AUSTRALIAN RAIL TRACK CORPORATION LTD

Discipline: Engineering (Track and Civil) **Category: Procedure**

Mechanised Track Surfacing

PP-135

Applicability

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

Document Status

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1.0	21 Nov 08	Standards & Systems	Corridor staff, Alliance Partners	Chief Operating Officer	Risk & Safety Committee 10/12/2008

Amendment Record

Version	Date Reviewed	Clause	Description of Amendment
1.0	21 Nov 08		New procedure for ARTC owned and operated surfacing plant

Document Distribution List

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Contents

1 Introduction

1.1 Purpose

The purpose of this document is to specify procedures for mechanised track surfacing of plain line track, and for turnouts.

This procedure is primarily for ARTC owned and operated surfacing plant. It may be used by contractors (Alliance Partners and others) throughout ARTC however this is to be at the discretion of the ARTC Alliance/Project Manager involved.

1.2 Scope

This document provides technical and operational procedures for mechanised track surfacing, including:

- Planning and carrying out surfacing;
- Additional requirements for special situations;
- Description of surfacing machines; and
- Operation of surfacing machines.

The procedures are applicable to ballast tampers capable of continuously levelling, lining and tamping track, ballast regulators, and ballast stabilisers.

ARTC staff involved in planning and executing mechanised track surfacing are affected by this procedure. This procedure may be specified for contract tamping but normally contract tamping is to a performance specification.

1.3 Procedure Owner

The Manager Standards is the Procedure Owner and is the initial point of contact for all queries relating to this procedure.

1.4 Responsibilities

ARTC Delivery Managers and Project Managers are responsible for implementing this procedure.

1.5 Reference Documents

The following documents are referenced in this procedure:

- RAP 5135 Inspection of Track Clearances - Procedure
- RAP 5140 Inspection and Maintenance of Rail Lubricators – Procedure
- TCS 10 Steel Sleepers – Usage and Installation Standards
- TEP 10 Track Examination: Examination Track & Structural Clearances
- TMP 14 Maintenance of Welded Track (Summer Period)
- TCS 01 Track standards Construction
- TCS 02 Upgraded Track Standards – Main Line
- TS 3105 Track Geometry Maintenance Standards (RIC)
- ETG–05–01 General Appendix to ARTC Track & Civil Code of Practice – Track Geometry

1.6 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
Alignment/Line	A setting in a true line of a number of points e.g. successive lengths of track.
Automatic curve lining	Tamper equipment which allows curves to be better automatically aligned based on computer programs.
Basic lift	The nominal uniform lift applied during face tamping, not taking into account corrections needed to smooth out variations in top
Ballast Regulator	A machine for distributing and profiling ballast
Ballast Stabiliser/Compactor	A machine for improving track stability by consolidating the ballast
Calibration	Comparison of measurements shown on the measuring device in question, by checking it against a known item/measurement
Capping layer	Well graded, compacted granular material which is placed over the top of embankment or formation material. Ballast normally is placed on top of the capping layer.
Centre Bound Sleepers	Sleepers packed and supported in the centre, or ballast consolidated so it is supported in the centre.
Cold weather	Defined as the air temperature below which the rail temperature is below Stress Free Temp (usually 38 degrees)
Cross Level	The difference in level of the two rails in track
Curve shift	After curve liner on tamper does first run it calculates ideal configuration and laterally "shifts" the track to ideal location.
Face tamping	Tamping of significant continuous lengths of track to improve overall track geometry, as compared to spot tamping, which is over short lengths.
GPS	Global positioning system – a method of measuring location
Hot weather	Defined as the air temperature above which the rail temperature is above Stress Free Temp (usually 38 degrees)
Design lining	The process of lining, when track is shifted to a design alignment
Interspersed sleepers	A combination of different sleeper types (timber, concrete, and/or steel) in a random or regular pattern
Levelling	The process of raising track to its correct level and cross-level
Lift	The dimension by which track is raised during tamping
Lining	The process of shifting track onto its correct alignment, or of smoothing existing alignment
Long Slack	Vertical misalignment longer than the reference length of a surfacing machine i.e. a dip in the track over a long distance.
Long Swing	Horizontal misalignment longer than the reference length of a surfacing machine.
Limited monuments	Track where some monuments are missing
Rail stress	Force per unit in rail. May be in compressions (more likely when hot) or tension (more likely when cool) See also Stress Free Temperature.
Monument	Fixed marker adjacent to track for which vertical or horizontal alignment can be measured. Often a concreted post or a star dropped.
Run-in/Run-out	A progressive change in track level leading into or out of an area which has been lifted during tamping
Passive level and active crossings	Passive level crossings are only protected by signs such as give way and stop signs. Active crossings have one or more of - lights, boom

Term or acronym	Description
	gates, audible warning devices or lit signs.
Setting	Adjusting controls on a machine, such as a tamper, regulator or stabilizer, so that they complete regular actions to a required dimension or as specified.
Shift	The amount by which track is moved laterally during lining
Smoothing	The process of lining, when track is shifted to an improved alignment but not to a design alignment
Spot tamping	Tamping of short lengths of track to remove specific defects
Stress Free Temperature (SFT)	Temperature at which there are no temperature induced longitudinal stresses in the rail
Surfacing	The combined process of levelling, lining and tamping track – also known as resurfacing
Surfacing machine combinations	Broadly a tamper, regulator, or stabiliser. Strictly speaking only a tamper lifts and lines track i.e. completes actual "surfacing"
Superelevation/Cant - track Rail Cant	Track cant or superelevation is the difference in level of the two adjacent rails usually in curved track Rail cant is the inclination of the base of the rail relative to the sleeper base.
Tamper	A machine for tamping ballast (larger machines are also capable of levelling and lining track)
Tamping	The working and compressing of ballast into the voids beneath sleepers
Top	Vertical alignment of rails, which is usually, measured using the offset at a defined point along a chord of defined length.
Twist	The variation in actual track cross-level between two locations separated by a nominated distance interval along the track.
Track Geometry	The horizontal and vertical alignment, cross-level and cant of the track.
Turnout	Complete set of points and crossing from end of stock rail to end of crossing wing rail

2 Planning and Preparation

2.1 Planning

In developing surfacing programmes, candidate sites should be assessed for priority, and for the extent of work required at each. Assessment should include, as applicable, use of track geometry recording reports, train driver reports of rough riding, and track inspectors' observations of areas of deterioration.

In planning, consideration should also be given to the available budget allocations, and the capabilities and/or limitations of the equipment to be used. Equipment aspects include the tamping machine type, ballast regulator type, and the possible use of a ballast stabiliser.

The overall programme should aim to maximise the intervals between face surfacing, balanced against minimising the amount of between-cycle spot tamping and/or speed restrictions. On timber sleepered track, surfacing should be co-ordinated with sleeper renewal cycles.

Where appropriate, smaller machines (e.g. excavators fitted with tamping heads) may be used for spot tamping.

2.2 Preparation

As part of the detailed preparation for surfacing operations at a particular worksite, the following aspects should be assessed:

1) Extent of work – start and finish kilometerages, face tamping or spot tamping.
2) Access – particularly road condition for support vehicles.
3) Stabling sidings – location, availability, condition, and utilisation plan to minimise travelling time.
4) Safeworking requirements and crew qualifications, including local route knowledge.
5) Adequacy of drainage (to prevent ballast fouling).
6) Condition of sleepers and fastenings – refer section 2.3.
7) Face or cyclic tamping.
8) Proposed lifts – refer section 2.4.
9) Alignment control, having regard to the type of machine to be used and the availability of alignment reference monuments – refer sections 2.5 and 5.
10) Run in and out – refer section 3.5
11) Adequacy of ballast – refer section 2.6.
12) Depth of ballast on bridges – refer section 3.2.
13) Requirements for setting out – refer section 2.7.
14) Marking or removal of obstructions – refer section 2.8.
15) Limitations on surfacing at restricted clearance locations – refer section 6.2.
16) Notification of road closures (where level crossing panels are to be temporarily removed).
17) Co-ordination – refer section 2.9.
18) Requirements for Quality Assurance – refer section 7.3
19) Optimising windows e.g. try and get longer possessions where travel is lengthy. Tamp close to siding when windows are short.

Clear instructions for the tamping crew should be prepared, defining all relevant aspects of the work to be performed.

2.3 Sleepers and Fastenings

Sleepers must be in satisfactory condition and fastenings secure, so that when the rail is raised during tamping, sleepers remain attached. Defective sleepers and/or fastenings should be replaced or cross-bored before tamping.

Where sleeper or fastening condition is poor, consideration should be given to lifting from under the sleepers, rather than using rail clamps. This can prevent poorer sleepers falling off.

If sleepers need to be replaced after tamping, or lifted and refastened, the quality of the finished work will be degraded.

Timber sleepers must have at least 300 mm of sound wood beyond the rail foot if they are to be tamped effectively.

2.4 Proposed Lift

A preliminary assessment of the proposed basic lift should be made, taking into account the following aspects:

1) The surfacing requirement (i.e. spot or face tamping);
2) Track geometry recording charts;
3) The minimum permissible lift (refer section 3.1);
4) Locations and levels of fixed structures, such as road crossings, bridges and turnouts;
5) Vertical clearances to structures above the rail (e.g. road overbridges);
6) Rail height in relation to passenger platforms;
7) Formation condition and width; and
8) Ballast condition and available quantities.

Further guidelines are given in section 3.4.

2.5 Alignment Control

Refer section 4 for details of methods of alignment control on curves.

As part of job preparation (refer section 2.2), existing tangent points or cant values marked or monumented on site should be compared against the curve register, and any discrepancies resolved.

If required curve shifts are significant, consideration should be given to whether rail de-stressing will be required, and to any effects on clearances (particularly between track centres on multiple tracks, and to structures at minimum clearance) – refer sections 5.7 and 6.2.

In difficult situations (e.g. turnouts badly out of alignment or level), survey and redesign may be warranted.

2.6 Ballast Requirements

Before any tamping is undertaken, sufficient ballast should be on hand to ensure the desired profile can be provided after the lift.

It is important that enough ballast remains after surfacing, otherwise slacks and holes may develop prematurely. In hotter months, a full ballast profile after tamping is essential for track lateral stability – refer section 6.4.

This is particularly important when tamping steel sleepers as it is important that pods are completely full.

To maintain the standard ballast profile, a 20 mm lift requires at least 2 tonnes of additional ballast per 20 m of track.

Ballast discharged in preparation for tamping should be ploughed off at least to half the rail height, so that the tamping machine clamps can grip the rail, and so that the tamper operator can identify sleeper positions.

2.7 Setting Out

Setting out markings should be provided to guide the tamper operator, as follows:

- Curve tangent points (where not already monumented);
- Any locations of zero or restricted lift or line adjustment; and
- Start and end points for tamping, and limits of run-in/run-out ramps (refer section 3.5).

Where practicable, it is desirable to start and finish work on straight track. Starting or finishing work in transitions should be avoided.

2.8 Marking or Removal of Obstructions

Track components which may impede surfacing or ballast regulating operations, or are at risk of being damaged, must be identified with fluorescent paint prior to tamping commencing, so that they are visible to machine operators. Such components include:

- Signalling leads, cables, or other equipment;
- Pipes and conduits; and
- Rodding.

Where necessary, the following components should be temporarily removed to facilitate ballast tamping and regulating:

- Rail lubricators (refer RAP 5140: Inspection and Maintenance of Rail Lubricators – Procedure);
- Guard rails at bridge ends;
- Modular level crossing panels.

2.9 Co-ordination

Where applicable, signals staff should be advised of proposed tamping kilometerages, to facilitate co-ordinated identification of vulnerable equipment, or buried or unmarked cables.

3 Surfacing Operations

3.1 Objective

The objective of surfacing is to achieve a long lasting improvement in the vertical and horizontal geometry of the track, with minimum disturbance, and with a minimum use of ballast. Lifts should always be kept to the minimum necessary to achieve the desired result.

3.2 Ballast Depth

On new work, the track must be lifted a minimum of 100 mm above the formation before being tamped. This is to avoid the tamping tynes penetrating and damaging the capping layer. The prevention of damage is particularly important if geotextile has been laid. In new construction work, separate placement and compaction of bottom ballast before tracklaying is desirable. This is to avoid excessive settlement when rail operations commence.

On ballast deck bridges, there must be at least 100 mm depth of ballast below the underside of sleepers before tamping is attempted, to avoid damaging the tamping machine or the bridge deck.

3.3 Maximum Lift

In all surfacing, the maximum desirable lift is 50 mm per pass.

Where a lift exceeding 50 mm is required, multiple passes must be made. If excessive lifts are attempted, the full depth of ballast beneath the sleeper will not be adequately consolidated by the tamper tynes.

For additional lifting restrictions applicable in hot weather, refer section 6.4.

3.4 Basic Lift

In face (production) surfacing, it is necessary to establish the basic lift which will best achieve the overall surfacing objective (section 3.1). The basic lift can be assessed from site inspection, local knowledge, measurements, and/or examination of track geometry recordings.

Factors influencing nomination of the basic lift include:

- Minimum lift sufficient to the track geometry tolerances specified in Section 4.1 should be employed. Where special conditions exist (mud spots etc), additional lift may be required.
- The extent of irregularities in the original vertical profile – the highest point(s) in the track must receive at least the minimum lift;
- The basic lift should not exceed the availability of ballast to provide a full profile on completion of the work;
- If the ballast is clean and of sufficient depth, a smaller basic lift will suffice to fluidise the material and achieve compaction, whereas if the ballast beneath the sleeper is poor, additional fresh ballast will be needed for a good result;
- If sleepers show evidence of being centre bound, the basic lift needs to be sufficient to eliminate the centre binding, taking into account that some subsequent settling of completed surfacing will occur;
- Where cross-level correction is required, at least the minimum lift needs to be applied at every rail seat;
- Local experience will assist in determining the basic lift needed to achieve a lasting improvement in track geometry.

If the quality of completed work is unsatisfactory, an inappropriate basic lift is one of several possible causes – refer section 8.8.

When spot surfacing is being carried out, the defect(s) should be rectified by blending the surfacing into adjacent track levels; a basic lift will not normally apply.

3.5 Run-in / Run-out

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.

3.6 Lining

Lining may be carried out to a design alignment, or by smoothing out irregularities in the existing track.

For methods aligning curves, refer section 5.

3.7 Tamping Operations

During tamping, ballast must be fully compacted under the sleeper, for a uniform width on each side of both rails. Tamping should not be carried out in the centre of the sleeper.

As an exception, full support of sleepers should be provided during the tamping of level crossings, by using a switch tamper. Care should be taken not centre bind concrete sleepers.

It is important that the depth of the tamping tynes below underside of sleeper is set to match the rail size and sleeper type, so that the top of the tamper tyne is 15 – 20 mm below the underside of sleeper (refer section 8.4). Particular care must be taken:

- When rail size changes, e.g. there is a difference in height of 13 mm between 53 kg and 60 kg rail; and
- With concrete bearers on turnouts, which have a depth of approximately 450 mm from rail level to underside of bearer.

On interspersed sleepers, tamping depth should be set to suit the deepest sleeper type.

Special tamping procedures, including double tamping, apply to steel sleepers – refer current standard for steel sleepers.

Where double tamping is required, the tamping tynes must be inserted into the ballast twice. Multiple squeezes following a single insertion can result in inconsistent compaction.

3.8 Ballast Regulation

Guidelines for ballast regulation are as follows:

1) Undertake ballast regulating and brooming to restore ballast profile to the planned dimensions.
2) Avoid wasting ballast, and minimise contamination.
3) If additional ballast is available, use it to strengthen the shoulders, rather than placing it ineffectively off to the side.
4) Keep a sharp watch for marked obstructions, and for any other obstacles.
5) Minimise dust generation whenever possible.
6) Avoid ploughing ballast into bridge openings, over retaining walls or into watercourses.
7) Care must be taken not to block side drains or damage track drainage structures.
8) Broom excess ballast from the tops of the sleepers, particularly for 100 mm each side of the rail so that fastenings and the rail foot are visible.
9) Heaped ballast shoulders are beneficial, but the ballast must not infringe operating clearances (i.e. must not come within a line joining the tops of the rails, extended each side).

3.9 Ballast Stabilisation

The objective of ballast stabilisation is to accelerate the compaction of newly tamped ballast, a process which occurs naturally under traffic. Stabilisation improves track lateral stability, and reduces the need for speed restrictions. Stabilisation can be achieved in one of two ways:

- With a ballast compactor, which uses vibrating plates to apply pressure directly onto the ballast surface; or
- With a dynamic track stabiliser, which imparts a horizontal vibration (normally at about 35 cycles per second) and a static vertical load onto the rails.

Stabilisation is typically equivalent to about 100,000 gross tonnes of rail traffic.

Guidelines for ballast stabilisation are as follows:

1) Only stabilise track which has been recently tamped and which has good quality ballast. Stabilisation has no beneficial effect elsewhere.
2) With dynamic track stabilisation, sleepers and fastenings must be in good condition, to satisfactorily resist the loadings applied to them.
3) Bring a dynamic track stabiliser to its operating frequency as quickly as possible and while the machine is moving – avoid low frequency vibrations.
4) Use of stabilisation on or within 10 m of bridges is limited to modern concrete structures. Set dynamic stabilisers to 40 cycles per second when working over bridges.
5) Do not stabilise over or near structures, weak formation, or other areas which may not adequately withstand vibration.
6) Use of stabilisers in tunnels is prohibited.
7) When track is being tamped with multiple lifts, stabilise the ballast after each lift.

3.10 Over-lifted Track

If any track is over-lifted, it should be rectified by resurfacing over a minimum distance of 200m, plus the run-in and run-out.

Note: At fixed overhead structures (tunnels, overpasses, etc) the lift is not to cause an infringement for vertical clearances. If in doubt consult local Track or Delivery Manager

4 Track Geometry Tolerances

4.1 General

Track geometry should be checked before the line is reopened to traffic. Subsequent checks should be made as part of quality assurance or contract compliance assessments – refer Sections 7.1, 7.2 and 7.3.

Initial checks before the line is reopened normally involve cross level measurements using a combination track gauge or cant board, supplemented by visual assessment (refer section 7.1). Subsequent verification may comprise continuous measurement by track recording car or geometry measuring machine.

All surfacing work must be carried out to the construction or maintenance tolerances specified in Table 1.

Measurement	Construction Tolerance [1]	Maintenance Tolerance [2]	
		Limit Value [3]	95 % Value [4]
Line (variation from design, over 10 m chord length)	± 5 mm	± 9 mm	± 7 mm
Top (over 10 m chord length)	± 5 mm	± 9 mm	± 7 mm
Cross level/superelevation (variation from design) (refer section 4.2)	± 5 mm	± 7 mm	± 5 mm
Twist (over 2 m)	± 3 mm	± 7 mm	± 5 mm

Notes:

1 Construction tolerances apply immediately after surfacing of new work or major upgrading. Generally concrete sleepers and survey line.

2 Maintenance tolerances apply to maintenance surfacing, and to new work after consolidation (refer section 7.3).

3 Limit values are the maximum permitted variations.

4 95% values are to be achieved over at least 95% of completed work, as derived from continuous geometry measurement.

5 The tolerances are for application on ARTC main lines, including on the leased network in NSW. Additional tolerances will be required for tracks of other classes on the CRN in NSW, and for sidings.

Table 1 – Geometry tolerances for surfacing

4.2 Cross Level / Superelevation

Cross level applies to straights; superelevation applies to curves.

Spot checks of completed work (refer section 7.1) should be to the “95% value” tolerance.

When a cross level variation is detected, additional measurements should be made to ensure that limits for twist are not exceeded.

4.3 Line

Where there are no survey monuments, the track alignment should be regularly sighted to ensure no long swings have developed behind the tamping machine.

Particular care is required at curve transitions, to ensure the transitions are smooth, and are correctly aligned.

4.4 Top

Care should be taken to ensure any top irregularities are consistent over both rails and do not present a twist fault.

The track should be regularly sighted to ensure no long slacks have developed behind the tamping machine.

4.5 Twist

Twist is the most significant parameter with regard to train ride quality and wheel unloading.

4.6 Alignment and Clearances

Following surfacing, clearances must be checked in accordance with sections 7.2 and 7.3.

On new construction, major upgrading, or where survey monuments are available, track horizontal and vertical alignment should conform to the limits in Table 2.

Measurement	Construction Tolerance	
	Open track	Restricted Locations [1]
Horizontal alignment (variation from design)	± 25 mm	± 10[2] mm
Vertical Alignment (variation from design)	+ 40 mm - 25 mm	± 15[2] mm

1 Restricted locations include platforms, and areas where track centre clearances or clearances to structures infringe standard requirements

2 Under some circumstances, it is not permissible to shift the track closer to the obstacle. The centreline must be shifted to compensate for any tolerance. Likewise for vertical clearance there may be a maximum track height.

Table 2 – Tolerances for horizontal and vertical alignment

For alignment control in curves, refer section 5.

5 Alignment of Curves

5.1 General

Providing and maintaining correct alignment of curves during surfacing is important:

- To achieve correctly aligned curves and correctly lined and located transitions; and
- To ensure that rail stress free temperature is not inadvertently altered.

5.2 Methods of Alignment Control

Alignment of curves during surfacing may be managed by one of the following means:

- Smoothing;
- Lining to offset pegs or sleeper markings (existing, or following redesign);
- Lining to monuments at outer and inner tangent points and in the body of the curve, then by smoothing;
- Automatic lining control (measurement of alignment, and calculation and application of a design alignment by a suitably equipped tamper); or
- An independently surveyed and calculated design alignment transferred electronically to a suitably equipped tamper.

The method to be adopted in each case will depend on:

- The amount of realignment required;
- Capabilities of the tamper to be used; and
- The availability of site monuments or offset pegging.

5.3 Smoothing

When the track is lined by smoothing, irregularities in line are automatically evened out – refer section 8.3 for a description of the process.

Alignment can only be corrected over the length of the tamping machine (i.e. between its front and rear measuring points). This means that the line can be substantially improved, but not made perfect. If the line does not require extensive correction, this nevertheless produces a satisfactory result.

If curve monuments or offset pegs are available, design lining (refer sections 5.4 and 5.5) must always be used in preference to smooth lining.

5.4 Design Lining to Monuments or Offset Pegs

For new track construction, or for re-alignment to a design, the site should be surveyed to the design alignment with offset pegs at a minimum spacing of 20 metres on curves (including transitions), and 100 metres on tangent track. Pegs should also be placed at all tangent points (inner and outer).

The track slew required at each offset peg should be determined, and applied to the tamping machine.

5.5 Lining to Limited Monuments

If a curve is not monumented, successive smoothing can distort alignment, particularly in transitions.

This can be overcome by monumenting the tangent points (inner and outer), and at intervals of about 300 m through the curve. During surfacing, the curve is design lined to these monuments and smoothed in between. In particular, this assists in preserving the correct location and geometry of curve transitions.

5.6 Automatic Curve Lining

If a tamper is equipped for automatic curve lining, the machine initially measures the alignment of the curve, and calculates a proposed new alignment. It is necessary to know the location of the outer tangent points.

The proposed alignment can be influenced by the operator, including by:

- Specifying a transition length and/or cant ramp rate;
- Specifying a radius;
- Controlling slews at critical points (e.g. at a bridge or road crossing); and
- Managing the increase or reduction in overall curve length (affecting stress free temperature).

When a satisfactory proposed alignment is determined, the curve is tamped and the calculated alignment applied automatically. The completed alignment is normally remeasured as a quality check.

As a variation of this concept, the design alignment can be determined from an independent survey of the existing curve, and the design details (shifts) transferred electronically to the tamper.

5.7 Effect of Curve Shift on Rail Stress

A consistent shifting of a curve inwards or outwards during surfacing can have a considerable effect on rail stress free temperature, particularly on sharp curves.

Figure 1 shows the average realignment around a curve required to give a change in stress free temperature of 5ºC, for curves of different radius. As can be seen, on sharper curves, a minor alteration in alignment is sufficient to produce such a change in stress free temperature.

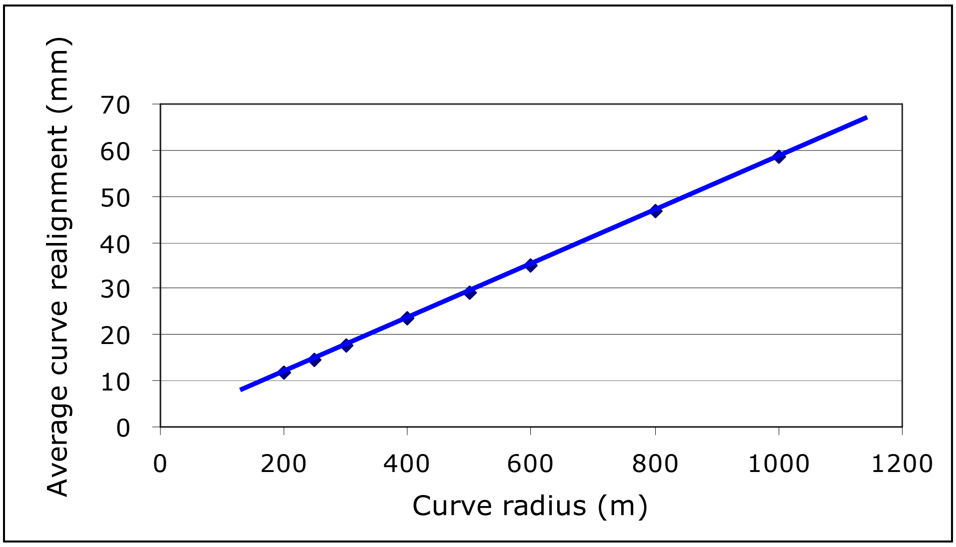

Figure 1 – Average curve realignment required to give a 5°C variation in stress free temperature

Rail stress should be checked (by Verse/RailFrame measurement or by de-stressing) if the average alignment change around a curve is such that, by reference to Figure 1, a stress free temperature variation of 5ºC or more may have resulted.

However, a rail stress check is not required if the curve is being restored to a design alignment, and conformance of stress free temperature at the design alignment can be verified from de-stressing records or from previous testing.

5.8 Limitations

The ability of a tamper to achieve the desired alignment depends on the required shift, size and capability of the machine, and on the lateral resistance of the track.

On CWR, the obtaining of design alignment can be assisted by cutting temporary joints into the rails, lining the curve, and then de-stressing to convert back to CWR. Realignment is also assisted if rail temperature is close to design neutral temperature.

6 Special Situations

6.1 Fixed Points

Ramps complying with section 3.5 should be provided when face tamping up to or away from fixed points, such as:

- Transom deck bridges;
- Turnouts (where surfacing is not planned to extend through the turnout);
- Tunnels and slab track; or
- Road crossings and pedestrian crossings (where surface panels are not removed for tamping).

Notwithstanding the locations of the ramps, it is important to ensure that each sleeper right up to the fixed point is tamped. This is to prevent faults developing immediately adjacent to fixed points, due to insufficient tamping. Where possible, the direction of working should be away from fixed points.

6.2 Restricted Clearance Locations

Restricted clearance locations include areas with:

- Multiple tracks;
- Platforms;
- Adjacent structures close to or within the permissible structure gauge; or
- Overbridges, tunnels, or other structures with potentially restricted vertical or horizontal clearance.

In areas with two or more tracks, care must be taken to ensure that tracks are not realigned to an extent that track centre clearances are infringed.

Standards for platform clearances have limited tolerances, both horizontally and vertically, to maintain an appropriate relationship between carriage steps and the platform. Track alignment and level near platforms therefore requires close control. Line at platforms should be maintained to tolerances listed in Section 4.1.

In all side clearance situations, assessment of clearances must include provision for centre throw and end throw on curves, and for the possible effect of differing cants on adjacent curves – refer TEP 10: Track Examination: Examination Track & Structural Clearances, and RAP 5135: Inspection of Track Clearances – Procedure.

Overhead clearances should always be checked after surfacing. Notices limiting track lifting, or requiring notification before surfacing work, must be complied with.

Surfacing in tunnels should not be commenced without first obtaining clarification of permissible track adjustments, both laterally and vertically.

6.3 Points and Crossings

Tamping through turnouts should meet the standards for main line track. In addition, bearers must be tamped over their full length (i.e. at all rails) when any part is lifted. Bearers must be lifted evenly, and remain horizontal throughout.

Guidelines for tamping points and crossings are as follows:

1) Work should commence on the track requiring the largest lifts – this is normally the through road, which is also the straight track.
2) The basic lift should be determined in accordance with section 3.4 or, if the turnout is low, to raise the turnout to the level of adjoining tracks.
3) Lining should be carried out from the straight track.

4) When the straight track has been completed, tamping should continue on the other track(s).
5) Jacks should be used where necessary to assist with the lifting and stability of long bearers (particularly concrete bearers).
6) Surfacing should continue onto the plain track at each end of the turnout, with any run-in/run-out located at least 20 m clear.
7) The entire turnout should be tamped in one operation, so that trains do not run over partially completed work.
8) Hand operated tampers or manual tools should be available for locations inaccessible to the tamping machine.
9) On completion of work, all ballast etc must be cleared from point rodding.
10) On completion of work, points should be checked for correct adjustment and operation. It is particularly important to ensure ballast is clear of the gap between the stock rail and switch blade.

6.4 Hot Weather

Surfacing activities in hot weather must comply with the procedures and limitations applicable in the jurisdiction (e.g. TMP 14: Maintenance of Welded Track (Summer Period) in NSW).

As a default requirement on timber sleepers, tamping should not be carried out when the air temperature exceeds 35ºC (nominally equivalent to a rail temperature of 45ºC). However, when work at hotter temperatures is unavoidable (e.g. a programmed possession) or is considered to be of low risk (e.g. concrete sleepers, good quality ballast, minimum lift, and minimum speed), a review of associated risks should be undertaken to establish appropriate mitigation actions, listed in section 7.7.

Sufficient ballast must always be available to restore a full profile as the work proceeds.

6.5 Cold Weather

In cold weather, particular care should be taken to ensure that curves do not pull downhill during or following surfacing, when ballast disturbance reduces lateral resistance.

Recently tamped track may need inspecting after one or more cold nights, even if initially appearing stable.

7 Completion of Site Works

7.1 Track Geometry Tolerances

As specified in section 4, surfacing should be accompanied by progressive and final checks of track geometry, to verify compliance with the required standards.

Cross-level of the surfaced track should be checked at intervals of about 300 m, more frequently in curves, and in detail (every 10 m) through transitions and turnouts. Top should be checked by eye, to locate twists, dips, or humps in the track. Line should be checked by sighting along the rail.

If track geometry does not meet the required tolerances (refer section 4), the cause must be investigated and the track resurfaced.

7.2 Reopening the Track

Before reopening the track after surfacing, the following procedures must be completed:

- Verification of track geometry, in accordance with sections 4 and 7.1;
- Rectification of any defects, where immediately necessary;
- Inspection for any damage to signalling equipment, track leads, etc;
- Confirmation of operating clearances (including of ballast awaiting regulating); and
- Application of any necessary speed restrictions (particularly in hot weather – refer section 7.5).

Modular level crossing panels should be removed only for the minimum time necessary for surfacing through the crossing.

7.3 Quality Assurance – Completed Work

The following aspects of completed work should be checked, and rectification carried out where necessary:

- The Maintenance Tolerances in Table 1 will apply. Where feasible, the track shall be inspected between 10 and 30 days following the tamping work. In all cases, visual inspections shall be carried out every 7 days by track patrols, with any obvious non-compliances to be reported.

  Where it is unfeasible for the track to be inspected within 10 and 30 days following the tamping work, inspection of the track geometry will be carried out by the AK Car on its next scheduled pass over the area.
- Clearances – a final check of all operating clearances potentially affected by the work;
- Quality documents for geometry and clearance;
- Ballast – including shoulder and crib profiles, standard of finish, drop through on bridges, obstruction of culverts and waterways, etc;
- Sleepers and fastenings – including damage, dropped sleepers with plate under the rail foot, bunching or out of square sleepers, etc;
- For requirements for switch tamping, see Section 6.3;
- Clear flangeways of ballast at road crossings;
- Access roads and fences – damage, requirements for reinstatement, etc; and
- Site cleanliness – rubbish, oil spills, etc.

7.4 Follow-Up Works

The following follow-up works should be arranged as required:

- Rail adjustment (including resetting of creep monuments);
- Refitting of rail lubricators; and
- Reinstatement of bridge end guard rails.

7.5 Speed Restrictions – General

Speed restrictions following surfacing may be necessary for either of two reasons:

- Track geometry is inadequate, or there is a risk of a geometry fault developing as the track settles; or
- Track lateral stability has been reduced.

7.6 Speed Restrictions – Track Geometry

Requirements for temporary run-outs are addressed in section 3.5.

Other track geometry risk scenarios warranting consideration of a speed restriction include:

- Geometry defects potentially developing on new construction with a significant depth of unconsolidated ballast; or
- Partially complete work.

In such cases, a speed restriction appropriate to the circumstances should be applied.

The track must always be inspected immediately before a speed restriction is removed.

In maintenance surfacing of track, a speed restriction because of track geometry should not normally be required.

7.7 Speed Restrictions – Lateral Stability

The risks associated with reduced lateral stability generally apply in hot weather, but may be present at other times if, for example, the ballast profile is inadequate.

Where risks have been identified, particularly on timber sleepers, the following guidelines are suggested for the application of speed restrictions;

Between 1 November and 31 March, a speed restriction in accordance with Table 3 to be applied between at least 10:00 and 20:00 daily, to cover the highest risk time. This can be extended as required. Where a restriction has been applied, the restriction should remain for 7 days or 100,000 tonnes, whichever comes first.

Normal Line Speed (km/h)	Temporary Speed (km/h)
$\geq$100	80
75 – 95	60
40 – 70	40
<40	No reduction

Table 3 – Default speed restrictions for lateral instability

Where ballast stabilisation is used, the restriction may be removed after 1 day.

In situations of lower risk (e.g. concrete sleepers, mild weather, or jointed rail), a risk assessment should be carried out to assess requirements for speed restrictions.

The track must always be inspected immediately before a speed restriction is raised or removed.

7.8 Documentation

The following surfacing information should be recorded:

- Date;
- Location surfaced (start and end kilometerage);
- Basic lift applied;
- Method of aligning curve (smoothing, design lined to monuments, etc);
- Curve shifts, before and after offset measurements, and/or automatic alignment control output;
- Completed track geometry – confirmation of compliance;
- Completed ballast profile – confirmation of compliance; and
- Any defects, corrective actions required, or other comments

8 Surfacing Machines - Principles

8.1 Principles of Operation

Tamping machines operate by lifting the track to the required level, shifting the rails and sleepers laterally to the correct alignment, and then compacting the ballast beneath the sleepers. Compaction is achieved by the use of vibrating tynes, which are inserted into the ballast on each side of the sleeper and squeezed together.

8.2 Levelling

The levelling process is shown diagrammatically in Figure 2.

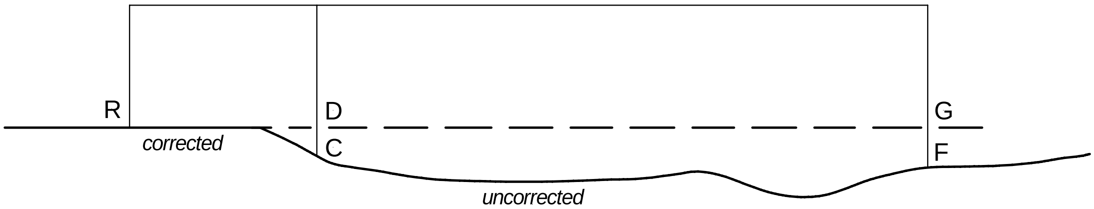

Figure 2 – Levelling process

Laser beams or taut wires are provided between the extremities of the tamper, at points R and F. Point R is on the corrected track, at the rear of the machine. Point F is on the uncorrected track, at the front of the machine.

The track is to be lifted by the height FG. At correction point C, the rails are raised to a level D, on the straight line RG. Cross-level is adjusted at the same time.

8.3 Lining

Lining is carried out by a process similar in concept to levelling, as shown diagrammatically in Figure 3.

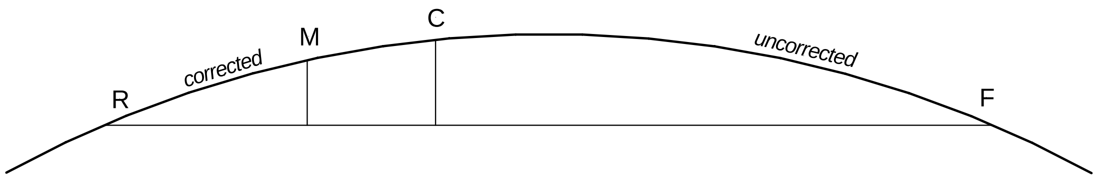

Figure 3 – Lining process

R (at the rear of the machine) and measuring point M are on corrected track, and F is at the front of the machine. A laser beam or taut wire is provided between points R and F, from which offsets are measured at M and C. In smoothing, a curve of best fit between R, M and F is calculated, and the track shifted at correction point C to lie on this curve. In design lining, the required shift is additionally applied at F, so that the front of the machine follows the desired geometry.

8.4 Tamping

When tamping tynes are submerged into the ballast, the co-ordinated action of vibration and squeezing force determines the extent to which the ballast beneath the sleeper is compacted.

To produce optimal compaction, it is important to have the top of the tynes inserted to a depth of approximately 15 – 20 mm below the underside each sleeper (refer section 3.7). If the depth is too shallow, the ballast will be pressed against the sides of the sleeper. If the depth is too great, ballast will flow past the tyne spades and leave voids and/or unevenly compacted ballast immediately underneath the sleeper.

The lifting action of the tamping machine is designed to create a level surface (top) on the rail. This action creates a void under the sleeper, which must be filled during the squeeze cycle. It is therefore important to restrict the lift to that which can be effectively compacted.

During each tamping cycle, resistance from the ballast builds up in front of each tyne. The tamping machine is designed to sense this resistance – each tyne will continue to squeeze until a preset pressure is reached.

This means that if the voids under the sleeper are not uniform, one pair of tynes will squeeze further than the other, in order to achieve the same pressure on each tyne.

Figure 4 shows the method of operation of a typical tamping head.

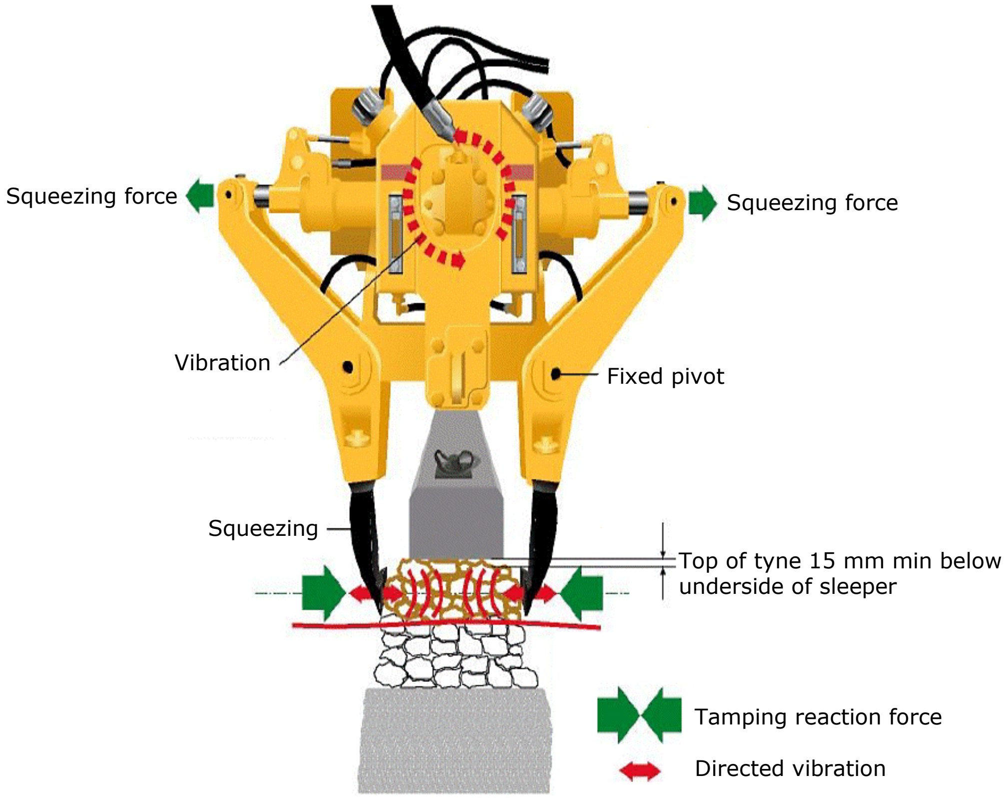

Figure 4 – Typical tamping head

8.5 Settings

The main settings available to the tamper operator are:

- Tamping (squeeze) pressure – this is normally set to between 115 and 125 bar for maintenance work. When tamping new construction, a pressure of 95 – 110 bar should be used.
- Squeeze time – optimum time is normally between 0.8 seconds (on new construction) and 1.2 seconds (for maintenance tamping).
- Tamping depth – optimum depth is with the top of the tyne 15 – 20 mm below the underside of sleeper (refer section 8.4).

8.6 Calibration

Calibration of tampers must be maintained in accordance with the manufacturer's instructions.

Calibration should be confirmed by checking completed work after the initial stage of each tamping shift.

8.7 Machine Operation

It is important to follow the manufacturer's instructions when setting up a tamping machine.

The tamping cycle should be monitored, to ensure that the action of the tynes is smooth and effective. If the tynes move too far, particularly if they touch the sleeper, the squeeze pressure may be too high. Similarly, a small squeeze action is likely to indicate that the squeeze pressure is too low. Similarly, if a flow of ballast at the sleeper ends can be clearly seen during the squeezing movement, the tamping pressure is likely to be too high.

The tynes should only be submerged into the ballast once the tamping head is centralised over the sleeper, and is stationary. If the tamping head is not centralised, incorrect compaction and/or sleeper movement may result. High production machines which tamp more than one sleeper at a time can only be used successfully where sleeper spacing is regular.

The working speed of the tamping machine must take rail surface condition into account. Working speed will need to be lower if the rails are wet or oily. Skidded wheels must be avoided.

Always apply at least the basic lift (refer section 3.4), to ensure the top can be properly smoothed and alignment adjusted.

8.8 Quality of Output

If a quality and long lasting output is not being achieved, the following possible causes should be investigated:

- The lift on each pass is too great – refer section 3.3;
- The basic lift is insufficient – refer section 3.4;
- There is not enough depth of good quality ballast beneath the sleepers – track with poor drainage and/or fouled ballast will not compact properly;
- Tamping depth is incorrect – if the depth is insufficient, ballast will be ineffectively pressed against the sides of the sleepers, refer section 8.5;
- Tamping rate is too fast – if the squeeze time is too low, optimum ballast compaction may not be achieved, refer section 8.5;
- Incorrect calibration of tamper measuring or control systems;
- Operator error, including the special procedures for steel sleepers – refer section 3.7; and
- Worn tamping tools – a tamping tyne must be replaced when more than 20 – 25% of the tyne face area has worn away or broken off.

9 Surfacing Machines – Safety

9.1 Operation of Safety Equipment

All surfacing machines must carry the safety equipment specified in applicable plant operating procedures.

Any defects in safety related fittings such as brakes, horn, lights, silencers, etc, must be promptly attended to.

A complete set of safeworking equipment must be carried on each surfacing machine. Similarly, a complete set of safeworking equipment must be carried on any machine likely to be working independently e.g. ballast regulator.

9.2 Operator Qualifications

Before travelling or operating track surfacing machines, operators must hold the safeworking qualifications applicable to the relevant jurisdiction(s), and machine operating qualifications.

9.3 Machine Safety – Avoidance of Hazards

Particular hazard mitigation actions applicable to surfacing operations include:

- Maintaining a safe distance between tamper and regulator when working;
- Ensuring all procedures for latching and locking equipment have been completed before travelling to or from work sites; and
- Testing key operating functions when commencing work.

9.4 Environmental Management

Care should be taken to suppress dust, to the extent that this is practicable.

Oil leakage and spillages should be treated in accordance with applicable procedures. Any fittings leaking hydraulic oil should be repaired promptly.

10 Surfacing Machines – Travelling and Stabling

10.1 Preparation

Before a surfacing machine travels, the operator must ensure that the machine has been secured for travel in accordance with the manufacturer's operating instructions or applicable work method statement.

10.2 Route Knowledge

If a surfacing machine operator is unfamiliar with the route to be travelled, the operator must be accompanied by a person who:

- Is familiar with the route; and
- Holds appropriate safeworking qualifications.

10.3 Travelling

Irrespective of the maximum permitted speed of a surfacing machine, all applicable track speeds (including temporary restrictions) must be complied with.

Surfacing machines must travel at a speed which will to allow the machine to be stopped within the clear distance ahead, including to any preceding machine.

A safe distance must be maintained between tamper and regulator when travelling, or the machines coupled together, as specified in applicable safeworking rules.

10.4 Level Crossings – Passive Protection

When a surfacing machine approaches a road or pedestrian crossing with passive protection (i.e. signage only), the operator must:

- Reduce the speed of the machine to a level which avoids any possibility of a collision;
- Establish that the road or pedestrian crossing is clear and that any approaching road or pedestrian traffic has come to a halt;
- Verify that it is safe to proceed; then
- Pass over the crossing at a safe speed.

Note: Where two track machines are travelling in convoy, they are required to close the gap and proceed across in accordance with the relevant safeworking rules and procedures.

10.5 Level Crossings – Active Protection

When a surfacing machine approaches a road or pedestrian crossing with active protection (i.e. flashing lights, bells, etc), the operator must:

- Reduce the speed of the machine to a level which avoids any possibility of a collision;
- Establish that the level crossing warning devices have activated;
- Verify that the road crossing is clear;
- Confirm that it is safe to proceed; then
- Pass over the crossing at a safe speed.

If the level crossing warning devices cannot be verified as having activated, the procedures specified for crossings with passive protection (refer section 10.4) apply.

Note: Where two track machines are travelling in convoy, they are required to close the gap between the two to ensure both machines traverse the crossing while it remains active, in accordance with Network Rules and Procedures and the Code of Practice.

10.6 Turnouts

When a surfacing machine approaches a set of points, the operator must reduce the speed the machine such that:

- The position (normal or reversed) of the points can be verified; and
- If the points are not set for the intended route, the machine can be stopped before reaching the points.

10.7 Stabling

Surfacing machines must be stabled in accordance with the applicable safeworking rules.

Where stabled on a siding, appropriate authorisation must be obtained. Protection must be placed where required by safeworking rules.