Rail Replacement Guideline

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Applicability

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1.0	07 Mar 19		First issue of guideline

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1 Introduction

1.1 Purpose

The purpose of this guideline is to support consistency across rail replacement (rerail) projects by providing a baseline, or minimum requirements checklist, in preparation of any Inspection Test Plans (ITP) or Risk Assessment tasks. The document is not aimed at fully guiding the initial decision to use various rail sizes, new or used, with that action an Asset Strategy decision driven by cost factors not covered herein.

This guideline aims to ensure that multiple ARTC standards requirements are met simultaneously. It acts as information to assist in the project planning. Additional instruction is required due to the complexity of existing combinations of rail sizes on either leg/side of the track, added to the many factors that influence superelevation and track clearances.

1.2 Scope

The guideline focusses on the track geometry and clearance implications arising from rerail works, many other factors such as Track Stability, Welding, Structures and fixed points interfaces are not yet covered in detail here. Later versions may incorporate additional guidance on these topics however the normal processes of project management will refer to the relevant standards for guidance as required.

1.3 Document Owner

The Manager Standards is the document owner and is the initial point of contact for all queries relating to this guideline.

1.4 Relevant Procedure

This guideline supports numerous track and civil procedures relating to rail and track geometry. It is not subordinate to any single document and aims to establish relationships between multiple track management principles.

1.5 Responsibilities

The rerailing project manager is responsible for managing the process.

1.6 Reference Documents

The following documents support this procedure:

- Track and Civil Standard Section 7 Clearances
- Route Access Standard (RAS) General Information, Section 5 Rolling Stock Outlines
- ETM-07-01 Management of Clearances
- Track and Civil Standard Section 5 Track Geometry
- ETF-05-01 Track Geometry Standards for Construction, Upgrading and Maintenance Works
- PP-135 Mechanised Track Surfacing
- Track and Civil Standard Section 1 Rail
- EGP-20-02 Inspection and Test Plans

1.7 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
ARTC	Australian Rail Track Corporation Ltd.
Superelevation and cross-level	Noting that the term “superelevation’ is sometimes interchangeable with ‘cross level’ in various documents. Cross level applies to all track situations, tangent and curved, as a defined measurement (the difference in mm between the height of the two rails in relation to absolute level): whereas superelevation is more appropriate to describe the cross level *applied* to curves by canting, in order to achieve balanced rolling stock forces and acceptable track forces at designated track speeds
TP	Tangent Point of the curve at which tangent track begins
TRS	Transition Point of a curve where the transition length meets the arc of the curve
ITP	Inspection Test Plan
TSR	Temporary Speed Restriction

2 Background: Summary of Track Geometry Consideration

When replacing major sections of curved track (typically >200m) with new or used rail there is very likely a difference in rail height between the existing worn rail and the new rail being installed. This rail height difference will translate to a change in the track superelevation when the following cases occur;

- Common rail size both sides but differential wear, typically small differences <10mm.
- Existing rails different sizes e.g. 47kg/m low leg and 60kg/m high leg, typically 10-20mm differences.

The following track conditions should be reviewed prior to rail replacement to ensure a perceived minor height change will not combine with other factors to create a clearance infringing risk;

- Actual superelevation (not just the design, but the current measured data).
    - Data can be sourced from the most recent AK car run or any recent survey works.
    - If no automated data is available, then manual measurement of the track superelevation is required prior to rerailing being undertaken, with enough time to calculate and plan accordingly.
- Short and long twist conditions, any pre-existing defects from the Asset Management System (AMS).
- Known clearance infringement issue with adjacent tracks and structures; overbridges, tunnels, signals etc.
    - These may be sourced from track design detail, manually gathered or detailed (Trimble trolley etc).
    - Pre-existing defects from the AMS.
- Finally, any other local area knowledge on issues that may add value to decisions around super-elevation and clearance topics.

Guidance on the unique clearance management required for any given track can be sourced from Track and Civil Standard Section 7 Clearances, combined with rolling stock information available in the Route Access Standard (RAS) General Information, Section 5 Rolling Stock Outlines.

- Special consideration should be made to any dual gauge tracks and ensure that all following guidance considers the dual gauge (broad or narrow) factors in terms of clearances.

3 Planning Steps for Rail Replacement Project Works

It is assumed here that an assessment, typically economic and/or risk based, has already decided the site under consideration is to proceed with rail replacement of either one leg or both legs. However, as guidance on the topic some points are noted below to ensure the cost-driven factors are not left too late in the planning process;

- Resurfacing machines (Tampers). If tamping is required, the following should be considered:
    - The practical ability of the machines available to do the resurfacing and meet Track Geometry standards.
    - Availability and timing coordination of machines for post rail replacement before running trains.

- Alternatives for use of speed restrictions until any geometry and/or clearance exceedances can be rectified. The implications to train operations at each unique site should be considered.

- Review of the F-Sheet or Curve & Gradient data to ensure the details used in planning are correct for issuing to rerail staff. If any major doubts are raised, then a full track survey may be required.

Once a validated decision has been made that replacement of rail (new or used, and of any given size) is viable at the required locations, the following steps are recommended. The steps here are predominantly for curved track, where tangent rerailing occurs simply skip the curve-only requirements;

3.1 Phase 1 Pre-Rerail Planning

The following steps are the minimum planning required to ensure all effects of the rerailing task on existing track have been assessed. Additional information on rail heights and acceptable runout rates for tamping are included in Appendix A.

At the location chosen for rail replacement;

3.1.1 For Single Track:

a. locate and check existing Tangent Point (TP) / Transition Point (TRS) permanent survey markings.

b. Walk out & measure length of the rerailing section from TP to TP.

c. Measure the actual track superelevation at intervals (2m curve/ 10m tangents) within the rerail and geometry runout work zones each end of the curve. Runout lengths should be checked at 2m intervals in all cases to ensure excessive twist has not been created. Validated AK data may be an alternative method here.

d. Determine if junction closures (to accommodate rail height steps) will be required in the runout lengths, ensuring that welds meet all requirements in standards for maximum allowable steps at the foot, and stepped welds kits are used if required.

e. Assess the overall track condition, focusing on sleeper voids and foul formation / ballast to avoid rail deflection.

f. Confirm the horizontal clearance management status of the site, ensuring any existing infringement controls are always considered in the rerail work plans.

g. Assess the site for vertical clearance issues; over-bridges, signals, tunnels etc (even without any super elevation changes, rerail of both legs may raise track by 30mm if fully worn 47kg is replaced by new 60kg/m rails).

h. Capture details and record into a format suitable to calculate new track geometry required for tamping calculations.

3.1.2 For Double Track:

a. locate and check existing TP and TRS permanent survey markings.

b. Walk out & measure length of the rerailing section from TP to TP.

c. Measure track centres.

d. For both tracks:
   - Measure the actual track superelevation at intervals (2m curve/ 10m tangents) within the rerail and geometry runout work zones each end of the curve. Runout lengths should be checked at 2m intervals in all cases to ensure excessive twist has not been created. Validated AK data may be an alternative method here.
   - Assess the overall track condition, focusing on sleeper voids and foul formation / ballast to avoid rail deflection.
   - Confirm the horizontal clearance management status of the site, ensuring any existing infringement controls are always considered in the rerail work plans.
   - Assess the site for vertical clearance issues; over-bridges, signals, tunnels etc (even without any super elevation changes, rerail of both legs may raise track by 30mm if fully worn 47kg is replaced by new 60kg/m rails).

e. Determine if junction closures (to accommodate rail height steps) will be required in the runout lengths, ensuring that welds meet all requirements in standards for maximum allowable steps at the foot, and stepped welds kits are used if required.

f. Capture details and record into a format suitable to calculate new track geometry required for tamping calculations.

g. Noting here that double track issues may require tamping on both tracks to remove any pre-existing clearance infringement that could be made unacceptable when the rerailed track is completed.

3.1.3 Final Calculations:

To summarise the rerail pre-works planning above; Create a spreadsheet to calculate the following as a minimum:

- All track geometry and rail height details as measured at the site prior to rerail (2/10m gathered interval data, from the ends of all runouts)
- Calculated results showing: the differences between the existing pre-rerail data collected in the step above, and the desired end plans. i.e. the mm gaps between the actuals and the planned end results, at each interval point.
- Geometry Standards details and relevant limits: During all calculations the relevant defect limits utilised from standards should be recorded in the sheet and referring to the standards they were derived from.
- Summarise the details for site management using TSR's before & after rerailing (TSR's if needed: Where defects have been found during measurements and/or are to be temporarily left in track during works stages)

3.2 Phase 2 Post Rerail Requirements

Following completion of the rerail works a range of track geometry factors will need to be incorporated into the final ITP component of the project. These factors are outlined predominantly in Section 5 Track Geometry however any relevant standards documents should be reviewed prior to each project commencement to ensure changes have not occurred, and/or new standards have been implemented since previous works.

The high-level steps involved for restoration of track geometry after rerailing are outlined below. The completed project goal to aim for is based on;

- Acceptable cost and risk solutions in line with the project plans
- Acceptable minimisation of customer train delays
- At all times the track is fit for purpose and meets the Clearance Standards with controls applied where any infringements have been identified
- Consideration shall be made to the effects of any temporary superelevation on passenger ride comfort at the speeds in use
- The final track quality meets the project target levels as determined, and all ITP data recorded is managed according to EGP-20-02 Inspection and Test Plans
- At all times the track is fit for purpose and meets the Track Geometry standards, with defects raised and response actions followed if required. A summary of the cross-level defect levels is given below in Table 1

Table 1: Cross Level Variation from Design

	Track Geometry Configuration & Responses			
	Tangent Track >2000m radius	**Curved track < 2000m radius**		
Cross level - Variation (mm) (Actual superelevation - Design superelevation)		**Excess superelevation +ve (mm)**	**Insufficient superelevation -ve (mm) and Additional TSR Response**	
> 75	E1	E1	E1	
51-75	P2	P1	E2	TSR 40kph below design
41-50	P2	P2	E2	TSR 30kph below design
15-40	-	P2	P1	TSR 20kph below design
<15	-	-	-	No action required
Absolute Superelevation				
> 170mm	E1			
160 - 170mm	The Track Geometry Car will record this as a P3 defect. However, no response action is required but this should be an indication the limits are approaching emergency response levels.			

Notes: *To determine the cross-level variation, knowledge of the design cross level is required. Some track recording cars may not be able to determine this parameter and alternative methods such as manual onsite assessment may be required.*

Source: *Track & Civil Code of Practice Track Geometry, Section 5, Table 5-11 and notes.*

3.2.1 Tamping Guidelines

If the rerail project has determined that tamping is required either due to rail height differences with new rails and/or existing track deficiencies, the following guidance is given:

- The current Standard for application in NSW; ETF-05-01 Track Geometry Standards for Construction, Upgrading and Maintenance Works, does not mandate the completed tolerances for rerailing tasks. Section 4 Track Maintenance 4.1 allows the completed standard to be determined anywhere within acceptable ranges not exceeding any defects limits.
- PP-135 Mechanised Track Surfacing takes precedence for the completed works target tolerances. Specifically, in section 4 Track Geometry Tolerances 4.1 General Track geometry, aiming to achieve the Maintenance Tolerance Values designated.
- In the event of the rerailing and initial tamping being unable to achieve the required geometry finished tolerances, a plan must be created to capture the task of final production tamping to full project goals.
- Production tamping to install the design superelevation is recommended to occur within 90 days of rerail on most track segments (degradation factors such as MGT, TAL, speeds and grades should be considered). Without correct superelevation the low legs of curves will suffer accelerated failure modes.

Specific tamping guidance for the 3 main cases of post rerailing on curves is given below:

3.2.1.1 Curve: Both Legs Being Rerailed

Where both legs are being replaced with new rails (or recycled rails) of the same nominal size and height the existing track geometry will typically not be changed apart from any existing differential wear at each curve. As described earlier in Phase 1 the full track measurements should still be taken and any defects or degraded geometry and clearance issues should be assessed in terms of how the rail heights will improve or degrade the conditions.

a. For track effectively meeting the Maintenance tolerances for tamping prior to rerail, and no major wear differences exist between high and low legs of the rail removed, the choice of post rerail tamping generally becomes optional depending on project goals.

b. If the geometry is found to be outside the project goal tolerances, production tamping of the whole curve should be planned as per the guidance listed in Tamping Guidelines above (repeated here)

    - In the event of the rerailing and initial manual tamping being unable to achieve the required geometry finished tolerances, a plan must be created to capture the task of final production tamping to full project goals. The locations where such tamping has been undertaken, but not achieved the required geometry, are to be recorded for tracking to closeout once final production tamping has been completed.
    - Production tamping to install the design superelevation is recommended to occur within 90 days of rerail on most track segments (degradation factors such as MGT, TAL, speeds and grades should be considered). Without correct superelevation the low legs of curves will suffer accelerated failure modes.
    - Exceedances of Section 5 Track geometry standards found in the rerail work zone must have the mandated response and actions followed during the period prior to the next train, and until production tamping has been completed. Noting that Superelevation excess does not require any speed restrictions until it reaches >75mm above the design or it reaches 170mm absolute, both of which require E1 responses in current standards.

- Clearance issues that may have changed due to the new rail (height and gauge) and/or the tamping requirements of the site to reinstate geometry, must follow all aspects of Section 7 Clearances and ETM-07-01 Management of Clearances.
- At all times following completion of each work stage, the track shall be certified as safe for traffic by a person competent in track certification for the works performed and conditions specified in points above.

3.2.1.2 Curve: Single Leg Rerailed on High Leg Only

This applies to where only the high leg of a curve is being rerailed, and the new rail height is significantly different (nominally >5mm) than the worn rail being removed. In this situation the Phase 1 Pre-rerail planning steps above will have measured the tamping requirements to meet full project goal tolerances, however the runout from the curve tangent points will require a temporary method to maintain a track fit for purpose until the production tamping occurs. In this case production tamping of the full curve is highly likely to be required in all cases, to return track to correct design superelevation.

Again, it is highly likely that the high leg rerail will result in a Superelevation excess in the range of 10-30mm above the existing levels on the whole curve. However, this may or may not be an issue depending on where the pre-rerail superelevation was relative to design. There are two methods for temporary tamping this situation, either can be used:

a. **Tamp the high leg only (preferred):** If there is a need to lift the linear adjacent rail height at the tangent point (either tangent or reverse curve) and create an acceptable temporary runout length. In practical terms this creates a temporary extension of the superelevation beyond the normal tangent point;

    1. The length and ramp rate of the high leg runout must conform to PP-135 Mechanised Track Surfacing, section 3.5 Run-in/Run-out.
    2. There must not be any effect on the horizontal tangent point or existing alignment, all adjustments are purely vertical at the tangent point.
    3. The runout will require a single head tamper to allow lift on high leg only.
    4. The potential for twist defects is raised in the transition of the low leg, and manual measurements must check there are no defects defined in Section 5 Track Geometry present.
    5. Any fixed points present in the runout zone and/or within the rerail length itself are to be handled as per PP-135 Mechanised Track Surfacing, section 6 Special Situations (Structures, Turnouts, restricted clearance).

b. **Tamp both legs:** The tangent track adjacent to the rerailed high leg can be tamped to give zero superelevation at the tangent point. This will require;

    1. Lift and tamp the high leg as per steps above in a.
    2. Then lift the low leg at the tangent point and ramping out that lift in both directions.
    3. The length and ramp rate of the runouts into the tangent must conform to PP-135 Mechanised Track Surfacing, section 3.5 Run-in/Run-out.
    4. The low leg tangent point which has been lifted will require runout back into the curve transition. This runout into the curve must be at least to the TRS and conform to PP-135 Mechanised Track Surfacing, section 3.5 Run-in/Run-out.

5. There must not be any effect on the horizontal tangent point or existing alignment, all adjustments are purely vertical at the tangent point.
6. The potential for twist defects is raised in the transition of the low leg, and manual measurements must check there are no defects as defined in Section 5 Track Geometry present.
7. Any fixed points present in the runout zone and/or within the rerail length itself are to be handled as per PP-135 Mechanised Track Surfacing, section 6 Special Situations (Structures, Turnouts, restricted clearance).

Following any temporary tamping (or where no tamping was undertaken); If the geometry is found to be outside the project goal tolerances, production tamping of the whole curve should be planned as per the guidance listed in Tamping Guidelines above (repeated here);

- In the event of the rerailing and initial tamping being unable to achieve the required geometry finished tolerances, a plan must be created to capture the task of final production tamping to full project goals. The locations where such tamping has been undertaken, but not achieved the required geometry, are to be recorded for tracking to closeout once final production tamping has been completed.
- Production tamping to install the design superelevation is recommended to occur within 90 days of rerail on most track segments (degradation factors such as MGT, TAL, speeds and grades should be considered). Without correct superelevation the low legs of curves will suffer accelerated failure modes.
- Exceedances of Section 5 Track geometry standards found in the rerail work zone must have the mandated response and actions followed during the period prior to the next train, and until production tamping has been completed. Noting that Superelevation excess does not require any speed restriction actions until it reaches >75mm above the design or it reaches 170mm absolute, both of which require E1 responses in current standards.
- Clearance issues that may have changed due to the new rail (height and gauge) and/or the tamping requirements of the site to reinstate geometry, must follow all aspects of Section 7 Clearances and ETM-07-01 Management of Clearances.
- At all times following completion of each work stage, the track shall be certified as safe for traffic by a person competent in track certification for the works performed and conditions specified in the points above.

3.2.1.3 Curve: Single Leg Rerailed on Low Leg Only

Where only the low leg of a curve is being rerailed, and the new rail height is significantly different (nominally >5mm) than the worn rail being removed: In this situation the Phase 1 Pre-rerail planning steps above will have measured the tamping required to meet full project goal tolerances, however the runout from the curve tangent points will require a temporary method to maintain a track fit for purpose until the production tamping occurs.

Also, in this case the superelevation changes due to new low leg rail height are likely reversed (unless using old worn 53kg/m rail) giving a higher potential for an insufficient superelevation exceedance to occur, with defect(s) action response required. Priority/timing for production tamping of this case will be higher than the single high leg case simply because the risk of Temporary Speed response is much greater for insufficient superelevation, and unplanned delays may occur.

Where the low leg is rerailed alone, production tamping of the full curve is highly likely to be compulsory in all cases, to return track to correct design superelevation. Again, it is highly likely that the low leg rerail will result in insufficient superelevation in the range of 10-30mm below the existing levels on the whole curve. However, this may or may not be an issue depending on where the pre-rerail superelevation was relative to design.

Tamp the low leg only (preferred): If there is a need to lift the rail height up to the tangent point on the low leg (from within either adjacent tangent or reverse curve) and create an acceptable temporary runout length, in practical terms this creates a temporary extension of the superelevation beyond the existing tangent point on the low leg;

1. The length and ramp rate of the high leg runout must conform to PP-135 Mechanised Track Surfacing, section 3.5 Run-in/Run-out.
2. There must not be any effect on the horizontal tangent point or existing alignment, all adjustments are purely vertical at the tangent point.
3. The runout will require a single head tamper to allow lift on high leg only.
4. The potential for twist defects is raised in the transition of the low leg, and manual measurements must check there are no defects defined in Section 5 Track Geometry present.
5. Any fixed points present in the runout zone and/or within the rerail length itself are to be handled as per PP-135 Mechanised Track Surfacing, section 6 Special Situations (Structures, Turnouts, restricted clearance).

Following any temporary tamping (or where no tamping was undertaken); If the geometry is found to be outside the project goal tolerances, production tamping of the whole curve should be planned as per the guidance listed in Tamping Guidelines above (repeated here);

- In the event of the rerailing and initial tamping being unable to achieve the required geometry finished tolerances, a plan must be created to capture the task of final production tamping to full project goals. The locations where such tamping has been undertaken, but not achieved the required geometry, are to be recorded for tracking to closeout once final production tamping has been completed.
- Production tamping to install the design superelevation is recommended to occur within 90 days of rerail on most track segments (degradation factors such as MGT, TAL, speeds and grades should be considered). Without correct superelevation the low legs of curves will suffer accelerated failure modes.
- Exceedances of Section 5 Track geometry standards found in the rerail work zone must have the mandated response and actions followed during the period prior to the next train, and until production tamping has been completed. Noting that Superelevation excess does not require any speed restriction actions until it reaches >75mm above the design or it reaches 170mm absolute, both of which require E1 responses in current standards.
- Clearance issues that may have changed due to the new rail (height and gauge) and/or the tamping requirements of the site to reinstate geometry, must follow all aspects of Section 7 Clearances and ETM-07-01 Management of Clearances.
- At all times following completion of each work stage, the track shall be certified as safe for traffic by a person competent in track certification for the works performed and conditions specified in the points above.

4 Summary of Track Stability Considerations

All decisions and plans around the track stability and managing the stress-free temperature of the rail must follow Section 6: Track Lateral Stability, and consideration of any local Track Stability Management Plans at the rerail site is essential. This guideline does not provide any additional instruction on how to manage the Stress-Free Temperature (SFT) during the rerailing process. All normal practises are to be followed, in particular;

- Normal practise is to make stress adjustments immediately after the rail is replaced.
- Ensuring any work occurring at the rerail stage, including manual tamping of transitions, has not significantly changed the track alignment. If the tamping has adjusted the track alignment the final correct stressing must be achieved after that tamping occurs.
- If no production tamping is planned following rerail (geometry is acceptable), the management of the rail SFT at the site is still managed in accordance with all relevant standards for track stability.
- Where single legs have been re-railed it is advisable to check the SFT in the transitions of the curve on the leg not replaced. Although the opposite leg may not have been disturbed during works, the track stability management of the site will be simplified if both legs are confirmed at correct SFT.

5 Track Certification

At each stage where the track is open to traffic following the completion of rerail or tamping of the track, the track shall be certified by a competent worker as safe for operations during the period before the following stage of work.

At the completion of the total project all track shall be certified by a competent worker.

5.1 Appendix A

Rail Height Difference and Minimum Runout Transition Lengths

The tables below show the extremes of all rail sizes from new height to fully worn worst-case re-rail limits. All rerail sites will fall somewhere within these ranges, and this height change value will determine the effective change to superelevation at various points around the curve or tangent.

Noting that the critical height difference, to enable a runout calculation, is found at the transition point, and to ensure correct superelevation around full curves will require measurements (rail height and existing superelevation) defined at intervals of 2m.

Table 1: Difference in New Rail Heights (zero wear both rails)

		Existing Rail Size (zero wear)			
		47kg/m	50kg/m	53kg/m	60kg/m
New Rail Size (kg/m)	New Rail Height (mm)	141.3	154	157.1	170
47	141.3	0	-12.7	-15.8	-28.7
50	154	12.7	0	-3.1	-16
53	157.1	15.8	3.1	0	-12.9
60	170	28.7	16	12.9	0

Source: Track & Civil Code of Practice, Rail, Section 1, Table 1.4 and notes, Rail Section Drawing D81/108.

Table 2: Difference in Single Rail Worn Height (one rail fully worn to limits)

		Fully Worn Existing Rail Size (mm)			
		47kg/m	50kg/m	53kg/m	60kg/m
New Rail Size (kg/m)	Height (mm)	128.3	136	139.1	146
47	141.3	13	5.3	2.2	-4.7
50	154	25.7	18	14.9	8
53	157.1	28.8	21.1	18	11.1
60	170	41.7	34	30.9	24

Source: Track & Civil Code of Practice, Rail, Section 1, Table 1.2A, Table 1.4 and notes.

Notes: Shading = rail foot size change 127mm / 146mm

+ve = Increase in rail height (requires a transition runout)

-ve = Decrease in rail height

Table 3: Runout Length

	Runout Transition Length minimum (m)		
	Temporary	Permanent	Response
Rail Height Difference X (mm)	1 in 400	1 in 1000	
0	0	0	For all runout lengths, tamp track, box up and ballast regulate. Apply Temporary Speed Restrictions as required, consider: - track geometry condition criteria (twist, top, line) - rail fastening condition - ballast profile - track settlement period and track lateral stability requirements (and local TSMP restrictions) - track & structure clearances - other track conditions due to disturbed track
5	2	5	
10	4	10	
15	6	15	
20	8	20	
25	10	25	
30	12	30	
35	14	35	
40	16	40	
45	18	45	
50	20	50	
X = 50+	X*400/1000	X*1000/1000	

Notes: *Run-in / Run-0ut - Temporary run-outs must be no steeper than 1:400 (approximately 10 mm over 7 sleepers), with train speed restricted appropriately. Permanent run-outs must be no steeper than 1:1000 (approximately 10 mm over 16 sleepers). Run-outs should be kept 20 m clear of fixed points, such as bridges, turnouts or level crossings.*

Source: *PP-135 Mechanised Track Surfacing, ARTC Network Wide*