transitional grinding

The CRN Rail Engineer will specify the metal removal requirements for transitional and corrective grinding of transverse profile in accordance with Chapter 7.

This may allow some gauge corner cracking/ checking to remain in track after grinding as shown in Figure 8 below.

Where wheel slip damage, including surface skidding, is present, it should be treated by grinding a minimum of 0.5mm from the rail surface. Guidelines for corrective grinding of rail defects are provided in Section C8-4.

*Figure 8 - Example of Gauge Corner Checking Defects Left in the Rails After Grinding (Arrow Points to the Gauge Corner)*

## C5-7 Minimum metal removal for preventive grinding

Note: this includes initial grinding of new rail.

When rail is ground under the preventive grinding regime a minimum amount of metal is to be removed.

In conjunction with restoration of the rail profile to the designed template as specified in Section C5-2, a minimum of 0.2 mm of metal must be removed from all surfaces where there is wheel contact.

In sharp curves, the minimum metal removal of 0.2mm will generally be achieved each specified grinding cycle (refer to Section C8-3). However, in shallower curves (>1000m radius) and tangent track the metal removal may be reduced if the track sections are ground more frequently than the specified cycles (refer to Section C8-3). , as long as the minimum metal removal is achieved within the specified cycles.

It should be noted that the metal removal requirements of rails that are within the preventive grinding regime should be less than $20mm^2$. Rails having greater metal removal requirements are to be treated as out of cycle or transitional.

### C5-7.1 Measurement of metal removal

Measure the metal removal achieved by the grinding at the centre of the rail's running surface, at a particular checking location or locations.

Use accurate rail profile measurement devices with a proven accuracy and repeatability (must be better than ± 0.05mm).

Suitable procedures may involve the use of:

- A portable rail profile measuring system such as 'Railmate', or 'Miniprof', or
- A non-contact light or laser system, as described in Section C5-5.

All the above measuring systems shall have the required measurement accuracy.

## C5-8 Surface finish

### C5-8.1 Grinding facets

Rail grinding produces visible facets in the head and gauge face of the rail. These facets must be controlled to the tolerances specified in CRN CS 220 as per the below

*The following surface finish requirements are extracted from CRN CS 220*

| Characteristic | Tolerance |
|---|---|
| Facet width in the gauge corner region (see *Figure 1*) | ≤4mm |
| Facet width in the running surface region (see *Figure 1*) | ≤8mm |
| Facet width in the field side region (see *Figure 1*) | ≤12mm |

*Table 3 - Grinding Facet tolerances*

Grinding facets are a result of the application of the flat grinding stones to the curved rail surface. The grinding process leaves a number of flat surfaces or facets on the rail surface. The greater the number of facets the closer the rail profile is to a curved surface. Figure 9 illustrates a finished rail with acceptable facet width.

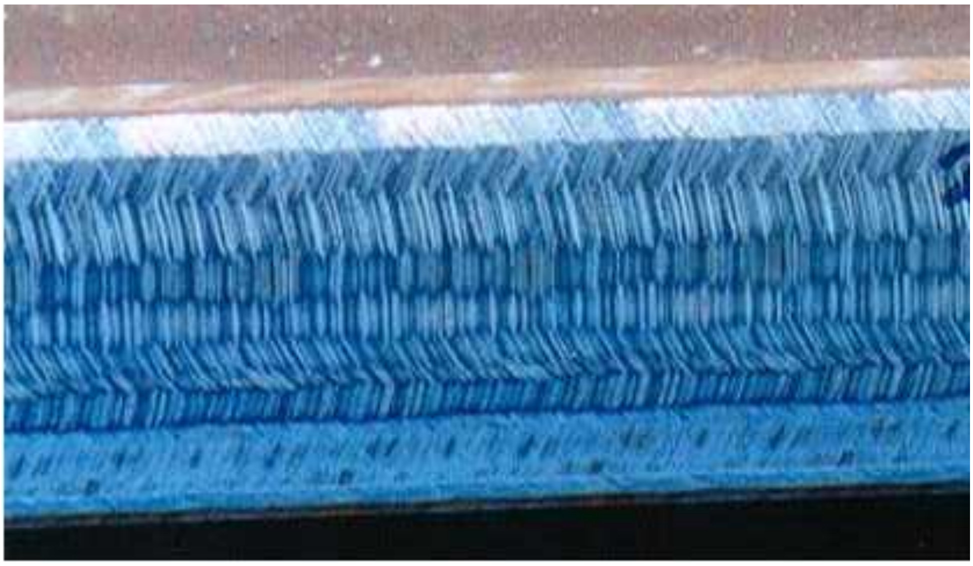

*Figure 9 - Acceptable grinding facets*

## C5-8.2 Other surface irregularities

The CRN Rail Engineer will specify the requirements for removal of isolated defects identified prior to grinding (such as dipped or peaked welds or wheel burns). Noting that they may not be able to be removed efficiently by the grinding process and do not necessarily have to be removed.

Otherwise, longitudinal rail surface defects such as corrugations must be removed, and the overall surface finish must also meet the following minimum standards

*These requirements are extracted from CRN CS 220*

| Characteristic | Tolerance |
|---|---|
| Short pitch corrugation (30-90mm wavelength) | Average <15µm<br>Maximum 0.05mm amplitude in any 1m length |
| Long pitch corrugation (200-450mm wavelength) | Maximum 0.10mm amplitude in any 1m length |

| | |
|---|---|
| Roughness | 10µm arithmetic mean surface roughness (RA) within 5km of dwellings<br>15µm RA elsewhere |

*Table 4 - Grinding Surface finish tolerances*

- There shall be no sharp ridges especially at the interface of facets.
- There shall be no sharp "knife edge" on the outside edges of the rail that could cause a cutting injury.
- There shall be no gouging on the rail surface and sharp scratches.
- There shall be no indentations or longitudinal anomalies in the rail.
- There shall be no cyclic re-profiling scratch marks, as illustrated in Figure 10.
- Generally, the assessment of corrugations shall be conducted at the checking location. However, additional measurements may be conducted at any location within a ground section in which visual examination may indicate the presence of cyclic irregularities after grinding.
- Note that poor quality surface finish (as illustrated in Figure 11) will increase rail noise and may enhance the development of future rail surface defects.
- The resultant surface roughness shall be measured with a Surtronic 3+ roughness measuring system, or equivalent authorised by the Principal Track and Civil Engineer, using a measurement travel of 25mm. Any surface roughness measurements shall be taken at the checking locations, and will consist of three longitudinal traverses taken as follows:
  - In low and tangent rails – at the rail centre line and 15mm on each side of the centre.
  - In high rails – at the centre line and at angles of approximately 10° and 20° towards the gauge corner.

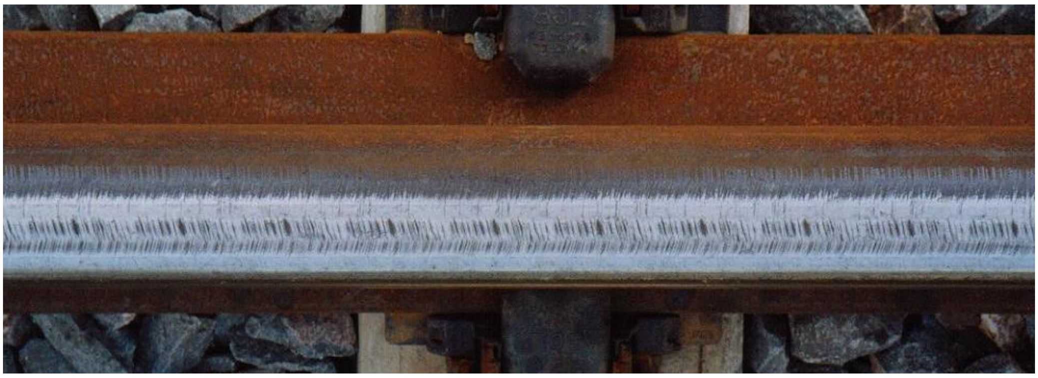

*Figure 10 - Example of unacceptable cyclic grinding scratches*

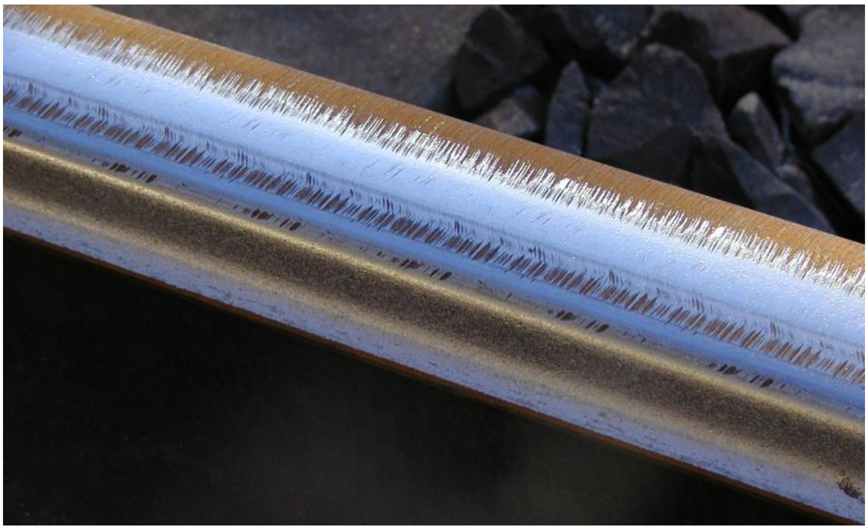

*Figure 11 - Example of unacceptable severe grinding scratches*

# C5-9 Monitoring and control

## C5-9.1 Inspection of grinding by CRN Grinding Supervisors

Check the achievement of grinding tolerances, metal removal and surface roughness on completion of the grinding work and prior to the running of trains as follows.

1. Examine checking locations for profile, metal removal and surface roughness
2. Check the remainder of the rail visually to ensure that the specified defect removal and surface condition requirements has been achieved.
3. Where vehicle mounted rail profile measuring system have been used:
   - record profile deviations from the template and metal removals at each checking location, then
   - measure and record profile deviations, metal removal and surface roughness on at least three checking locations for each grinding shift.
4. Check the required contact band width on the running surface (indicated in Section C5-4.2) by painting the running surface of the rails at the checking locations following grinding, and inspecting after a minimum of at least 3 or 4 trains or preferably after several days of operations. A preliminary check of the running band can be conducted using the contacts achieved by the wheels on the rail grinder.
5. Note any abnormal observations (i.e. when the actual contact band is outside the recommended limits) and notify the CRN Rail Engineer to arrange for monitoring for possible future action.

Note: When taking rail profiles, the cant bar must be used at all times to allow compensation for any deviations from the design rail cant of 1:20.

Alternative inspection/monitoring regimes that provide equivalent measurement of compliance may be approved by the CRN Representative.

### C5-9.2 Monitoring by CRN Rail Engineer

Rail condition needs to be monitored during the grinding cycle as follows:

1. Carry out spot checks of rail grinding at nominated checking locations as a follow up to the grinding operation.

The spot checks will evaluate the rail grinding efficiency and the continued effective functioning of the profiles in terms of the contact bands evident and any other rail surface anomalies.

Investigate variations to the designed contacts and report major anomalies to the Principal Track and Civil Engineer.

2. Carry out a visual inspection of all ground track at about 60% to 70% of the way through the planned grinding cycle.

   Where inspections identify any unusual deterioration conditions these are to be registered and an appropriate response determined. Additional inspections are to be scheduled for such locations. The timing will depend on the condition assessment.

### C5-9.3 Records

The technical details for either preventive, transition or corrective rail grinding, which need to be recorded in an electronic database by the CRN Grinding Supervisors are as follows:

- Grinding machine.
- Date of grinding and inspection.
- Location of grinding carried out (start and end points), to closest 5 metres.
- Location of checking points, to closest 5 metres.
- Nature of the grinding strategy adopted (e.g. preventive/transitional/corrective/ defect).
- Grinding template(s) used.
- Rail type and size.
- Effective track kilometres ground (work completed satisfactorily).
- Location of any section within a track segment that has not been ground, and the reason for not grinding (for example: high ballast, crossing, etc.)
- Minimum metal removal at the rail centre line, to the closest 0.05mm.
- Deviations of the rail profile from the template.
- Surface roughness achieved after grinding.
- Number of grinding passes applied to each rail.
- Grinding efficiency of machine, i.e. number of grinding motors working.
- Details of any condition from pre-grinding inspection or any other specific inspections of rail condition.
- Details of the rail contact band assessments carried out immediately after grinding.
- Details of any non-conformances in the grinding process or standard of completion.

The above information shall be available in daily form within 24 hours of the end of each shift, and in weekly form within 48 hours of the completion of each week's work.

# Chapter 6 Rail Grinding in Turnouts

## C6-1 Rail profiles

### C6-1.1 Rail Profiles and associated templates

Select the profile specified for turnouts in Section C5-2.1.

## C6-2 Preparation for grinding

### C6-2.1 Turnout geometry

Grinding should be conducted on track that has good top and line, preferably after the turnout has been surfaced.

### C6-2.2 Rail condition assessment

Visually assess rail condition before grinding.

This assessment will assist in determining the specified requirements for the grinding operation.

### C6-2.3 Remove track obstructions

Identify all track obstructions that prevent grinding within or adjacent to the turnout/(s). This includes:

- high ballast
- lubricators
- wayside monitoring devices

The amount of protrusion allowed may vary depending on the characteristics of the grinding machine being used. This should be confirmed prior to the inspection being carried out.

Remove all track obstructions that prevent grinding within a section prior to grinding and replace them after grinding.

The Project Manager shall advise the Maintenance Superintendent when arranging for the removal and re-instatement of all components of rail-mounted infrastructure and wayside equipment which may obstruct grinding not more than 7 days before the scheduled grind, and not later than 7 days after grinding.

### C6-2.4 Track to be ground

It is permissible to grind only the through road or the turnout road of a turnout. Normally this occurs when one road (the one to be ground) is dominant. If only one road is to be ground consideration needs to be given to the fit of both switches to the stockrails and their relationship to train wheels.

## C6-3 Application of templates and associated tolerances

### C6-3.1 Placement

Rail template placement requirements are given in Section C5-4.1.

### C6-3.2 Tolerance to template

Apply the rail template tolerance requirements given in Section C5-4.2 with the following exceptions:

- Remove ALL flow on the gauge side of rails.

- The lug on the template does not have to fit snug against the gauge face of the rail as long as the ground rail profile is no more than 2mm from the edge of the template (4mm from weld to weld through the crossing). There is no requirement to reduce this distance by grinding

### C6-3.3 Gauge Corner Relief

Generally, any required gauge corner relief is built into the rail template and no gauge corner relief is to be applied.

### C6-3.4 Field Side Relief

Generally, any required field side relief is built into the template.

The CRN Rail Engineer may specify additional relief requirements but only up to the tolerances specified. (See Section C6-3.2)

## C6-4 Minimum metal removal for corrective/transitional grinding

The CRN Rail Engineer will specify the metal removal requirements for corrective grinding of transverse profile.

This may allow some gauge corner cracking/checking or squats to remain in track after grinding (as illustrated in Figure 12).

To minimise the amount of metal removal required, any major rail rectification, such as the repair and build-up of the nose at crossings, shall be conducted prior to the rail grinding. This will be the responsibility of the CRN Rail Engineer).

An additional consideration in establishing the metal removal requirements will be the level of rectification required to reduce/control any excessive vertical dipping that may exist at the aluminothermic welds.

*Figure 12 - Acceptable residual gauge corner defects after grinding*

## C6-5 Minimum metal removal for preventive grinding

Metal removal requirements are as specified in Section C5-7 except where the CRN Rail Engineer makes allowance for lesser metal removal. (See Section C6-3.2).

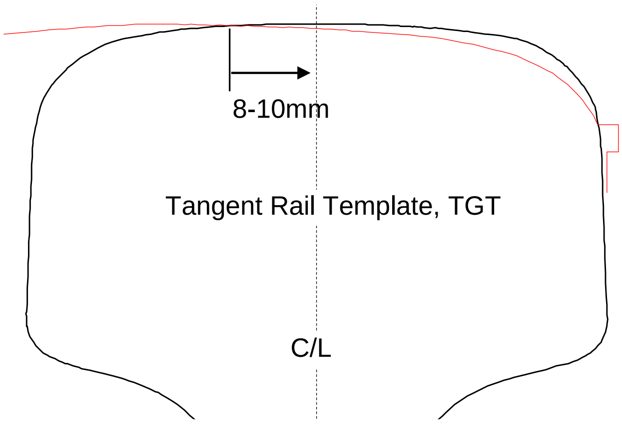


*Figure 13 - New 60 Kg/m rail in turnout with tangent (TGT) template*

Figure 13 provides an illustration of the tangent profile (TGT) in relation to a new 60 kg/m rail. It is evident that considerable amount of material needs to be removed particularly from the gauge corner region of the new rails. This is because the rails in turnouts are not canted, and hence do not match the wheel profiles. For new rails, the grinding would not extend beyond 8-10mm on the field side of the rail centre line, as illustrated in Figure 13.

The TGT profile exhibits an undercut in the gauge corner region, to ensure that wheel/rail contact is made near the centre of the running surface, rather than the gauge corner region, of the turnout rails.

Special care is required, however, to ensure that excessive grinding of the stock rail towards the tip of the switch (as illustrated in Figure 14) is avoided. This can occur due to the double grinding of the stock rails, with the switch both closed and open.

*Figure 14 - Unacceptable excessive gauge corner grinding on the stock rail near the switch tip*

## C6-6 Surface finish

### C6-6.1 Grinding facets

The requirements for rail surface finish are given in Section C5-8.1.

### C6-6.2 Other surface irregularities

The requirements for identification and removal of other surface irregularities are given in Section C5-8.2.

## C6-7 Grinding operation

- Conduct the initial grinding of turnouts on the through road, and continuing beyond the points and crossing for a distance of 10-20m or as required to overlap with the plain track grinding. The overlap will require feathering in to avoid excessive metal removal.
- The narrow areas of the switch tip on the through road of the turnout should not be ground by the turnout grinder and should be ground by hand grinding.
- Grind the turnout road from the end of the switch tip (to avoid additional grinding of the rails on the through road). Continue grinding beyond the crossing for 15m to 20m or as required to complete a full crossover. The pick up and put down points in the area of the switch will need to be modified depending on a number of factors. These include
  - the need not to over grind in the area of the switch tip,
  - the need to marry up the profile of the switch and the stockrail in the region of the switch tip,
  - the presence of a joggled stock rail, and
  - the need to remove metal from the field side of the stock rail.
- In new turnouts, grind all possible parts of the turnout and/or crossing, including switches, closure and stock rails. This will require the resetting of switches during the grinding operation. (Signalling and other support requirements for this must be in place for restoration of the work).

Generally, standard grinding passes can be applied up to 500mm from the nose of the crossings (this depends largely on the configuration and limitations of the grinding machine) and up to 1m from the tip of the switches. Take special care with the grinding applied within these distances to ensure that excessive metal is not removed. For those parts that can still be ground, this will usually entail the application of only a limited number of grinding passes to clean up the gauge corner region and reduce the plastic flow lipping (refer to Figure 15 and Figure 16).

*Figure 15 - Acceptable grinding finish at switch and stock rails*

*Figure 16 - Acceptable grinding finish at switch and stock rails*

From the point where the crossing nose is about 35-45mm wide (refer to Figure 17), grinding is to be in the trailing direction only. In this zone, machine grinding of the top surface of the nose should be avoided.


*Figure 17 - Grinding of Crossing Nose*

- Some areas of the turnout may not be able to be ground by current on-track grinding machines (normally towards the tip of the switches and the crossing nose). In these cases, use suitable hand held grinding devices to cover the areas that require grinding. In addition hand held grinders may also be used to grind any anomalies on the gauge face of the rail (such as rail flow), which similarly have been missed by the on-track grinding machines.
- In worn turnouts, the regions that should not be ground with the rail grinding machine include the following (refer to Figure 18):
  - Within 500mm from the theoretical point of the crossing nose, or about 300mm from the practical point.
  - Within 50mm - 100mm from the approach to the crossing throat or set point and beyond on the wing rails.
  - Over the transfer region on the wing rails.

This restriction is applied to limit removal of excessive metal in areas of high wear.

- Take special care towards the end of the switch to ensure that the top of the switch blade is no higher than the running surface of the stock rail and preferably about 5mm lower, as illustrated in Figure 15. This is essential to provide the back of the switch blade with appropriate lateral support by the stockrail; otherwise the top of the switch blade may break off, as illustrated in Figure 19.
- Note that towards the nose end of the crossing region the standard TGT template cannot be used to check profiles. The profile can be assessed using a modified TGT template that extends from the gauge corner up to an angle of 1º towards the gauge region (refer to Figure 1), with a 1:10 run off, as illustrated in Figure 20.
- At the completion of grinding blow, vacuum or wash down (using pressurised water) switch chair plates and all insulated connections to remove grinding particles/dust. Apply any necessary lubrication to the chair plates and ensure that the switches are working properly. (Signalling staff will be required to ensure the switches are working properly).

Note: in areas of slab track, remove filings from all ground areas. Filings will lie on the slab and may be blown by wind or train movement to sensitive track areas.

- Hand grind areas of the turnout where the grinding machine could not reach and to carry out the following functions.
  - Remove flow from the area of the crossing nose. Shape the crossing to the required profile, as specified in CRN Engineering Manual CRN CM 222 “Rail Welding”.
  - Remove flow and burring from the back of the switch and run a 1mm chamfer on the corner of the top and back of the switch. Remove any remaining flow on the stockrail where the switch needs to fit against the stockrail.

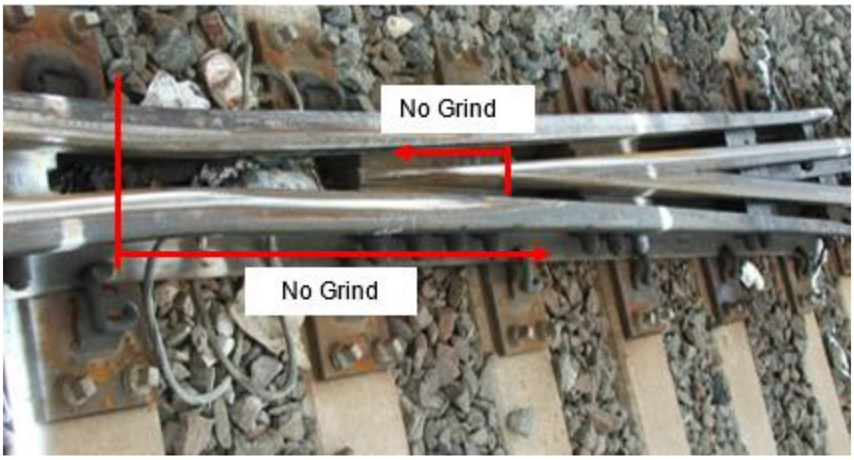


*Figure 18 - Regions in worn crossing that should not be ground with grinding machine*

*Figure 19 - Example of failure at end of switch*

*Figure 20 - TGT template*

# C6-8 Monitoring and control

## C6-8.1 Inspection of grinding by CRN Grinding Supervisors

Check the achievement of grinding tolerances, metal removal and surface roughness on completion of the grinding work and prior to the running of trains as follows:

- Examine checking locations for profile, metal removal and surface roughness.
- Check profiles at the following locations
  - switches,
  - stockrails,
  - crossings, and
  - in the approximate middle of the turnout

No paint-marking of checking locations is required.

- Check the remainder of the turnout visually to ensure that the defect removal and surface condition requirements have been achieved, as specified by the CRN Rail Engineer.
- Closely examine visually crossings, switches and stockrails.
- Check the required contact band width on the running surface (indicated in Section C5-4.2) by painting the running surface of the rails at the checking locations following grinding, and inspecting after at least 3 or 4 trains.
- Note any abnormal observations (i.e. when the actual contact band is outside the recommended limits) and notify the CRN Rail Engineer to arrange for monitoring for possible future action.
- Check the fit of the switch and stockrail as shown below. Grinding will change the relationship of the wheel to the rail and may increase the risk of a wheel striking the front edge of the switch.
  - Standard 53 kg switch. Use the switch tip gauge as shown in TMC 203 Section 23-3 to ensure wheels will not hit the leading edge of the switch. If the switch fails the examination, grind sufficient metal, using a hand grinder or equivalent, from the switch tip till it the switch tip gauge fits.
  - Heavy Duty switch opposite Housing. No check is required as the housing keeps the wheel flange away from the gauge corner.
  - Heavy Duty 53 switch not opposite housing. Place a 1.5 metre straight edge along the running face of the rail in front of the points. Slide the straight edge towards the points. If the end of the straight edge hits the end of the switch grind a “knife edge” at the tip of the switch, using a hand grinder or equivalent, that will deflect a wheel onto the correct path.
  - 60 kg conventional switch. Check with a switch tip gauge. Due to 60kg switches being “undercut” it is unlikely that any switches will fail. If the switch tip fails grind the switch tip sufficiently till it passes.
  - 60 kg tangential switch. Visually check the tip of the switch sits below the Gauge face of the stock rail.

## C6-8.2 Records

The requirements for recording of information for turnout grinding are detailed in Section C5-9.3 with the following additional records:

- Location of turnout on which grinding was carried out specifying from and to km, description of the turnout (e.g. crossover, diamond, catchpoints) and the points number(s).

- Effective track kilometres ground (work completed satisfactorily) counting both the mainline and turnout road.

# Chapter 7 Guidelines for grinding decisions

The following information is provided for use by the CRN Rail Engineer to make determinations of grinding requirements for both plain track and turnout grinding. Where specific requirements are required for turnout grinding they have been separately identified.

## C7-1 Application of templates

Implementation of an effective preventive grinding strategy with specified rail head profiles will reduce wheel / rail contact stresses and reduce the development and propagation of associated defects, increase the service life of wheels and rails and improve steering of vehicle bogies.

The rail head profiles in Table 1 shall be applied within the CRN network. Coordinated Profile coordinates are shown in CRN CS 220.

In the case of Transitional Grinding the TGT and L1 templates are used on all high rails and low rails respectively to reduce the metal removal required to produce the template. H3 template can be used for curve radius between 300m and 900m to allow leaving some of the gauge corner cracking which will be removed in the following grinding cycle.

## C7-2 Application of the locating lug on low rails and tangent rail templates

Specify the application requirements for the locating lug on low and tangent rail templates (beyond those given in Section C5-4.2). This may take the form of a strategy to bring the template into conformance over successive Transitional Grinding cycles as described in Section C5-4.2.

In adopting the above procedure, appropriate matching of the lug and the side of the rails will be achieved within several transitional grinding cycles, and any plastic flow of the rail in the gauge corner region will be progressively removed.

## C7-3 Gauge corner relief

Specify any special gauge corner relief requirements for the application of the high rail template (see Section C7-1).

Gauge corner undercutting leads to two point wheel/rail contact conditions in the sharper curves as illustrated in Figure 6.

More details of the procedure to be adopted in these special cases are given in Section C5-4.3.

Gauge corner relief is not applicable in turnouts.

## C7-4 Field side relief

Specify field side relief additional to that specified in Section C5-4.4 when, after the application of the normal templates, there is still evidence of excessive tread hollowing on wheels (this is normally observed as a well-developed contact band extending beyond the contact bands shown in CRN CS 220 and towards the field side of the rail head).

Under the above circumstances, additional field side relief needs to be applied to ensure that minimum wheel contact occurs in the field side region, i.e. within approximately 15mm from the field side rail face.

In such cases implement additional field side relief in the low rails of curves (relative to the L2 profile), or in tangent rails (relative to the TGT profile). When introducing such relief, apply the required tolerances with reference to the template; namely:

- up to 0.5mm measured at 15 mm from the rail field side

- Check the nominated measurements with suitable feeler gauges.

The additional field side relief should not extend into the contact zone, as illustrated in the Appendix of CRN CS 220.

An additional problem that may occur on plain track, particularly in passenger lines, is that the wheel profiles generally do not exhibit hollowing and consequently the field side of the rails may develop a coating of rust. However, if a light locomotive with hollow wheels travels over the rails and makes the primary contact on the field side, the coating could act as an insulator and cause loss of shunt. Such locations should be separately identified. Only tangent rails are affected by this problem.

The grinding facet limits as specified in Section C5-8.1 must also still be observed within the field relieved zone.

There is no requirement to address these problems in turnouts.

## C7-5 Minimum metal removal for preventive grinding in turnouts

When grinding relatively new turnouts for the first time reduce the specified minimum depth of metal removal on the contact surface (0.2mm) to 0.0 mm near the field side edge of the contact surface (refer to Figure 16). This will reduce the metal removal requirements.

## C7-6 Minimum metal removal for corrective grinding

The CRN Rail Engineer should specify the metal removal requirements for corrective grinding. These arise primarily because of rolling contact fatigue or squat defects present in rails that have not been cyclic ground. Such damage may inhibit the routine ultrasonic inspection of the rails, particularly if located in the gauge corner region (gauge corner checking and squats).

Complete removal of the severe gauge corner checking and squat defects is generally NOT recommended as it requires considerable metal removal, and hence rail grinding effort, and it removes protective work hardened material from the surface. (See Figure 8 for plain track and Figure 12 for turnouts).

The recommended procedure to be implemented in these cases is as follows:

- Remove a minimum of 0.2mm (and usually more than 0.4mm - 0.5mm) of metal from all contact surfaces including the gauge region, as specified in Section C5-7 for plain track or Section C6-5 for turnouts.
- Ensure that all checking cracks have been removed from the running surface above the rail web, and preferably from a distance of 20mm - 25mm from the gauge corner (exclusive) towards the field side. As illustrated in Figure 8 for plain track and Figure 12 for turnouts, some gauge corner checking may be left on the rails.
- Establish the recommended profiles, and where the gauge corner is affected allow a gauge corner relief of 0.3 mm - 0.6 mm in the high rails, to reduce the gauge corner contact for a limited time. It should be emphasised that the grinding facet limits as specified in Section C5-8.1 must also still be observed within the gauge corner relieved zone.
- Note the track sections in which the above procedure has been implemented, so that (depending on the degree of damage) in following grinding cycles the additional gauge corner relief may be able to be reduced to within the normal limits specified in Section C5-4.2 for plain track and Section C6-3.2 for turnouts.

It is emphasised however that the above procedure should not be required when the rails have been subjected to a number of preventive grinding cycles.

Where wheel slip damage, including surface skidding is present, it should be treated by grinding a minimum of 0.5mm from the rail surface. Guidelines for corrective grinding of rail defects are provided in Section C8-4.

## C7-7 Transitioning grinding and the progressive removal rail surface defects and of long wavelength corrugations

Establish transition arrangements where considerable grinding effort is required to achieve full correction to profile or to remove long wavelength corrugations, rail plastic flow on the gauge side, or severe RCF and squat defects. These must involve the correction of the problem over time such that each grinding cycle brings about a progressive improvement.

The CRN Rail Engineer is responsible to advise the CRN Grinding Supervisors on the Transition Strategy for correction of rail defects in main line and turnouts as follows:

- The implementation of transitional rail profiles (C5-2.1) for the removal of surface defects that require greater than the preventive grinding metal removal requirement.
- The transition strategy to address the correction of the problem over time such that each grinding cycle brings about a "progressive" improvement in rail profile and rail surface condition.
- The maximum number of grinding passes that may be allowed for each grinding cycle to establish the most appropriate profiles
- The relaxation of the required tolerances (C5-4.2) outside the contact band to be applied as follows
  - The grinding applied during each cycle must reduce the maximum deviation of the rail profile relative to the template outside the contact band by at least 0.3mm.
  - Within the contact band the tolerances shall remain as specified above.
  - A minimum metal removal of 0.2mm shall still be achieved within the contact band, as specified in (Section C5-7).
  - The distance of the lug from the gauge face after grinding must be no greater than the distance before grinding.
- The expected wheel rail contact band and surface defect condition after each Transitional Grinding cycle.

# Chapter 8 Grinding Strategy

## C8-1 General

The grinding strategy contains:

- mandatory requirements for grinding new rail and other rail where its orientation has been altered
- mandatory requirements for grinding new turnouts (or new turnout steelwork where existing bearers are kept);
- guidelines for preventive grinding guidelines for corrective grinding
- guidelines for transitional grinding

The requirements are applicable to Class 1 track and heavily utilised Class 2 track. Where targeted grinding strategies have been approved for specific lines by the Principal Track and Civil Engineer, then these will take precedence.

The guidelines are provided for the preventive grinding strategy and as such will provide an indication of the minimum rail grinding requirements. In the initial stages additional grinding may be necessary to rectify defective track sections by using corrective or transitional grinding.

The strategy does not cover manual grinding for minor maintenance associated with crossings and switches.

## C8-2 Grinding of new or reoriented rail (mandatory requirements)

For plain track

*The following requirements are extracted from CRN Engineering Standard CRN CS 100 "Civil Technical Maintenance Plan"*

- Grind all new rail installed on Class 1 and 2 mainline tracks as part of re-railing (and not as closures for replacement of defects)
- Grind all existing rail on Class 1 and 2 mainline tracks when concrete sleepers are installed or when substantial back canting is corrected
- Grind all rail that has been cascaded or transposed on Class 1 and 2 mainline tracks
- Standard Carbon rail to be ground within 7.5 MGT of installation (or 20% of the grinding cycle for preventive grinding (whichever is the larger) following the re-railing. This shall apply even if the re-railing occurs in only part of a curve or section.
- Head Hardened rail to be ground within 10 MGT of installation (or 20% of the grinding cycle for preventive grinding (whichever is the larger) following the re-railing. This shall apply even if the re-railing occurs in only part of a curve or section.

Special care is required in sections within which partial re-railing has occurred between grinding cycles. In these sections, the new rails will require some additional initial grinding prior to the final profile grinding applied to the whole section.

For turnouts

*The following requirements are extracted from CRN CS 100*

- Grind any new turnouts on Class 1 or heavily used Class 2 tracks to profile within 8 MGT for standard carbon rails and Manganese crossings and 10 MGT for Head Hardened rails (or 20% of the grinding cycle for preventive grinding detailed in Table 3, whichever is the larger) following installation.

## C8-3 Guidelines for preventive grinding

For plain track

The recommended guidelines for preventive rail grinding are summarised in Table 5

*The following requirements are extracted from CRN Engineering Standard CRN CS 100 "Civil Technical Maintenance Plan"*

| | Nominal Grinding Cycle (MGT) | | | | | |
|---|---|---|---|---|---|---|
| **Track Curvature (m)** | **Tracks with Heavy Freight (25TAL) Traffic** | | **Tracks with General Freight (<25TAL) Traffic** | | **Tracks with predominately Passenger Traffic** | |
| | **Std** | **HH** | **Std** | **HH** | **Std** | **HH** |
| 450 or less | 7.5 | 15 | 10 | 20 | 20 | 30 |
| **>** 450 to 1000 | 15 | 30 | 20 | 40 | 20 | 40 |
| > 1000 | 30 | 45 | 40 | 60 | 30 | 50 |

*Table 5 - Preventive grinding frequencies for plain track*

To allow for track possession and grinding irregularities a tolerance of 3MGT may be applied to the nominal grinding cycle or up to 20% of the recommended cycle tonnages given in Table 5 (whichever is the larger).

The nominal grinding cycle however will generally be maintained.

Because of adverse wheel/rail contact conditions, the grinding cycles in Table 5 might not be suitable for some track sections. Such sections should be reported, monitored and if necessary adjusted to a different cycle category. An example could be rails subjected to higher tractive efforts which may exhibit higher deterioration rates and hence would require more frequent grinding.

The nominal grinding cycle in Table 5 should be achieved at least on average. If necessary individual cycles may be adjusted to suit particular circumstances but generally within the maximum allowable cycles given in Table 5.

The curve classes and the grinding frequencies given in Table 5 may change in the future, depending on the characteristics of the rail performance observed between grinds, and recognising that the most efficient strategy would consist of grinding cycles which are multiples of each other, thus allowing relatively long sections of track, containing several curve classes, to be covered at any one time.

To improve the logistics of the grinding operation and hence efficiency, grinding may be programmed to cover track sections containing different curve classes at the same time, even though the shallower curves may be within the specified cycles. In this case, as discussed in Section C5-7, the metal removal requirements in the shallower curves may be reduced, as long as the minimum metal removal is achieved within the specified cycles.

**For turnouts**

The recommended guidelines for preventive rail grinding for turnouts is more stringent than the requirements for the adjacent main line.  Note that tonnages on the mainline and the turnout road are to be combined when determining when to grind as per Table 6.

*The following requirements are extracted from CRN Engineering Standard CRN CS 100 "Civil Technical Maintenance Plan"*

| | Nominal Grinding Cycle (MGT) | | |
|---|---|---|---|
| **Rail Type** | **Turnout Type** | | |
| | **1:8.25** | **1:10.5** | **1:15 or higher** |
| Head Hardened | 13 | 18 | 25 |
| Standard Carbon | 8 | 13 | 18 |

*Table 6 - Guidelines for preventive grinding of turnout road*

To allow for track possession and grinding irregularities a tolerance of up to 20% of the recommended cycle tonnages given in Table 6

The nominal grinding cycle however will generally be maintained.

Because of adverse wheel/rail contact conditions, the grinding cycles in Table 5 and Table 6 might not be suitable for some track sections. Such sections should be reported, monitored and if necessary adjusted to a different cycle category. An example could be rails subjected to higher tractive efforts that may exhibit higher deterioration rates and hence would require more frequent grinding.

As a general rule the metal removal (cross sectional area of the rail head) for preventative grinding should be less than 20 mm2.

## C8-4 Corrective grinding

Special grinding requirements apply for the treatment of various rail surface defect conditions. These will require separate assessment and must be dealt with on a case by case basis. The more serious of these will be identified by the track examination process and suitable remedial measures planned in advance.  Lesser conditions that are uncovered in the pre-grinding inspection may be dealt with in association with the normal grinding operation. If this cannot be done economically the work will be rescheduled for special treatment at a later date.

Localised defects such as isolated squats or dipped welds may be more effectively treated by other means such as re-railing, which should be completed prior to grinding to achieve a better final finish.

Rails that have been subjected to wheel slip damage are prone to squat development. Surface damage, created by wheels which are moving and slipping at the same time, should be treated by grinding a minimum of 0.5mm from the rail surface. Wheel burns, created by a stationary spinning wheel, are usually deeper and require alternative treatment such as wire feed welding. These rails should also be ground to remove 0.5mm, to ensure that all heat affected material is removed from adjacent rail surfaces.

Experience shows that grinding to remove squats usually requires removal of in excess of 5mm of metal from the wheel rail contact area, in order to be effective. The practice of grinding more than 5mm off the rail head is NOT an approved practice in the CRN, as this removes the work hardened layer and leads to rapid failure of the rail head soon after grinding. The typical maximum amount of head removal in the wheel rail contact area is 1mm so as to not have a detrimental impact on the work hardened layer, and may only be completed in order to improve ultrasonic inspection where compromised, or to provide short term relief to noise and vibration from squats, other RCF defects and corrugations.

At locations with recently developed squats, consideration should be given to grinding to remove 0.5mm from the rail surface. The purpose of this action is to remove any residual heat affected material from the rail surface. It will not remove the existing squats, but is intended to prevent the development of more squats. It should be restricted to locations where squats have developed without RCF involvement.

Typical defect conditions and their treatment are as follows: -

| Condition | Detail |
|---|---|
| **Rail Corrugations:** | Cyclic (wave like), generally vertical, irregularities on the running surface of the rails. Corrugations are thought to form from either the differential wear caused by a repetitious sliding action of the wheel on the rail, whether through acceleration, braking or lateral motion across the rail, or from plastic flow of the rail material due to excessive contact stresses and the combined resonance of the wheelset unsprung mass and the track. Corrugations are generally 0.1mm to 0.5 mm in depth and:<br>• Short pitch - from about 30 mm to 90 mm in wavelength, which are usually associated with the lighter axle load passenger traffic; or<br>• Long pitch - from about 200 mm to 450 mm in wavelength or more, which are usually associated with the heavier axle load freight or in particular coal traffic. |
| **Wheelburns:** | Structural discontinuities which occur on the running surface of both rails (directly opposite) and are due to the localised slip of a locomotive wheelset. This can cause either severe localised deformation or overheating and the transformation of the rail material into a hard and brittle martensitic microstructure. The contamination of the running surface of the rails, by for example lubricants, greatly enhances the development of wheelburns. |
| **Tread Hollowing:** | A condition where there is a worn hollow in the wheel tread which is then able to make contact with the field side of the rail. Additional field side relief can moderate this problem as indicated in Chapter 7. If possible, offending rolling stock should be identified and reported. |
| **Rail Flow:** | Plastic flow of the rail surface material, which may occur on high, low and tangent rails, both on the field and gauge sides. It results from exceeding the yield strength of the material, which can occur because of various |

| Condition | Detail |
|---|---|
| | reasons including higher tractive effort and poor matching of wheel and rail profiles (including hollow wheels). Correction of head flow (which may be causing tight gauge) may be rectified by grinding, which shall be applied as required to address track geometry standards |
| **Shielding** | 'Shielding' occurs where the ultrasonic testing of rail is inhibited. In this case rail grinding will be conducted at the earliest possible time following the reporting of 'shielding'. Sufficient defective metal will be removed from the rail surface to allow the ultrasonic beam to pass through the rail head, web and foot. This will be checked using manual ultrasonic inspection procedures. |
| **Rolling Contact Fatigue (RCF):** | This is a generic term used to describe a range of defects which are due to excessive wheel/rail contact stresses and which may be of the following types:<br>• **Head or gauge corner checking** is a surface condition that develops from the shear stresses applied to the gauge corner contact region of the high rail in curves. It results in the deformation of the rail surface, and could be described as being like "fish scales". The head checks generally occur at about 2mm - 5mm intervals and can grow to the same depth, gradually spreading across the rail head. Once this occurs they can break out as small "wedges". The effect of lubricants (water and grease) can accelerate their propagation into longer and deeper cracks. If left in track, head checking will deteriorate further into a shelly flaw or "squat", and in turn, possibly a transverse defect.<br>• **Flaking or running surface checking** is a surface condition that develops from the shear stresses applied to the rail head at the contact areas of the low rail. It appears as a mosaic or snakeskin like pattern on the rail head. In the latter stages of growth these cracks begin to 'spall', mainly in the centre of the rail head, and can be continuous over the rail length.<br>• **Shelling** is an internal defect (some 2 mm to 8 mm below the gauge corner), that normally initiates at oxide inclusions or 'stringers' of such inclusions that may be present in the rail steel. It is usually confined to the gauge corner radii of rails on the high side of curves. Shelling cracks form on a horizontal or longitudinal plane consistent with the shape of the rail on the gauge corners. The cracks can continue to grow on that plane for some distance, and then either spall out into a shell or turn down and form transverse defects which can continue to grow on a transverse plane and eventually lead to rail failure if not detected in time. The longitudinal separation from which these transverse defects propagate is not always visible. Again, the presence of lubricants (water and grease) can enhance the growth of shells, particularly in the presence of head checking. |
| **Squats** | Squats have been regarded as RCF defects. However, it has been found that the squats that form on the crown of the rail head and towards the gauge corner region are actually initiated from a hard and brittle 'white' surface layer, which develops due to the microslip that occurs within the wheel/rail contact patch, particularly at the higher traction and creep levels associated with locomotives, particularly if the locomotives have insufficient power. As such they have been classified as thermal-traction defects, noting that the subsequent growth of squats is due to rolling contact fatigue. The majority of cracks associated with well-developed squat defects are about 3mm - 5mm deep and 40mm - 100mm in length.<br>Squat defects can also develop from gauge corner checking defects, shelling defects and skid defects. |

| Condition | Detail |
|---|---|
| **Skids** | Are also a type of thermal/traction defect that can occur over a substantial length of the rail running surface, due to microslip of the locomotive wheels. Skid defects are generally 1-2mm deep and tend to spall out, due to their hard and brittle nature. |

*Table 7 - Common surface defect types*

RCF and squat defects are of particular concern because of the following main reasons:

1. They can lead to rail failure if not detected in time; and/or
2. They can mask the ultrasonic signal during routine inspection and hence prevent the detection of larger and deeper defects that may be present within the rail; and/or
3. Their rectification requires considerable amounts of metal removal; and/or
4. Severe squat defects can lead to a considerable increase in the wheel/rail noise and vibration levels.

Corrective grinding involves aggressive grinding procedures that remove considerable amounts of metal (at least 0.5 mm and up to 5 mm depth).

## C8-5 Transitional Grinding

Transitional Grinding is preferred method for removal of surface defects, as removal between 0.3 to 0.7mm will not remove the work hardened layer, details of application of Transitional grinding strategies are provided in Section C7-7. Such a strategy must involve the correction of the problem over time such that each grinding cycle brings about a progressive improvement. It should be noted that to implement a transitional grinding strategy certainty of funds to complete grinding must be present, otherwise corrective or other means (re-railing) may be more economical.

Guidelines for depth of cut for defect types transitional grinding strategies is provided in Table 8.

| Defect Type | Severity | Added Depth of Cut (mm) |
|---|---|---|
| Spall | Very Light | 0.05 |
| | Light | 0.15 |
| | Moderate | 0.25 |
| | Severe | 0.50 |
| Check | Very Light | 0 |
| | Light | 0.15 |
| | Moderate | 0.25 |
| | Severe | 0.50 |
| Corrugation | Light | 0.15 |
| | Moderate | 0.25 |
| | Severe | 0.50 |

| Defect Type | Severity | Added Depth of Cut (mm) |
|---|---|---|
| Shelling | | 0 |
| Wheel Burns | | 0.20 |
| Low Welds | | 0.25 |
| New Rail | | 0 |
| Crushed Head | | 0.25 |

*Table 8 - Transitional grinding depth of cut*

# Chapter 9 Template fabrication and calibration

## C9-1 Template fabrication

Manufacture the rail template as follows:

1. Manufacture rail templates from hardened steel (or a product of equivalent or superior strength, wear resistance, dimensional stability and durability) to a tolerance of ± 0.025 mm at the profile surfaces.
2. Tolerances at the fixing points for connection to the gauge bar must be adequate to ensure that overall superelevated profile tolerances (as detailed below) are not compromised.
3. Permanently scribe the template name, date of manufacture and designed contact band details (including position of the contact bands and the contact angles) on the face of the template.
4. Manufacture the template with the 1 in 20 (2.86%) rail cant included, noting that the co-ordinates for the various templates given in the Appendix in CRN CS 220 include the allowance for rail cant.

## C9-2 Gauge bar fabrication

Use a gauge bar with the rail template. Manufacture the gauge bar as follows:

1. Manufacture the gauge bar from mild steel, aluminium or other product of equivalent or superior strength, dimensional stability and durability. The gauge bar must be insulated so that there is no electrical contact between the rails during its application.
2. The gauge bar shall have fixing holes matching those on the template.
3. The gauge bar is to provide a reference to the other rail to give a super-elevated reference plane for the application of the template to within ± 0.2 degrees (i.e.. a deviation of less than 2.6 mm from a 1.5m straight edge).

Figure 21 illustrates a gauge bar that could be used to hold the profile template and applied for quality assurance during rail grinding.

## C9-3 Calibration

1. Check template calibration at initial fabrication and thence six-monthly.

   The template must be within 0.05mm at manufacture and thence within 0.1 mm of the designed shape.

   Conduct the calibration with the template fitted to the gauge bar or with a suitably designed calibration block that will allow the proper alignment and matching of the template and the calibration block.

If a calibration block is used it must be within 0.05 mm of the design geometry.

2. Check the gauge bar against a straight edge at monthly intervals to ensure that it has not been deformed.

   The gauge bar needs to be within the original specification of ± 0.2 degrees (i.e. a deviation of less than 2.6 mm from a 1.5m straight edge).

3. Any other equipment (including electronic measuring devices and vehicle mounted systems) used in the application or verification of templates and rail profiles must meet equivalent calibration and repeatability requirements.

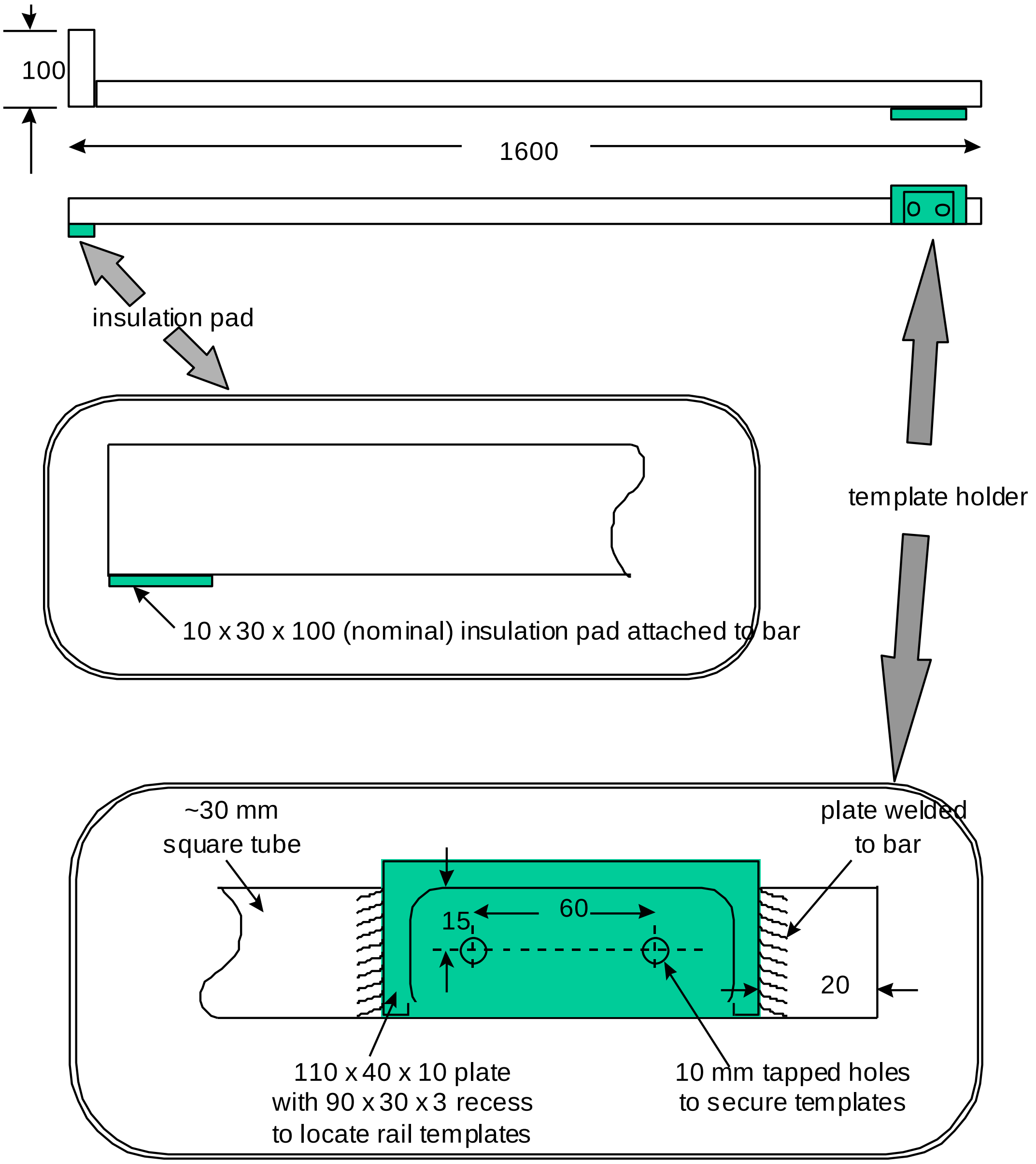


*Figure 21 - Holding Bar for template*

# Appendix 1 Rail Profiles

This section has been intentionally deleted, see CRN CS 220