AUSTRALIAN RAIL TRACK CORPORATION LTD

Discipline: Engineering (Track & Civil) **Category: Standard**

Rail Reprofiling Standard for Plain Track

ETM-01-02

Applicability

ARTC Network Wide	✓	**Western Jurisdiction**	
New South Wales		**Victoria**	

Primary Source

NSW Standard TMS 05 Rail Grinding Plain Track Version 1.3 dated 06 May 2005

Document Status

Version	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
1.2	14 May 15	Standards	Stakeholders	Manager Standards	GM Technical Standards 15/05/2015

Amendment Record

Version	Date Reviewed	Clause	Description of Amendment
1.0	30 Jan 08		Supersedes NSW Standard TMS 05, RIC Standard HVNW TS001 and A2 Rail Profile Rectification contract documents. Includes minor editorial changes, mainly to Sections 1 and 8.1, made following SC approval.
1.1	21 May 08		Minor changes for clarification of referencing points
1.2	14 May 15	Various	Updated title to "Rail Reprofiling Standard for Plain Track" (previously "Rail Grinding Standard for Plain Track"), Changes to allow use of other rail profiling processes other than grinding where they are an accepted process on the ARTC network, and competencies section deleted.

Contents

1 Introduction

1.1 Purpose

This standard specifies requirements for work undertaken to profile in service rail.

The main objectives of rail profiling are to:

- Progressively establish rail profiles that improve the wheel/rail interaction characteristics, and hence reduce rail (and wheel) wear, surface defects, and the risk of unstable vehicle performance (hunting), as well as increasing the rail wear life.
- Rectify or control existing rail surface defects, and hence reduce the risk of rail failures and track deterioration.
- Control rail surface condition so that defects such as Rolling Contact Fatigue (RCF) do not shield/prevent efficient Ultrasonic Testing of rail.

1.2 Scope

This standard covers the main specifications for rail profiles to be used for plain track on Australian Rail Track Corporation (ARTC) network and describes the methods by which the rail profiles are to be applied and the quality standards to be achieved..

More stringent and specific requirements may be applied as part of a regional profiling strategy.

1.3 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
ARTC Representative	A person who has formally been allocated maintenance responsibility for a particular area at Engineer level or a person who has been delegated with engineering authority with respect to Rail Condition/Profiling Management by ARTC.
Checking Locations:	Specific points marked on the rail where the achievement of the defined rail profile and/or metal removal is checked and monitored.
Contact Band:	The 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.
“Corrective or Defect Profiling”:	Profiling 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 or isolated rolling contact fatigue defects).
Field Side:	The side of the rail opposite the gauge face (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).
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.
Gauge Corner:	The top corner of the rail above 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).
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.
“New Rail Profiling”:	Profiling to profile of rails which have been in track for less than 10 Million Gross Tonnes (MGT).
Plain Track	All track up to the last of the 1:20 rail cant plates before and after turnouts.
“Preventive or Cyclic Profiling”:	Profiling 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 profiling cycle.
"Previously profiled Rail Profiling":	Profiling of rail to profile which has been profile ground previously but is beyond the specified cycle, noting that the actual rail profiling effort in this case will depend on the tonnage level beyond the specified cycles which the rails have experienced, i.e. more profiling effort will be required as the tonnage beyond the specified limits increases.
Rail Profiling 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.
Running Surface:	The zone on top of the rail head which makes contact with the wheel tread (refer to Figure 1).

2 Additional Safety Specific to Rail Profiling

Profiling supervisors and profiling personnel nominated by the contractor shall obtain Rail Safety Awareness certification for the relevant state jurisdiction and appropriate training in fire risk management.

All rail profiling work must be conducted in accordance with all relevant OH&S requirements, ARTC Standards and Environmental Licenses, relevant legislation and relevant Safeworking requirements (including for work affecting interlocked points).

In particular all Fire Restrictions, Fire Bans, EPA dust and noise limits **must** be met by the contractor.

Rail profilers must be fitted with full dust aspiration, dust disposal systems and adequate water reservoir for fire fighting.

4WD hi-rail fire fighting chase vehicles are required for grinding, for milling a risk assessment should be done to determine requirement.

3 Track Certification

Following profiling works track shall be certified safe for passage of trains by a person with the appropriate Rail Safety Worker Competency.

4 Qualifications

Both grinding and milling are acceptable rail profiling methods for use on the ARTC network. The choice of method should be based on cost efficiency for the metal removal required in particular locations, and on the cost effective management of environmental risks in sensitive locations and at particular times of the year.

5 Quality

A process shall be in place for monitoring, planning, and controlling rail profiling activity to include not only the production work of the rail profilers but also the monitoring of the profiling results so that the objectives of the profiling program are achieved.

5.1 Rail Profiles

The rail shapes required have been determined for tangent track and curved track (including for high and low rails). The same basic shapes apply to all rail sizes and types.

The main rail shapes are designed to suit current wheel profiles in both the new and worn conditions, if the latter are within the prescribed wear tolerances. The designed rail shapes required have been converted into matching templates for use with the rail profiling operation.

The templates to be used are summarised in Table 1.

Table 1: Rail Profile Templates (also see Appendix 1)

Situation	Profile Name	Template
Tangent track and curves with radius > 900m. Also used for the high rails in very sharp curves (radius less than 300m) and low operating speeds (less than 25 kph)	RTG2000	ARTC TGT
Curved track (≤ 900m radius) high rails.	RMH2000	ARTC H2
Curved track (≤ 900m radius) low rails.	RML2000	ARTC L2
Curved track (≤ 900m radius) low rails, transitional profiling strategy.	RPL2000	ARTC L1
Curved track (≤ 900m radius), high rails exhibiting severe RCF defects in the gauge corner region, transitional profiling strategy.	H3	ARTC H3
Curved track (≤ 900m radius) low rails, with additional field/gauge side relief.	L3	ARTC L3
Tangent track and curves with radius > 900m, with additional field/gauge side relief.	TGT1	ARTC TGT1
Curved track (≤ 900m radius) high rails, with additional field side relief.	H2R	ARTC H2R

It should be noted that profiles ARTC L1, ARTC H3, ARTC L3, ARTC TGT1 and ARTC H2R are applied in special circumstances, at the discretion of the ARTC representative..

The templates used for tangent and low rails contain positioning lugs. The purpose of this lug is to provide a referencing point for the template relative to the centreline of the rails. 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.

5.2 Rail Templates

The measurement of profiles and tolerances before/during/after profiling is to be conducted by the Contractor preferably using a non-contact approved profile measuring system. However, approved contact (mechanical) systems may be used as a means of conducting any post profiling quality assurance assessments.

Rail templates for contact systems are to be constructed of hardened steel (or a product of equivalent or superior strength, wear resistance, dimensional stability and durability) to a tolerance of ± 0.025mm at the profile surfaces. The template name, date of manufacture and designed contact band details are to be permanently scribed on the face of the template. The template is to be manufactured with the 1 in 20 (2.86°) rail cant included.

A gauge bar is to be used with the rail template. The gauge bar provides fixing holes that are to match those on the template. 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 (ie. a deviation of less than 2.6mm from a 1.5m straight edge). The gauge bar is to be made of mild steel, aluminium or other product of equivalent or superior rigidity, dimensional stability and durability. The gauge bar must be insulated so that there is no electrical contact between the rails during its application.

Template calibration must be checked at initial fabrication and thence six-monthly. The template must be within ±0.025mm at manufacture and thence within ±0.05mm of the designed shape. Calibration shall be carried out 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 ± 0.025mm of the design geometry.

To ensure that the gauge bar has not been deformed, it shall also be checked against a straight edge at monthly intervals. The gauge bar needs to be within the original specification of ± 0.2 degrees (ie. a deviation of less than 2.6 mm from a 1.5m straight edge).

All of the tolerances specified for the manual measurement system, shall apply to the non-contact vehicle mounted profile measurement system.

The measuring system must have a proven accuracy and repeatability of better than ± 0.13mm. This will be checked by the Contractor at intervals no longer than 3 months.

Calibration of measuring systems shall be the responsibility of the Contractor and in accordance to the quality plan accepted by ARTC.

6 Preparation for reprofiling

All track obstructions that prevent reprofiling within a section (including high ballast, lubricators and wayside monitoring devices) shall be removed before works commence and replaced within 2-3 days following completion of works at the location and in accordance with the requirements specified by ARTC representative.

Determine locations for reprofiling, the number of passes per location and speed at each location. Locations can be determined from track inspection, rail wear and condition data (for example Track Geometry inspection car or manual inspections by competent inspector).

7 Application of Rail Profile Templates

For contact measurement systems, the rail template is to be affixed to the gauge bar. Tolerances at the fixing points for connection to the gauge bar must be adequate to ensure that the overall superelevated profile tolerances (as detailed below) are not compromised.

With the non-template end of the gauge bar resting on the other rail, the template is to be placed onto the rail to be checked and moved down and across to maximise the contact of the template onto the rail. In all cases, the rail contact point must make contact with the rail gauge face. The contact point generally occurs at an angle of 50°±1° to the vertical for the high rails and 65°±1° for the low and tangent rails.

Where the template is provided with a gauge positioning lug (for low and tangent rails), the lug must be pushed up against the gauge face of the rail (subject to the details given in the following Section on tolerances).

For the high rail templates without lugs, the template must make contact with the gauge region of the rail at the start of the template run off (the rail contact point), as illustrated in Appendix 1. The run off is not part of the profile.

Note: It is important that no excessive force be placed by the operator on the template or gauge bar, which may lead to their distortion or accelerated wear.

When using the non-contact measuring system, the acquired rail profile can be aligned to the following reference points on the respective template:

The top of the template, i.e. the (0,0) point and

- The rail contact point, which is located at a distance of about 7.5-7.6mm from the top of the template, for the ARTC H2, ARTC H3 and ARTC H2R profiles.
- The top contact point of the lug, which is located at a distance of 16.0mm from the top of the template, for the ARTC TGT, ARTC TGT1, ARTC L1, ARTC L2 and ARTC L3 profiles.

8 Tolerance to Templates

The rail is to be profiled so that the profile matches the template. When applying mechanical means, the tolerance is to be checked by measuring the visible gap between the rail and the template using a feeler gauge no more than 3-4mm wide at the end. The maximum allowable gaps between the rail profile and the template will be as follows:

- 0.20mm (i.e. a 0.25mm feeler gauge must not pass between the template and the profiled rail head covered by the template) within the contact bands (minimum and maximum) on the contact band of any template. This includes the gauge corner region in the case of the high rail templates (ARTC H2, ARTC H3 and ARTC H2R).
- 0.40mm (i.e. a 0.45mm feeler gauge must not pass between the template and the profiled rail head covered by the template in the gauge corner and field side (up to 5mm from the field side corner) regions outside the contact bands (minimum and maximum) where low and tangent rail templates have been used, and the field side region where the high rail templates have been used.

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

Some rails may exhibit plastic flow lips, which may increase the difficulty of matching the templates with the locating lugs to the rails.

For the low rail and tangent rail templates the Contractor shall follow the following requirements for application of the positioning lugs:

- The distance of the lug from the gauge face after profiling must be no greater than the distance before profiling.
- The distance between the lug and the gauge face of the rail must be reduced by at least 50% during each profiling cycle, and eventually must be less than 0.5mm.

In certain cases the application of the above tolerances may necessitate the requirement for additional profiling effort particularly on the gauge corner/face region. It will be the responsibility of the Contractor to advise the ARTC representative of this aspect.

Furthermore, when the rail profiles before reprofiling are significantly different to the required profiles, due to excessive gauge corner and/or field side relief applied during previous profiling cycles, the rails can be treated as being in a transitional regime. To reduce the number of profiling passes that may be required to establish the most appropriate profiles, a relaxation of the required tolerances outside the contact band may be applied at the discretion of the ARTC representative as follows:

- The profiling 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 a following Section.

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

Initially, it is envisaged that the non-contact systems will be used in a manner similar to the contact measurements, i.e. at the specific checking locations, each representing a track segment as described in a following Section. In this case the allowable maximum deviations from the template shall be +0.05mm/-0.20mm within the contact band, and +0.05mm/-0.40mm outside the contact band.

In the longer term (within about 12 months from the start of the profiling contract and following appropriate field profiling and assessment trials) it is envisaged that additional and more detailed rail profile measurements after profiling will be taken using the vehicle mounted system on at least one track segment profiled in each profiling shift (or day).

The measurements will be taken at 20-25m 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:

- 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:

- 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

Excessive exceedences that may occur at rail irregularities such as welds and closures will be ignored in the above statistical analysis.

The detailed measurements described above will be in addition to the profile measurements taken at the checking locations in all other track segments.

9 Metal Removal

9.1 General

Sufficient metal must be removed to achieve reprofiling objectives. Avoid excess metal removal as it is expensive in terms rail head metal loss and wasted metal removal activity.

9.2 Measurements required

Measurements of metal removal from the rail head are required to demonstrate compliance with the minimum or maximum depth of metal removal in clause 9.3.

9.3 Acceptance criteria for metal removal

In conjunction with restoration of the rail profile to the designed template, a **minimum** of **0.2mm** of metal should be removed from the contact band as specified in Section 7 and Appendix 1. The exception being the gauge face of the high rails (at an angle >50° to the vertical) in the sharper curves, where gauge face wear has been occurring.

The maximum depth is to be specified by ARTC Engineer responsible for rail performance.

Rail profile measurement devices will be used to measure the metal removal achieved the centre of the rail's running surface, at a particular checking location or locations. This will require taking rail profiles both before and after reprofiling. Subject to the proven accuracy and repeatability obtained (preferably better than ±0.05mm), suitable procedures will involve the use of:

- A vehicle mounted non-contact system which is capable of achieving an accuracy and repeatability of better than ± 0.05mm.
- A portable rail profile measuring system such as 'Railmate', 'MiniProf'' or other device approved by ARTC capable of achieving an accuracy and repeatability of better than ± 0.05mm).

All of the above measuring systems shall have the measurement accuracy required to quantify the metal removal achieved by the profiling process.

It should be noted that the metal removal requirements of rails that are within the preventive profiling regime should be **less than about 18-20mm^2** (cross section). Rails having greater metal removal requirements are to be treated as out of preventative cycle and may be profiled in a transitional mode at the discretion of the ARTC representative.

The templates in Table 1 contain the required gauge corner and field side relief. Unless otherwise instructed by the ARTC representative, the Contractor shall not apply gauge corner or field side relief in excess of the tolerances to template specified above.

The ARTC representative in consultation with the Contractor will specify the metal removal requirements for corrective or transitional profiling of transverse profiles. This may also allow some gauge corner or running surface cracking/checking defects to remain in track after profiling.

Notwithstanding the metal removal requirements, the recommended rail profiles shall always be achieved.

9.4 Rail Surface Finish

The profiling process leaves visible facets on the head of the rail and gauge face. These facets must be controlled if excessive contact stress points are to be avoided. The maximum facet width shall be:

- 6 mm in the gauge corner region.
- 10 mm elsewhere on the profiled surface.

When necessary, a lower power/higher speed finishing profiling pass shall be applied in track sections to cross cut facets and improve the surface finish of the contact band.

The ARTC representative will specify the requirements for removal of isolated defects identified prior to profiling (such as corrugations, dipped or peaked welds or wheel burns). Noting that they may not be able to be removed efficiently by the profiling process and do not necessarily have to be removed in one profiling cycle.

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

- There must be no sharp ridges especially at the interface of facets.
- There must be no excessive gouging on the rail surface and sharp profiling marks.
- There must be no indentations in the rail.
- There must be no cyclic profiling marks.
- There must be no continuous indication of overheating (blueing) of the rail surface.
- Surface Roughness

Note: A poor quality surface roughness will increase rail noise and may enhance the future development of rail surface defects.

The profiled rail surface must be no rougher than an average of 10μm R_A within 5km of any dwelling and 15μm R_A elsewhere.

The resultant surface roughness shall be measured by the Contractor, within at least one track segment ground in each grinding shift or day, or at the discretion of the ARTC representative, with an acceptable roughness measuring system, or equivalent, using a measurement travel of 25mm. Surface roughness measurements shall be taken on both rails at or near the checking locations, and will consist of at least three longitudinal traverses taken on each rail at the rail centre line and 10-15mm on each side of the centre.

Short pitch surface irregularities (30-150 mm in wavelength), which could introduced by the profiling process, shall be removed so that the remaining **cyclic** average longitudinal unevenness along the rail running surface (peak to peak) shall be less than 15μm, and the remaining longitudinal unevenness along the rail running surface shall be less than 0.10mm, when measured at the centre of the running surface over any 1m length (excluding welds), using a suitable measuring system, which would generally be laser based.

9.5 Longitudinal Profile

9.5.1 Principle

Measurements are made using one of the following methods

- An accelerometer or mechanical based hand operated system, such as the 'CAT' or equivalent. In this case, both rails in at least 5% of the profiled track per shift shall be measured.
- An accelerometer, mechanical or non-contact based system incorporated on the rail profiling unit or auxiliary vehicle. This would be the most preferred option. In this case, both rails in at least 10% of the profiled track per shift shall be measured.
- Approved equivalent method.

9.5.2 Measurements required

The longitudinal profile of the finished reprofiled rail shall be recorded continuously using one of the methods identified in 10.3.1.

All measurements undertaken in order to demonstrate compliance with shall be recorded.

Measurements should be taken immediately after work. Measurements shall be undertaken at the latest within 2 days of work .

9.5.3 Acceptance criteria

9.5.3.1 General

The acceptance of reprofiled sites shall be on the basis of percentage of irregularities shown in table 2 for the specified rail.

9.5.3.2 RMS value

The overall longitudinal profile shall be processed to provide a filtered profile within each of the wavelength ranges given in Table 3.

The cut-off wavelengths for each wavelength range and the length of the corresponding window within which the pertinent moving average is to be calculated are also given in Table 3.

The percentages of any site in which the moving average RMS amplitudes exceed the values specified in Table 4 shall be calculated.

Table 2 – Acceptance criteria for longitudinal profile expressed in terms of maximum allowable percentage exceeding

Wavelength range (mm)	10-30	30-100	100-300	300-1000	1000-1500
All rail sections ≥53 kg	5%	5%	5%	10%	No requirement
<53 kg rail	5%	5%	5%	10%	10%

Table 3 - Parameters for calculation of RMS

Wavelength range (mm)	10-30	30-100	100-300	300-1000	1000-1500
Window Length (m)	0.15	0.5	1.5	5	15

Table 4 – Moving Average RMS limit

Limit of moving average of RMS amplitude (mm)	0.004	0.004	0.012	0.040	0.040

The classification concerns the total length of each reprofiling section, where level crossings and points and crossings work within the length of track are to be excluded.

9.6 Lateral (Transverse Profile

Some sections of track, in particular shallow curves and tangents, may contain indications of a cyclic gauge region wear pattern that has been produced by wheel set/bogie hunting. This requires special profiling procedures to remove/control.

In sections of track that have no prior indications of hunting wear on the rails, the rail profiling operation shall not induce any form of cyclic wear, in the form of ‘skipping’. Skipping is an intermittent, sometimes cyclic variation, in the depth of metal removed along the gauge corner of the rail.

To ensure that the profiling operation does not introduce any cyclic ‘skipping’ wear on the rails, the Contractor will measure after the completion of at least one track segment profiled following each profiling shift or day, or as directed by the ARTC representative the deviation of the rail profile from the template at an angle of 0-50° from the vertical towards the gauge corner region.

Where possible, the track segment shall be either a shallow curve or a tangent section, and both rails will be measured, excluding any rail closures that may be present within the track segment.

To quantify skipping the following measures shall apply:

- Rail profiles are measured every 0.5m for 200m
- For each measured profile the variation from the appropriate template (using the alignment given in section 3) is to be calculated at 1° intervals from 0-50° (measured from the track plane).
- For each profile the maximum variation is determined.
- The standard deviation is to be calculated for a moving window 20m in length for the 200m section.
- The mean of the standard deviation is calculated over the 200m length.

For any 200m length the mean of the standard deviation shall be less than 0.2mm.

The Contractor may recommend an alternate quality assurance procedure for ensuring that no 'skipping' wear is introduced on the rails, as long as the procedure ensures that the above profile deviations are not exceeded.

Once confidence is established in relation to the performance of the rail profiler in terms of 'skipping' wear, the detailed measurements described above could be extended to once every 5-7 days or as directed by the ARTC representative.

10 Rail Reprofiling Operation

Each curve must be fully profiled between the tangent points (TPs) defining that section as indicated in the appropriate Track Geometry Data Sheets. Generally it is not permissible to profile only a portion of a curve, unless for defect removal.

Some curves or track sections have multiple radii. In these cases, to simplify the process and to ensure that a continuous rail profile is established, the full curve or track section shall be profiled according to the profile required for the smaller or smallest radius within the curve or track section, which satisfies the requirement of making up at least 20% of the total curve length or track section.

A limited number of track sections may require special consideration in relation to the profiles to be adopted. For example, when two curved track sections are joined by a relatively short (less than 200m but generally less than 100m) tangent section. In these cases, the middle tangent segment shall be treated the same as the adjoining curve segments. On the other hand, if short curved sections (less than 80m) are separated by tangent sections, they shall also be treated the same as the adjoining longer tangent segments.

The characteristics of the rail profiling unit applied within the ARTC Network shall include:

- Full dust aspiration
- Maximum noise emission during profiling of less than 90dBA sound pressure at 10m from the work site.

11 Monitoring and Control

11.1 Contractor's responsibility

In the process of profiling the track is broken up into segments. Each segment must be assessed separately by the Contractor. Each segment shall have a consistent rail surface shape and condition. A segment cannot be longer than a whole curve, although individual curves can be broken up if required, depending on the curve length.

At this stage, set locations in each segment will be nominated as checking locations and shall be used for the ongoing profiling programme. These are to be positioned towards the centre of the segment to be profiled but avoiding closures or anomalous profile conditions. The rail web and foot are to be clearly paint-marked on both the field and gauge sides and its location recorded. An equivalent procedure may be adopted that will allow the checking location to be accurately

defined. Each checking location will represent a track segment generally no longer than 500m in curved track with radii up to 900m, and 1000m in tangent track and shallower curves, or no longer than 300m in the case of corrective/defect profiling. The length of the track segments may be increased at the discretion of the ARTC representative.

The achievement of profiling tolerances, metal removal and surface condition must be checked on completion of the profiling work and prior to the running of trains as described below. Checking locations must be examined for profile, metal removal, surface roughness, short and long pitch corrugations, and the remainder of the rail checked to ensure that the specified defect removal requirements and surface condition have been achieved, as specified in previous Sections.

The Contractor will take the required measurements in this standard after the completion of profiling on at least one track segment profiled in each profiling shift or day, or at the discretion of the ARTC representative.

The vehicle mounted rail profile measuring system (or equivalent) will record profile deviations from the template and metal removals at the checking locations, as specified in a previous Section. If it is felt that vehicle mounted non-contact systems do not have the required accuracy to measure metal removal, the Contractor shall then use a mechanical system ('Railmate' or 'MiniProf') to measure both the metal removal at the rail centre line and the overall metal removal area.

The required contact band width on the running surface shall be checked by painting the running surface of the rails at the checking locations following profiling by the Contractor, and inspection after a minimum of at least 3 or 4 trains or preferably after several days of operations. A preliminary check of the running band by the Contractor can be conducted using the contacts achieved by the wheels on the rail profiler. Any abnormal observations (i.e. when the actual contact band is outside the recommended limits) will be reported to and recorded by the ARTC representative during the auditing process and monitored for possible future action.

11.2 ARTC's responsibility

For quality assurance purposes, profile deviations, metal removal, surface roughness, contact band width and corrugations will also be assessed and recorded by the ARTC representative as part of the auditing process. Such an assessment will be conducted within 1-2 days after rail profiling. It is noted that when taking rail profiles with the 'Railmate' system, the cant bar must be used at all times to allow compensation for any deviations from the design rail cant of 1:20. Field audits of the profiling operations by competent personnel should be conducted at regular intervals, which would range from about 2-4 weeks in the Hunter Valley, where profiling is conducted more regularly, to 8-12 weeks in other regions, where profiling is conducted less regularly.

The ARTC representative is responsible for monitoring rail condition. Basic rail inspection is carried out as part of the Track Examination System. In addition the rail condition is to be assessed visually, by a suitably qualified person, prior to profiling. This assessment will assist in determining the specific requirements for the profiling operation.

Spot checks are also to be carried out of the rail profiling efficiency and the continued effective functioning of the profiles in terms of the contact bands evident and any other rail surface anomalies. These checks will form part of the auditing process. Variations to the designed contacts are to be investigated and if required adjustments made to the templates used or profiling strategies.

Spot-checking should be carried out on at least 5% to 10% of profiling locations as a follow up to the profiling operation. In addition a visual inspection should be carried out for all profiled track at about 60% to 70% of the way through the planned profiling period.

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.

12 Records to be kept by the Contractor

The technical details for preventive, transitional or corrective rail profiling, which need to be recorded in an electronic database, such as Microsoft Access, are as follows:

- Profiling machine.
- Date of profiling and inspection.
- Location of profiling carried out (start and end points), to closest 10 metres.
- Location of checking points, to closest 5 metres.
- Nature of the profiling strategy adopted (eg preventive/transitional/corrective/defect).
- Profiling template(s) used.
- Rail type and size.
- Finished (work completed satisfactorily) and pass track kilometres profiled within 20m.
- Location of any section within a track segment that has not been profiled, and the reason for not profiling (for example: high ballast, crossing, etc).
- Minimum metal removal at the rail centre line, to the closest 0.05mm, and the overall metal removal area.
- Deviations of the rail profile from the template and reasons for this.
- Rail surface roughness achieved after profiling.
- Residual rail corrugations after profiling.
- Cyclic rail wear after profiling, including any visual indications of 'skipping' or any other surface irregularity.
- Number of profiling passes applied to each rail.
- Profiling efficiency of machine, i.e. number of profiling motors working.
- Details of any condition from pre-profiling inspection or any other specific inspections of rail condition.
- Details of the rail contact band assessments carried out immediately after profiling.
- Details of any non-conformances in the profiling process or standard of completion.

The above information shall be made available in daily form within 24 hours of the end of each shift/day by the Contractor.

13 Appendix 1 – Rail Templates

Main Templates

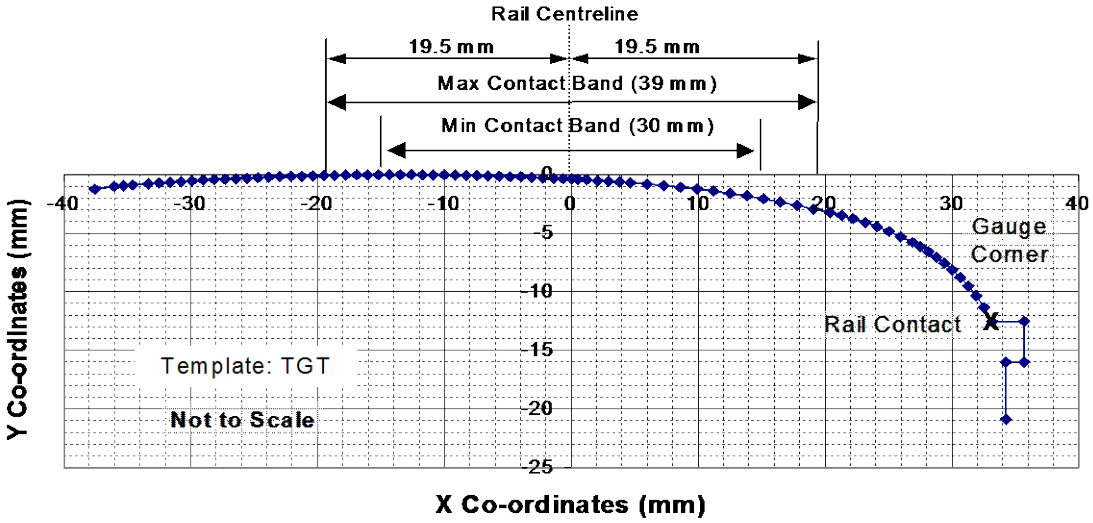
Fig A1: ARTC TGT	Template for tangent track and curves with radii >900m, with lug
Fig A2: ARTC L1	Template for low rails in curved track with radii ≤900m, applied in transitional profiling, with lug
Fig A3: ARTC H2	Template for high rails in curved track with radii ≤900m, without lug
Fig A4: ARTC L2	Template for low rails in curved track with radii ≤900m, with lug

Special Templates

Fig A5: ARTC H3	Template for high rails in curved track with radii ≤900m exhibiting moderate/severe RCF defects, without lug
Fig A6: ARTC L3	Template for low rails in curved track with radii ≤900m requiring additional field/gauge side relief, with lug
Fig A7: ARTC TGT1	Template for tangent track and curves with radii >900m requiring additional field/gauge side relief, with lug
Fig A8: ARTC H2R	Template for high rails in curved track with radii ≤900m requiring additional field side relief

Note: All profiles have been specified for rails with a cant adjustment of 1:20 (2.86°).

Figure A1: ARTC TGT – Template for tangent track and curves with radii >900m, with lug



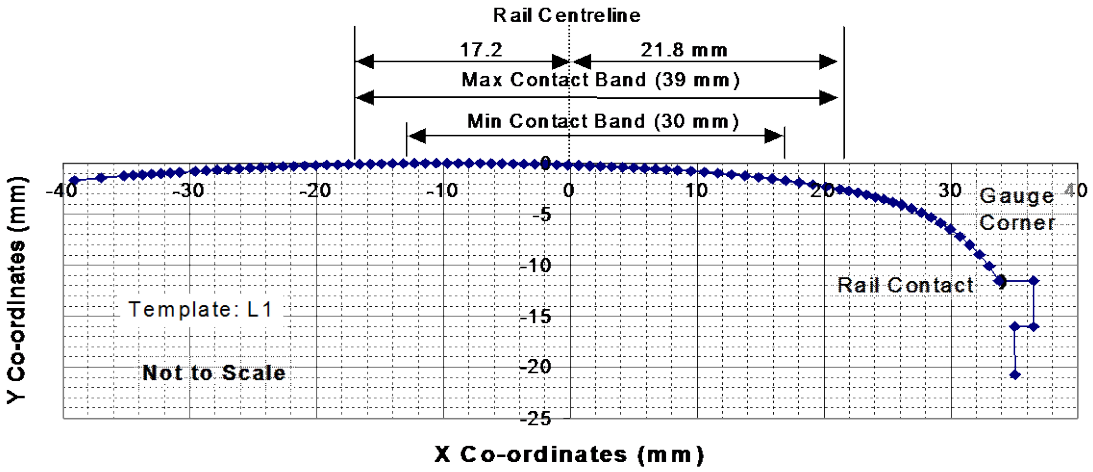
X Coordinates of Contact Band

Min Contact Band	Max Contact Band
+15	+19.5
-15	-19.5

X-Y Co-ordinates

X	Y	X	Y	X	Y	X	Y
-39.10	-1.44	-19.53	-0.07	-1.39	-0.31	21.29	-3.49
-37.59	-1.23	-18.67	-0.06	-0.63	-0.35	22.23	-3.76
-36.05	-1.00	-17.79	-0.04	0.00	-0.38	23.16	-4.08
-35.31	-0.94	-16.93	-0.02	0.54	-0.41	24.10	-4.44
-34.58	-0.87	-16.07	-0.02	1.21	-0.45	25.03	-4.84
-33.35	-0.78	-15.21	-0.01	2.07	-0.50	25.97	-5.29
-32.49	-0.71	-14.35	0.00	2.94	-0.56	26.90	-5.79
-31.62	-0.65	-13.48	-0.01	3.79	-0.62	27.53	-6.16
-30.76	-0.58	-12.62	-0.01	4.66	-0.68	28.16	-6.58
-29.89	-0.53	-11.76	-0.01	5.97	-0.79	28.78	-7.04
-29.03	-0.47	-10.88	-0.02	7.28	-0.91	29.41	-7.56
-28.17	-0.42	-10.02	-0.03	8.60	-1.06	30.03	-8.13
-27.30	-0.38	-9.16	-0.04	9.91	-1.21	30.66	-8.78
-26.44	-0.33	-8.29	-0.07	11.22	-1.40	31.28	-9.51
-25.58	-0.28	-7.43	-0.08	12.53	-1.61	31.90	-10.35
-24.71	-0.25	-6.57	-0.10	13.85	-1.83	32.53	-11.34
-23.85	-0.21	-5.70	-0.13	15.15	-2.08	33.16	-12.53
-22.98	-0.17	-4.84	-0.16	16.46	-2.34	35.70	-12.53
-22.12	-0.15	-3.98	-0.19	17.78	-2.62	35.70	-16.00
-21.25	-0.12	-3.12	-0.22	19.09	-2.92	34.26	-16.00
-20.39	-0.09	-2.25	-0.27	20.40	-3.25	34.26	-20.87

Figure A2: ARTC L1 - Template for low rails in curved track with radii ≤900m, applied in transitional profiling, with lug



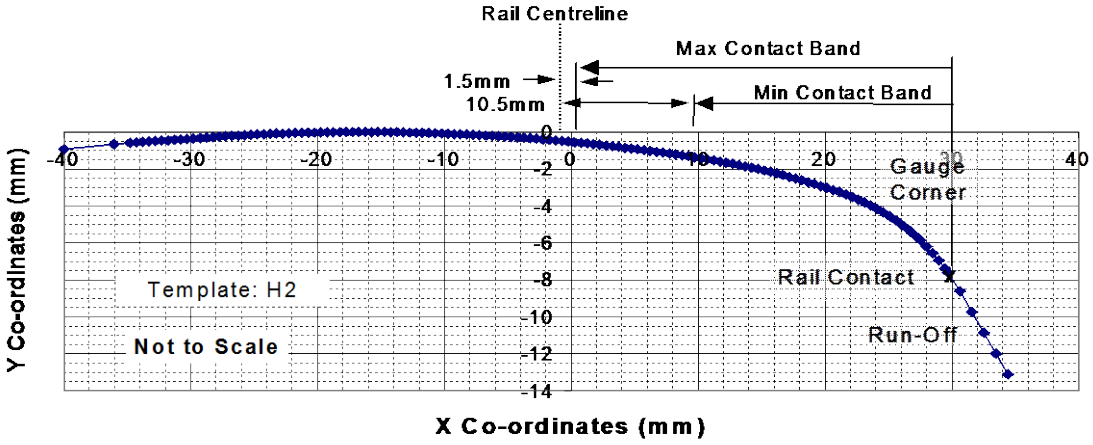
X Coordinates of Contact Band

Min Contact Band	Max Contact Band
-12.7	-17.2
17.3	21.8

X-Y Co-ordinates

X	Y	X	Y	X	Y	X	Y
-39.10	-1.69	-18.34	-0.13	0.66	-0.21	21.95	-2.71
-37.00	-1.45	-17.48	-0.11	1.53	-0.26	22.65	-2.87
-35.20	-1.23	-16.62	-0.08	2.39	-0.30	23.34	-3.07
-34.46	-1.17	-15.75	-0.06	3.25	-0.34	24.04	-3.29
-33.74	-1.11	-14.89	-0.05	4.11	-0.39	24.73	-3.53
-33.00	-1.04	-14.03	-0.03	4.98	-0.44	25.43	-3.79
-32.27	-0.99	-13.16	-0.01	5.84	-0.49	26.13	-4.08
-31.54	-0.93	-12.30	-0.01	6.71	-0.55	26.89	-4.44
-30.80	-0.86	-11.44	0.01	7.57	-0.61	27.66	-4.85
-29.58	-0.77	-10.57	0.01	8.44	-0.67	28.43	-5.31
-28.71	-0.70	-9.70	0.00	9.50	-0.75	29.19	-5.85
-27.85	-0.64	-8.84	0.00	10.57	-0.85	29.95	-6.47
-26.98	-0.57	-7.98	0.00	11.64	-0.96	30.72	-7.17
-26.12	-0.52	-7.11	-0.01	12.70	-1.08	31.49	-7.99
-25.26	-0.46	-6.25	-0.02	13.78	-1.22	32.25	-8.94
-24.39	-0.41	-5.39	-0.03	14.84	-1.37	33.02	-10.08
-23.53	-0.37	-4.52	-0.05	15.91	-1.54	33.79	-11.52
-22.67	-0.32	-3.66	-0.07	16.97	-1.71	36.52	-11.52
-21.80	-0.27	-2.80	-0.09	18.05	-1.89	36.52	-16.00
-20.94	-0.24	-1.93	-0.12	19.11	-2.10	35.03	-16.00
-20.08	-0.20	-1.07	-0.15	20.18	-2.32	35.04	-20.72
-19.21	-0.16	-0.20	-0.18	21.25	-2.54		

Figure A3: ARTC H2 - Template for high rails in curved track with radii ≤900m, without lug



X Coordinates of Contact Band

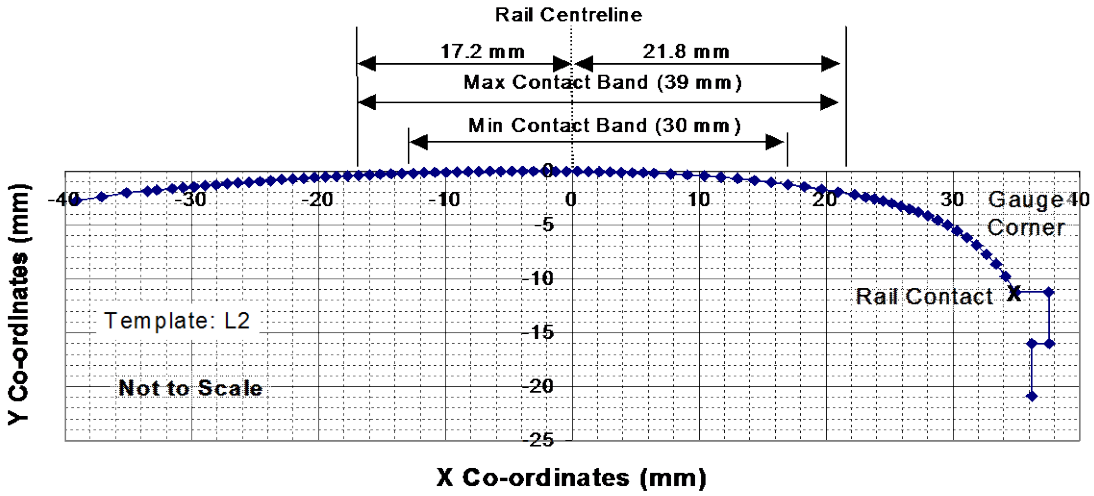
Min Contact Band	Max Contact Band
+ 9.5 to rail contact point on gauge side (at 50°)	+ 1.0 to rail contact point on gauge side (at 50°)

X-Y Co-ordinates

X	Y	X	Y	X	Y	X	Y
-40.00	-0.94	-18.25	-0.01	-0.75	-0.49	16.68	-2.33
-36.06	-0.67	-17.75	0.00	-0.26	-0.52	17.17	-2.43
-34.80	-0.59	-17.25	0.00	0.24	-0.56	17.67	-2.52
-34.30	-0.57	-16.75	0.00	0.74	-0.58	18.16	-2.62
-33.80	-0.54	-16.25	0.00	1.24	-0.62	18.66	-2.71
-33.30	-0.52	-15.75	0.00	1.74	-0.66	19.15	-2.82
-32.79	-0.49	-15.25	0.00	2.24	-0.70	19.65	-2.92
-32.29	-0.47	-14.75	0.00	2.74	-0.73	20.14	-3.03
-31.79	-0.44	-14.25	-0.01	3.24	-0.77	20.64	-3.14
-31.29	-0.42	-13.75	-0.01	3.73	-0.81	21.14	-3.25
-30.79	-0.40	-13.25	-0.02	4.23	-0.86	21.63	-3.37
-30.29	-0.38	-12.75	-0.02	4.73	-0.89	22.12	-3.50
-29.78	-0.35	-12.25	-0.04	5.23	-0.94	22.62	-3.66
-29.28	-0.33	-11.75	-0.04	5.73	-0.98	23.11	-3.81
-28.78	-0.30	-11.25	-0.06	6.23	-1.03	23.60	-3.98
-28.28	-0.28	-10.75	-0.06	6.73	-1.07	24.09	-4.16
-27.78	-0.25	-10.25	-0.08	7.22	-1.12	24.58	-4.35
-27.28	-0.24	-9.75	-0.09	7.72	-1.16	25.07	-4.55
-26.77	-0.21	-9.25	-0.11	8.22	-1.22	25.56	-4.77
-26.27	-0.19	-8.75	-0.12	8.72	-1.26	26.05	-5.01
-25.77	-0.17	-8.25	-0.14	9.22	-1.32	26.54	-5.27
-25.27	-0.16	-7.75	-0.15	9.71	-1.37	27.03	-5.55
-24.77	-0.13	-7.25	-0.17	10.21	-1.42	27.51	-5.86
-24.27	-0.12	-6.75	-0.19	10.71	-1.47	28.00	-6.19
-23.76	-0.10	-6.25	-0.21	11.21	-1.54	28.48	-6.56
-23.26	-0.09	-5.75	-0.23	11.71	-1.59	28.96	-6.95

-22.76	-0.08	-5.25	-0.25	12.20	-1.66	29.44	-7.37
-22.26	-0.07	-4.75	-0.27	12.70	-1.72	29.68	-7.60
-21.76	-0.05	-4.25	-0.30	13.20	-1.79	30.63	-8.61
-21.26	-0.05	-3.75	-0.32	13.70	-1.85	31.57	-9.73
-20.76	-0.03	-3.25	-0.34	14.19	-1.93	32.52	-10.86
-20.26	-0.03	-2.75	-0.37	14.69	-2.00	33.46	-11.99
-19.76	-0.02	-2.25	-0.40	15.19	-2.09	34.41	-13.11
-19.25	-0.02	-1.75	-0.43	15.68	-2.16		
-18.75	-0.01	-1.25	-0.45	16.18	-2.25		

Figure A4: ARTC L2 - Template for low rails in curved track with radii ≤900m, with lug



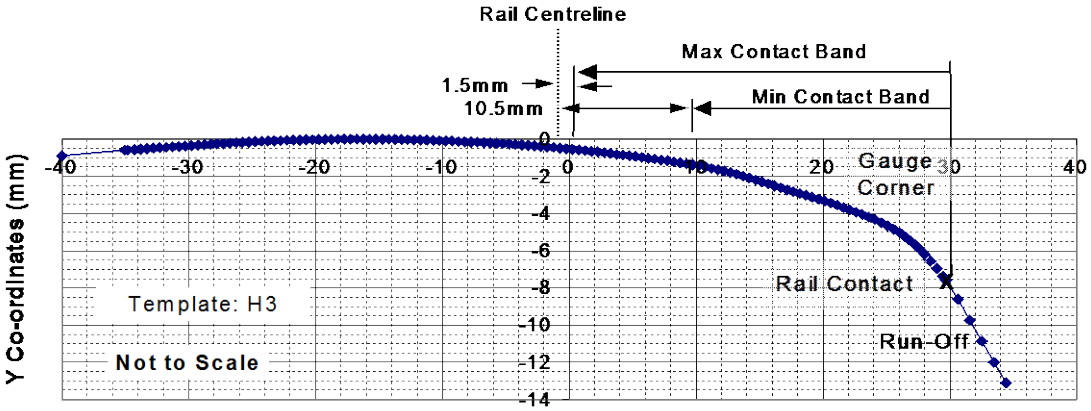
X Coordinates of Contact Band

Min Contact Band	Max Contact Band
-12.7	-17.2
17.3	21.8

X-Y Co-ordinates

X	Y	X	Y	X	Y	X	Y
-39.10	-2.74	-17.72	-0.43	0.40	-0.03	23.79	-2.58
-37.10	-2.38	-16.87	-0.38	1.26	-0.04	24.50	-2.78
-35.15	-2.01	-16.00	-0.33	2.13	-0.06	25.19	-2.99
-33.50	-1.84	-15.14	-0.29	2.99	-0.08	25.88	-3.23
-32.77	-1.76	-14.28	-0.25	3.85	-0.10	26.58	-3.49
-31.54	-1.62	-13.41	-0.21	4.72	-0.13	27.27	-3.78
-30.67	-1.52	-12.54	-0.17	5.58	-0.16	28.04	-4.13
-29.81	-1.42	-11.68	-0.15	6.44	-0.19	28.80	-4.54
-28.95	-1.34	-10.82	-0.12	7.76	-0.25	29.57	-5.01
-28.08	-1.25	-9.95	-0.09	9.08	-0.33	30.33	-5.55
-27.22	-1.16	-9.09	-0.08	10.40	-0.43	31.10	-6.17
-26.35	-1.08	-8.23	-0.05	11.72	-0.55	31.87	-6.87
-25.50	-1.00	-7.37	-0.04	13.03	-0.69	32.64	-7.69
-24.63	-0.92	-6.51	-0.03	14.36	-0.85	33.40	-8.64
-23.77	-0.86	-5.64	-0.02	15.67	-1.02	34.17	-9.78
-22.90	-0.78	-4.77	-0.01	16.99	-1.22	34.94	-11.22
-22.04	-0.71	-3.91	0.00	18.31	-1.44	37.54	-11.23
-21.18	-0.65	-3.05	-0.01	19.63	-1.68	37.59	-16.00
-20.31	-0.59	-2.19	0.00	20.95	-1.94	36.25	-16.00
-19.45	-0.53	-1.33	-0.01	22.27	-2.21	36.25	-20.87
-18.58	-0.47	-0.46	-0.02	23.10	-2.41		

Figure A5: ARTC H3 - Template for high rails in curved track with radii ≤900m exhibiting moderate/severe RCF defects, without lug



X Coordinates of Contact Band

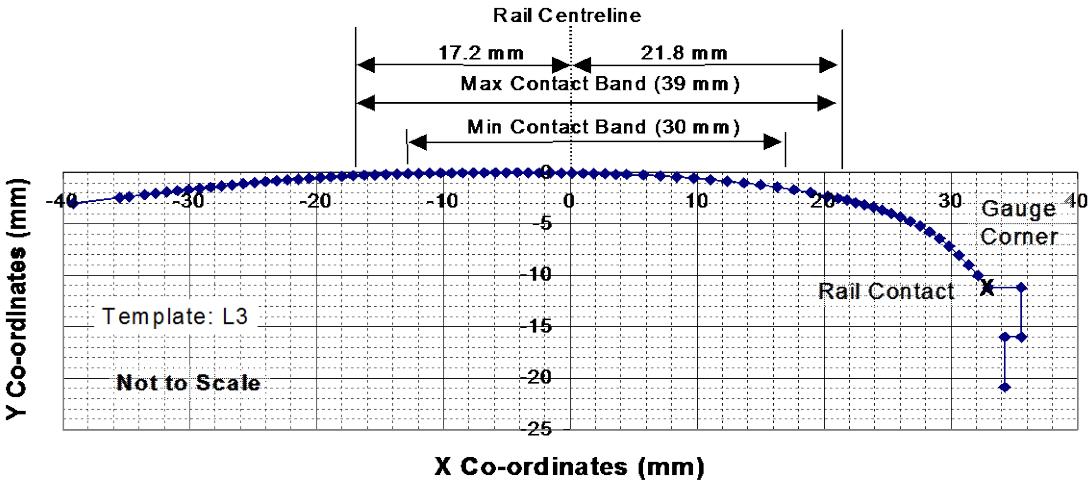
Min Contact Band	Max Contact Band
+ 9.5 to rail contact point on gauge side (at 50°)	+ 1.0 to rail contact point on gauge side (at 50°)

X-Y Co-ordinates

X	Y	X	Y	X	Y	X	Y
-40.00	-0.89	-18.25	-0.01	-0.75	-0.49	16.66	-2.62
-35.05	-0.60	-17.75	0.00	-0.26	-0.52	17.16	-2.72
-34.80	-0.59	-17.25	0.00	0.24	-0.56	17.65	-2.82
-34.30	-0.57	-16.75	0.00	0.74	-0.58	18.15	-2.92
-33.80	-0.54	-16.25	0.00	1.24	-0.62	18.64	-3.02
-33.30	-0.52	-15.75	0.00	1.74	-0.66	19.14	-3.13
-32.79	-0.49	-15.25	0.00	2.24	-0.70	19.63	-3.23
-32.29	-0.47	-14.75	0.00	2.74	-0.73	20.13	-3.34
-31.79	-0.44	-14.25	-0.01	3.24	-0.77	20.62	-3.45
-31.29	-0.42	-13.75	-0.01	3.73	-0.81	21.12	-3.56
-30.79	-0.40	-13.25	-0.02	4.23	-0.86	21.61	-3.68
-30.29	-0.38	-12.75	-0.02	4.73	-0.89	22.11	-3.80
-29.78	-0.35	-12.25	-0.04	5.23	-0.94	22.60	-3.93
-29.28	-0.33	-11.75	-0.04	5.73	-0.98	23.10	-4.05
-28.78	-0.30	-11.25	-0.06	6.23	-1.03	23.59	-4.19
-28.28	-0.28	-10.75	-0.06	6.73	-1.07	24.08	-4.32
-27.78	-0.25	-10.25	-0.08	7.22	-1.12	24.58	-4.49
-27.28	-0.24	-9.75	-0.09	7.72	-1.16	25.07	-4.66
-26.77	-0.21	-9.25	-0.11	8.22	-1.22	25.56	-4.85
-26.27	-0.19	-8.75	-0.12	8.72	-1.26	26.05	-5.03
-25.77	-0.17	-8.25	-0.14	9.22	-1.32	26.54	-5.29
-25.27	-0.16	-7.75	-0.15	9.71	-1.37	27.03	-5.55
-24.77	-0.13	-7.25	-0.17	10.21	-1.42	27.51	-5.86
-24.27	-0.12	-6.75	-0.19	10.71	-1.49	28.00	-6.19
-23.76	-0.10	-6.25	-0.21	11.21	-1.57	28.48	-6.56
-23.26	-0.09	-5.75	-0.23	11.70	-1.65	28.96	-6.95

-22.76	-0.08	-5.25	-0.25	12.20	-1.72	29.44	-7.37
-22.26	-0.07	-4.75	-0.27	12.70	-1.80	29.68	-7.60
-21.76	-0.05	-4.25	-0.30	13.19	-1.89	30.63	-8.61
-21.26	-0.05	-3.75	-0.32	13.69	-1.99	31.57	-9.73
-20.76	-0.03	-3.25	-0.34	14.18	-2.09	32.52	-10.86
-20.26	-0.03	-2.75	-0.37	14.68	-2.19	33.46	-11.99
-19.76	-0.02	-2.25	-0.40	15.18	-2.29	34.41	-13.11
-19.25	-0.02	-1.75	-0.43	15.67	-2.40		
-18.75	-0.01	-1.25	-0.45	16.17	-2.51		

Figure A6: ARTC L3 - Template for low rails in curved track with radii ≤900m requiring additional field/gauge side relief, with lug



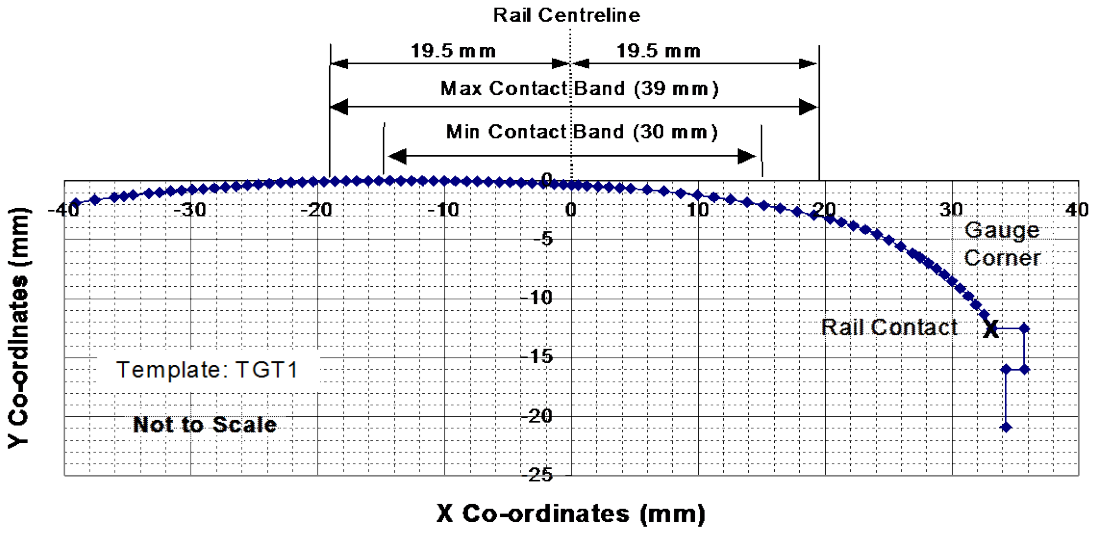
X Coordinates of Contact Band

Min Contact Band	Max Contact Band
-12.7	-17.2
17.3	21.8

X-Y Co-ordinates

X	Y	X	Y	X	Y	X	Y
-39.20	-3.01	-18.87	-0.44	-1.60	-0.03	21.10	-2.51
-35.53	-2.44	-18.00	-0.37	-0.74	-0.04	21.79	-2.68
-34.79	-2.33	-17.14	-0.32	0.14	-0.06	22.49	-2.93
-33.56	-2.16	-16.28	-0.27	1.00	-0.08	23.18	-3.14
-32.69	-2.03	-15.41	-0.22	1.86	-0.10	23.88	-3.38
-31.83	-1.90	-14.54	-0.17	2.73	-0.13	24.58	-3.64
-30.97	-1.79	-13.68	-0.15	3.58	-0.16	25.26	-3.98
-30.10	-1.67	-12.81	-0.12	4.44	-0.19	26.03	-4.33
-29.24	-1.55	-11.95	-0.09	5.76	-0.25	26.79	-4.74
-28.37	-1.44	-11.09	-0.08	7.08	-0.33	27.56	-5.21
-27.51	-1.33	-10.23	-0.05	8.41	-0.43	28.32	-5.80
-26.65	-1.22	-9.37	-0.04	9.72	-0.55	29.09	-6.42
-25.78	-1.13	-8.50	-0.03	11.04	-0.69	29.86	-7.15
-24.91	-0.99	-7.64	-0.02	12.36	-0.85	30.63	-8.03
-24.05	-0.89	-6.77	-0.01	13.67	-1.02	31.39	-9.01
-23.18	-0.81	-5.91	-0.01	15.00	-1.22	32.16	-10.04
-22.32	-0.73	-5.05	-0.01	16.32	-1.44	32.94	-11.22
-21.45	-0.65	-4.19	0.00	17.64	-1.68	35.55	-11.22
-20.59	-0.57	-3.33	-0.01	18.95	-1.94	35.55	-16.00
-19.72	-0.51	-2.46	-0.02	20.27	-2.31	34.25	-16.00
						34.25	-20.87

Figure A7: ARTC TGT1 - Template for tangent track and curves with radii >900m (with lug) requiring additional field/gauge side relief



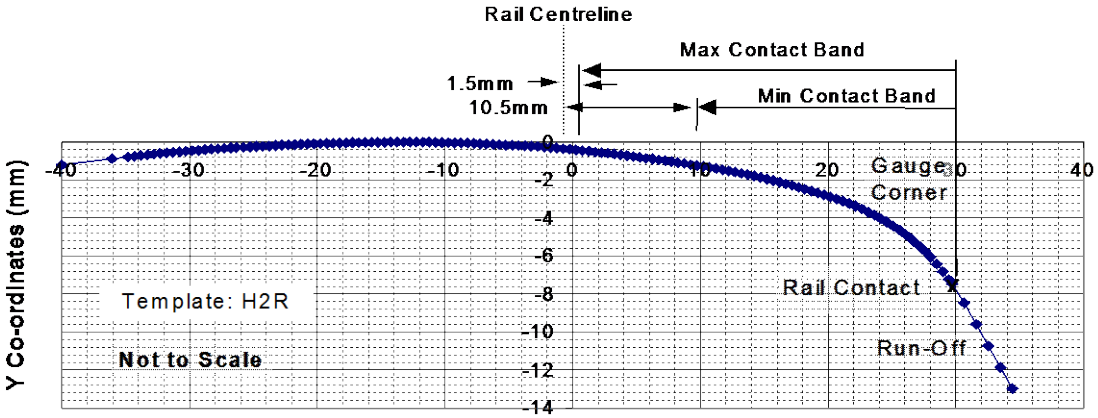
X Coordinates of Contact Band

Min Contact Band	Max Contact Band
+15	+19.5
-15	-19.5

X-Y Co-ordinates

X	Y	X	Y	X	Y	X	Y
-39.12	-1.89	-19.53	-0.07	-1.39	-0.31	21.29	-3.51
-37.61	-1.62	-18.67	-0.06	-0.63	-0.35	22.23	-3.81
-36.06	-1.40	-17.79	-0.04	0.00	-0.38	23.16	-4.15
-35.33	-1.32	-16.93	-0.02	0.54	-0.41	24.09	-4.55
-34.59	-1.23	-16.07	-0.02	1.21	-0.45	25.02	-5.02
-33.37	-1.08	-15.21	-0.01	2.07	-0.50	25.95	-5.56
-32.50	-1.01	-14.35	0.00	2.94	-0.56	26.89	-6.12
-31.64	-0.91	-13.48	-0.01	3.79	-0.62	27.51	-6.53
-30.77	-0.83	-12.62	-0.01	4.66	-0.68	28.14	-6.97
-29.91	-0.78	-11.76	-0.01	5.97	-0.79	28.76	-7.44
-29.04	-0.71	-10.88	-0.02	7.28	-0.91	29.39	-7.97
-28.18	-0.62	-10.02	-0.03	8.60	-1.06	30.01	-8.50
-27.31	-0.56	-9.16	-0.04	9.91	-1.21	30.64	-9.15
-26.45	-0.48	-8.29	-0.07	11.22	-1.40	31.27	-9.78
-25.58	-0.40	-7.43	-0.08	12.53	-1.61	31.89	-10.51
-24.72	-0.33	-6.57	-0.10	13.85	-1.83	32.53	-11.34
-23.85	-0.23	-5.70	-0.13	15.15	-2.08	33.16	-12.53
-22.98	-0.17	-4.84	-0.16	16.46	-2.34	35.70	-12.54
-22.12	-0.15	-3.98	-0.19	17.78	-2.62	35.72	-16.00
-21.25	-0.12	-3.12	-0.22	19.09	-2.92	34.26	-16.00
-20.39	-0.09	-2.25	-0.27	20.40	-3.25	34.26	-20.87

Figure A8: ARTC H2R - Template for high rails in curved track with radii ≤900m requiring additional field side relief



X Coordinates of Contact Band

Min Contact Band	Max Contact Band
+ 9.5 to rail contact point on gauge side (at 50°)	+ 1.0 to rail contact point on gauge side (at 50°)

X-Y Co-ordinates

X	Y	X	Y	X	Y	X	Y
-40.00	-1.20	-18.26	-0.05	-0.75	-0.35	16.68	-2.19
-36.07	-0.87	-17.76	-0.05	-0.25	-0.39	17.18	-2.29
-34.81	-0.79	-17.25	-0.03	0.25	-0.42	17.67	-2.38
-34.31	-0.75	-16.75	-0.03	0.75	-0.45	18.17	-2.48
-33.81	-0.71	-16.25	-0.02	1.25	-0.48	18.66	-2.57
-33.31	-0.68	-15.75	-0.01	1.74	-0.53	19.16	-2.68
-32.80	-0.64	-15.25	-0.01	2.24	-0.56	19.65	-2.78
-32.30	-0.61	-14.75	-0.01	2.74	-0.60	20.15	-2.89
-31.80	-0.57	-14.25	0.00	3.24	-0.63	20.64	-3.00
-31.30	-0.54	-13.75	0.00	3.74	-0.68	21.14	-3.11
-30.80	-0.52	-13.25	0.00	4.24	-0.72	21.63	-3.23
-30.29	-0.49	-12.75	0.00	4.74	-0.76	22.13	-3.37
-29.79	-0.46	-12.25	-0.01	5.23	-0.80	22.62	-3.52
-29.29	-0.44	-11.75	0.00	5.73	-0.85	23.11	-3.68
-28.79	-0.41	-11.25	0.00	6.23	-0.89	23.61	-3.84
-28.29	-0.38	-10.75	-0.02	6.73	-0.94	24.10	-4.03
-27.78	-0.36	-10.25	-0.03	7.23	-0.98	24.59	-4.21
-27.28	-0.33	-9.74	-0.03	7.73	-1.03	25.08	-4.42
-26.78	-0.31	-9.24	-0.03	8.22	-1.08	25.57	-4.63
-26.34	-0.30	-8.74	-0.04	8.72	-1.13	26.06	-4.88
-25.78	-0.28	-8.24	-0.05	9.22	-1.18	26.55	-5.13
-25.28	-0.26	-7.74	-0.07	9.72	-1.24	27.03	-5.42
-24.77	-0.24	-7.24	-0.08	10.22	-1.28	27.52	-5.72
-24.27	-0.22	-6.74	-0.10	10.72	-1.34	28.00	-6.05
-23.77	-0.20	-6.25	-0.12	11.21	-1.40	28.48	-6.42
-23.27	-0.19	-5.75	-0.14	11.71	-1.46	28.96	-6.81

-22.77	-0.16	-5.25	-0.15	12.21	-1.52	29.44	-7.24
-22.27	-0.15	-4.75	-0.17	12.71	-1.59	29.68	-7.46
-21.77	-0.13	-4.25	-0.18	13.20	-1.65	30.63	-8.47
-21.26	-0.11	-3.75	-0.20	13.70	-1.72	31.58	-9.60
-20.76	-0.10	-3.25	-0.22	14.20	-1.79	32.52	-10.73
-20.26	-0.09	-2.75	-0.23	14.69	-1.87	33.47	-11.85
-19.76	-0.08	-2.25	-0.27	15.19	-1.95	34.41	-12.97
-19.26	-0.06	-1.75	-0.29	15.69	-2.02		
-18.76	-0.06	-1.25	-0.32	16.18	-2.11		