



AUSTRALIAN RAIL TRACK CORPORATION LTD

Discipline: Engineering (Track & Civil)

Category: Specification – ARTC CoP

General Appendix to ARTC Track & Civil Code of Practice

Specification Clauses

Track Geometry

ETG-05-01

Applicability

ARTC Network Wide		Western Jurisdiction	✓
New South Wales		Victoria	✓

Primary Source

ARTC A1 Specification Track Geometry – Inspection & Assessment and Work on Asset/TCS-21)

Document Status

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Amendment Record

Version	Date Reviewed	Clause	Description of Amendment
1.0	01 May 06		First issue
1.1	03 Dec 07	5.7.1.2 (b); 5.7.2.4; 5.7.2.7	Removal of reference to minimum lift of 30mm; Update of parameters used to calculate TQI. TQI now calculated and plotted over 100m instead of 200m; Frequency of runs amended to reflect Section 5
1.2	04 Nov 08	Various; 5.7.1.7	Updated references to CoP section 5; Inserted table of parameters following track geometry rectification and changed inspection requirements

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5.7 Track Geometry

5.7.1 Construction and Maintenance

5.7.1.1 Manual Track Levelling, Aligning and Tamping

Manual methods of track levelling, aligning and tamping are permitted for spot repairs.

The Contractor shall comply with all relevant requirements of Mechanised Track Levelling, Aligning and tamping.

- Ballast shall be firmly packed under the rail seat area for a distance of not more than 300mm each side beyond the foot of the rail.

5.7.1.2 Mechanised Track Levelling, Aligning and Tamping

a) General

All mechanised track levelling, aligning and tamping shall result in the track being in conformance with the requirements of Clause 5.7.1.7.

b) Minimum lift

After the initial ballast run on new track it shall be lifted to a sufficient height to ensure that the subgrade is not damaged by insertion of the tamping tools.

c) Maximum lift

The Contractor shall not lift the track more than that required to remove the geometric deficiencies in the track.

The maximum lift of a single pass in a multi-lift tamp shall not exceed 100mm.

The final lift shall not exceed 50mm.

The Contractor shall specify how over-lifted track is to be corrected.

d) Method of Aligning Curved Track

The Contractor shall specify the method of aligning curves that may include any of the methods listed below:

- Smoothing of curves
- Lining to existing pegs
- Survey existing curve, redesign, peg and line to the new pegs

e) New Alignment

For new track construction or realignment to a design the alignment shall be surveyed to the design alignment with pegs at spacings as follows.

Pegs shall also be placed at all intersection points including tangent/start and finish of transition and transition/curve points.

- On transition curves at the outer and inner tangent points, and at not more than 20m intervals along transitions.
- On curves of up to and including 500m radius at not more than 20m intervals.
- On curves of above 500m radius at not more than 30m intervals
- On tangent track at not more than 50m intervals.

New and realigned track is to conform to the design within the following tolerances: -

- Horizontal alignment at platforms, on tangents and curves >600m radius \pm 4 mm
- Horizontal alignment at other surveyed locations \pm 10 mm
- Horizontal variation between any surveyed location 20m apart not to exceed 10 mm

- Vertical alignment – open track ± 25 mm
 - Vertical alignment – through platforms and overbridges ± 10 mm
 - Level variation between other surveyed with 20m: 10mm
 - Tolerance on gauge ± 4 mm [new track only].
- f) Lateral Alignment Correction
- Lateral Alignment corrections shall be tamped with Minimum Lift requirements.
- All tangent track on the final lift shall be laser aligned.

5.7.1.3 Sleeper Packing

Correction of track geometry defects by shimming on ballasted track is not permitted.

Where packing of sleepers to remove voids and restore the track geometry relative to the track either side of the worksite by tamping sleepers is permitted, it shall meet the following requirements:

a) Tamper Tynes

The Contractor shall specify the size and condemnation limits of tamper tynes to be used for the tamping of turnouts and plain track.

b) Tamping Operation

The Contractor shall operate tamping machines in accordance with the manufacturer's specifications.

The Contractor shall ensure that the ballast is fully compacted under the sleeper for a distance of 300mm in each direction from both rail seats. Tamping shall not be carried out in the centre of the sleeper to avoid centre-binding of the sleeper.

The track should be raised to the desired surface level and the sleepers tamped to a tight bearing against the raised rail.

The tamping process shall be controlled to prevent any damage to track and infrastructure elements such as sleepers and fastenings, subgrade, drainage, signalling equipment and cabling. Damage to the ballast during tamping should be minimized.

c) Run Outs

Temporary run out ramps shall not be steeper than 1 in 400. Temporary run outs shall not be considered as completed track.

Permanent run outs shall not be steeper than 1 in 1000.

5.7.1.4 Tamping in Restricted Clearance Locations and where Datums are Present

When Tamping track in restricted clearance locations the Contractor shall control the track geometry to ensure that it complies with the specified clearance limits from the datum markers and in conjunction with **Clause 7.8**.

At nominated restricted clearance locations without datum markers the Contractor shall before commencing work obtain approval from and comply with directions from ARTC.

At the completion of the work the Contractor shall inspect and assess the final clearances in accordance with **Clause 7.8**.

5.7.1.5 Tamping Near and Up to Fixed Points

The Contractor shall specify the process to control the track geometry and ballast profile when tamping up to or away from fixed points including:

- Transom Decked Bridges
- Tunnels
- Sleeper and Bearer Interfaces

- Road Crossings
- Concrete Slab Track

5.7.1.6 Tamping Turnouts and Diamonds

The track geometry through turnouts and diamonds shall meet the standards for plain line track.

The Contractor shall specify the method of tamping aligning and levelling turnouts and diamonds that shall include all the requirements of Mechanised Lifting, Levelling and Aligning and additionally:

- Bearers shall be tamped over their full length when any part is lifted.
- Bearers shall be lifted in an even horizontal manner, or to the designed superelevation as applicable.

5.7.1.7 Standard Following Track Geometry Rectification

Following tamping work, the track shall be inspected immediately for compliance with the Construction Tolerances in Table 5.7.

After this time, the Maintenance Tolerances in Table 5.7 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.

Table 5.7: Track geometry tolerances

Measurement	Construction Tolerance ¹	Maintenance Tolerance ²	
		Limit Value ³	95 % Value ⁴
Horizontal alignment (Line) (variation from design, over 10 m chord length)	± 5 mm	± 9 mm	± 7 mm
Vertical Alignment (Top) (variation from design over 10 m chord length)	± 5 mm	± 9 mm	± 7 mm
Cross level/superelevation (variation from design)	± 5 mm	± 7 mm	± 5 mm
Twist (over 2 m)	± 3 mm	± 7 mm	± 5 mm
Cyclic variation (wavelengths less than 200 m)	nil		
Maximum ramp angle at end of work	1 in 1000		
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. 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.			

5.7.2 Track Geometry Inspection and Assessment

5.7.2.1 General Assessment Requirements

Track Geometry shall be maintained to the tolerances and condition defined in this Section. Where the condition of Track Geometry fails to comply with the limits specified, or damage to the Track Geometry condition does not allow it to perform its intended function, actions shall be taken to repair or remove defects as specified.

It is expected that the infrastructure shall never be outside of the described conditions in this specification except in emergency situations. Where these specifications do not provide for the worst possible condition of the infrastructure or any of its components during operation, the Area Maintenance Contractor shall be responsible for determining the assessment of the condition and subsequent determination of operations over it.

5.7.2.2 Assessment of Ride Quality

a) Head End Inspections

All suspected defects shall be:

- Identified by location
- Subject to imposition of speed restrictions as deemed necessary by the local area inspecting worker (Train Control to be informed immediately)
- Subject to an unscheduled general inspection including a review of restrictions placed on the track in accordance with the above.

The inspecting worker should be aware that some locomotives and railcars may exhibit particularly good ride performance within the cab, and that there may be significant variations in the ride performance of particular locomotives and railcars dependent upon for example the condition of the locomotive or railcar and their type. The inspection shall therefore be carried out with knowledge of existing defects present in the track such that identification of locations at which the ride is poor, relative to the general locomotive ride, can be carried out.

The Area Maintenance Contractor shall be responsible to arrange the approval to ride in the cab of locomotives or railcars and the availability of train pick up and put down locations with operators. The payment of all costs related to the approval or function of locomotive inspection levied by the operator shall be the responsibility of the Area Maintenance Contractor.

b) Ride Quality

Ride quality can be measured by vehicle based measuring systems.

5.7.2.3 Assessment of Track Geometry Defects

- a) Table 5.5B groups defects into defect bands for each measured parameter and method of measurement. The track is also grouped into speed bands. The response category (i.e. E, U1, U2, P1 and P2, defined in the table 5.5B) required for a specific defect is determined from the intersection of the defect band (row) and the speed band (column).

Table 5.6A specifies the minimum requirements for the response categories, that is the maximum period allowed for inspection, assessment, and repair of identified geometric conditions.

The Area Maintenance Contractor and the Track and Rail Condition Monitoring Contractor responsible for the operation of the Track Recording Vehicle shall have the necessary protocols in place to enable all responses to be implemented.

The required response may be moderated by imposing a speed restriction. The response required is then determined using the restricted track speed. Management of the inspection and repair of a list of defects can therefore be achieved by adjusting the response requirements using speed restrictions.

The required responses defined in Table 5.6A are based on isolated geometric defects. A more stringent response than that mandated by the geometry alone may be required

taking into account the condition and rate of deterioration of the infrastructure both at the defect and on adjoining track.

Where the response required by the Table 5.6A requires inspection the location shall be subject to an unscheduled general inspection.

b) Defect Density by Track Section

Post analysis of the Track Geometry Vehicle measurement data will produce defect density information for E, U1, U2, P1 and P2 class defects for each Track Section.

The density of defects as measured by the Track Recording Vehicle for the various Track Sections shall not exceed the specified levels.

Where the density of defects does exceed the levels specified the contractor shall provide ARTC with a plan for work that demonstrates how the defect density level will be corrected within 28 days and maintained for future Track Geometry Measurement Campaigns. This work shall be carried out by the Area Maintenance Contractor as agreed with ARTC.

c) Superelevation in Curves

(c.1) Maximum Permissible Operating Speed

The maximum permissible operating speed (V_{max} in km/hr) on any curve may be calculated from the following using the formula in Clause 5.1.1(a).

Where the maximum permissible operating speed (V_{max}) is less than the posted curve speed an immediate speed restriction shall be applied which is less than (V_{max}) and be enforced until the defect is repaired.

(c.2) Rate of Change of Superelevation or Superelevation Deficiency

Where ever the rate of change of superelevation or superelevation deficiency exceeds 65mm/sec a speed restriction shall be applied to bring the track into compliance until repaired, subject to a curve design validation check

(c.3) maximum superelevation

For a train to operate the absolute maximum for the difference in rail levels is 170mm.

5.7.2.4 Assessment of Track Geometry Quality

Geometry Trending is done using the AK Car using a calculation that produces a Track Quality Index (TQI) for sections of track. These sections are then averaged (with distance weighting) over larger distances for a TQI for a section or corridor.

Four parameters are used to calculate a TQI:

- Surface (20m Inertial Top – average of Left and Right rail standard deviation),
- Line (5/10m chord emulation – average of Left and Right rail standard deviation),
- Twist (Short twist/2m)
- Gauge

These four metrics are recorded in 0.5 metre intervals; these figures are taken as 3 Standard deviations over **100m** and the 4 metrics added together to produce a TQI for that 100m. The TQI figure resulting is then distance averaged into sections (usually several track codes per corridor).

The frequency of AK Car runs is 3 per year for the defined interstate network and once per year for crossing loops. The average is taken to provide one value for the year.

Post analysis of the Track Geometry Vehicle measurement data will produce a cumulative TQI histogram for each Track Section, as designated by ARTC.

The cumulative TQI histogram as measured by the Track Recording Vehicle for the various Track Sections during each measurement campaign shall be equal to or better (in all TQI histogram bins) than the histograms to be specified, or as otherwise determined by ARTC.

Where the specified histogram for the track section(s) is not achieved the contractor shall provide ARTC with a plan for work that demonstrates how the track quality will be corrected

within 28 days and maintained for future track geometry measurement campaigns in the future. This work shall be carried out by the Area Maintenance Contractor or as agreed with ARTC.

5.7.2.5 Assessment of Track Geometry through Deviations and Worksites

The nominated operating speed for work sites, temporary tracks, such as deviations, and for tracks reinstated after major work or derailment will determine the standard of geometry to be achieved on those tracks. These tracks shall be monitored as specified by the Area Maintenance Contractor as required by deterioration rates until settlement has effectively ceased.

Specific attention is to be given to the junction of the old and new track where differential effects can occur.

5.7.2.6 Measurement Accuracy of Track Recording Vehicle

The Track and Rail Condition Monitoring Contractor shall specify the measurement accuracies of all measurement parameters taking into account the calibration and maintenance procedures. The Track and Rail Condition Monitoring Contractor shall ensure that the Track Recording Vehicles are maintained and calibrated to the specified accuracies.

5.7.2.7 Track Geometry Train or Car

This inspection is used to provide data for track maintenance planning purposes and providing notification of defects that require action to be taken.

Track geometry recording runs shall be carried out at least 3 times per year (at 4 monthly intervals) on the DIRN.

The Track and Rail Condition Monitoring Contractor shall be responsible for:

- Ensuring that the specified calibration checks has been carried for operation of the Track Measuring System or Equipment and that the equipment has passed such calibration checks in accordance with the procedures developed by the Track and Rail Condition Monitoring Contractor and as agreed with ARTC.
- Undertaking the specified calibration of the Track Measuring System or Equipment
- To monitor system output that may indicate a failure or requirement for maintenance or re-calibration of the Track Measuring System or Equipment and carry out such maintenance or recalibration as required
- Input and report the following data measurements:
 - Management area
 - Line (eg. TAR, Victorian North East Line)
 - Track Class (Line speed, defect or exceedence limits)
 - Start and finish locations of the measuring run or line section
 - Direction of measurement
 - Which end of the vehicle is leading
 - Date of run
 - Kilometre post locations
 - Coded events including track features such as the start and finish of curves, bridges/culverts, road crossings and turnouts
 - Special events or comments including calibrations, automatic trolley lifts, location names, resetting of zero alignment base, any incidents or features which can assist with the interpretation of the track charts and reports.
 - Delivering the production outputs including the Track Chart and Exception Reports as agreed with the Area Maintenance Management Contractor.

The Contractor shall deliver the following outputs:

- a) Track Chart

The Area Maintenance Management Contractor shall be able to view the track chart in real time on monitors on the vehicles.

The Track Chart shall also be printed in real time on multiple copy continuous paper (three copies) at suitable scales (normally 1:5000 longitudinal, 1:1 vertically except for cross level at 1:3). One copy shall be supplied to relevant the Area Maintenance Management Contractor and ARTC. The raw data shall be stored electronically for later backup, storage and analysis.

b) Exception Reports

The Multiple copy exception reports (three copies) shall be printed in real time. The exception reports shall list events, exceptions or defects, km posts, changes in track class and Track Quality Index (TQI) values over 1 km intervals for parameters defined in Clause 5.7.2.4.

One copy shall be supplied to the Area Maintenance Management Contractor as soon as possible following the completion of the measuring run.

c) Automatic Measuring Trolley Lift Report (EM80 only)

The incidence of a measuring trolley automatically lifting may occur from a track fault that has the potential to cause a train derailment and therefore all such incidences must be recorded and the following action taken:

- The EM80 is to be brought to a stop.
- The track chart and exception report are to be checked by the Contractor to see if a cause can be identified.
- The Contractor shall where practicable note which trolley has lifted.
- A visual inspection of the location at which the trolley lifted must be conducted by the Area Maintenance Management Contractors representative to confirm or identify a cause of the Trolley Lift.
- On curve worn rail, the width of the rail head is to be measured to determine the amount of rail wear and hence possibility of a trolley wheel climbing the angled gauge face of the rail.
- The event "Trolley Lift" is to be recorded on the Track Chart and Exception Reports.
- The following information shall be recorded on the Report Form titled Report of Automatic Measuring Trolley Lift:
 - Date
 - Location
 - Which trolley lifted
 - Direction of travel
 - Speed of EM80
 - Track type
 - Track features
 - Track components
 - Parameters identified as exceedances, their maximum value and safe speed
 - Cause and track defects identified
 - Actions taken

One copy of the form is to be handed to the Area Maintenance Management Contractor on board the car.

d) Backup of raw data and computer files.

The data files created during the measuring run shall be saved and stored electronically for permanent storage and any later or off-board analysis. A copy of this data shall be held by the Track and Rail Condition Monitoring Contractor and a copy forwarded to ARTC. A

hardcopy list of all file names with dates and data storage references shall be maintained by the Track and Rail Condition Monitoring Contractor and a copy forwarded to ARTC.

e) Track Quality Summary Information

Track Quality Summary data shall be produced by the Track and Rail Condition Monitoring Contractor as specified below.

(e.1) average track quality index trend

A plot of Average TQI against Date showing, for each line segment, the history of the average TQI value obtained for each measuring run.

(e.2) 100 metre track quality index

A plot of the TQI values calculated for each 100 metres of track plotted against kilometres. The TQI values plotted to be the total value plus the individual parameter values for top, twist, line and gauge. Each A4 sheet to be plotted for a maximum distance of 100 km. The average TQI value for the line section is also to be plotted on the same sheet, with the previous run value listed.

(e.3) track quality index comparison

A plot of the 100 metre total TQI values plotted against distance for the last five measuring runs. A plot of the algebraic difference between the last two measuring runs is also plotted on the same sheet to show where the track has deteriorated, been improved or stable. Each A4 sheet to be plotted to cover no more than 50 km track distance.

(e.4) defect density

The Rail Track and Rail Condition Monitoring Contractor shall produce Defect Densities per track section as detailed in Clause 5.7.2.3 for comparison with Line Section Defect Densities.

(e.5) cumulative track quality index histograms

The Rail Track and Rail Condition Monitoring Contractor shall produce Cumulative TQI Histograms as detailed in Clause 5.7.2.4 for comparison with Line Section Histograms (to be defined).

(e.6) summary report

The Rail Track and Rail Condition Monitoring Contractor shall prepare a written report summarising the observations and interpretations of results deduced from all of the Track Recording Vehicle information.

(e.7) record of recording runs

The Rail Track and Rail Condition Monitoring Contractor shall maintain records of runs undertaken, which may as applicable include any of the following:

- o Date
- o Start and finish location and times for the day
- o Recording or not recording (travelling)
- o Name of Area Maintenance Contractors representative on car
- o Summary of service details
- o Summary of any mechanical or measuring system faults or problems
- o Odometer reading at finish of day
- o Engine hours reading at finish of day
- o Amount of fuel taken on
- o Any other comments

f) Track Geometry Car (Area Contractor to Provide On-Board Representative)

General Requirements

This inspection is used to provide data for track maintenance planning purposes and providing notification of defects that require action to be taken.

The Area Maintenance Contractor shall provide an on board representative during all Track Geometry Vehicle measurements. The Track and Rail Condition Monitoring Contractor responsible for operation of the Track Geometry Vehicle shall be instructed not to measure track where such a representative is not actually on-board the car. Where this representative is not on-board, payment of any reasonable costs incurred by the Track and Rail Condition Monitoring Contractor responsible for operation of the Track Geometry Vehicle shall be the responsibility of the Area Maintenance Contractor.

For at least two (2) of the measurements taken during the year over each track section, the Area Maintenance Contractor's representative shall be the worker responsible for setting priorities and directing the rectification of defects.

The representative shall be responsible for:

- initiating actions for the inspection, application of restrictions on and repair of defects identified by the Track Geometry Vehicle
- confirming the schedule of calibration checks has been carried out by the Track and Rail Condition Monitoring Contractor responsible for operation of the Track Geometry Vehicle and that the equipment passed such calibration checks
- advising the Track and Rail Condition Monitoring Contractor responsible for operation of the Track Geometry Vehicle if at any time during a production run in his/her opinion the system output appears to be irregular or show geometric variations exceeding normally expected levels, that may indicate a failure or requirement for maintenance or re-calibration of the Track Geometry Vehicle.
- Confirming that the following information is input and reported with the data measurements:
 - Management area
 - Line (eg. TAR)
 - Track Class (Line speed, defect or exceedance limits)
 - Start and finish locations of the measuring run or line section
 - Direction of measurement
 - Which end of the vehicle is leading
 - Date of run
- Confirming that during the run the following information is input and reported with the data measurements:
 - Changes to track class due to permanent speed restrictions and/or curve speeds
 - Changes to input data (eg, Management area)
 - Kilometre post locations
 - Coded events including track features such as the start and finish of curves, bridges/culverts, road crossings and turnouts
 - Special events or comments including calibrations, automatic trolley lifts, location names, resetting of zero alignment base, any incidents or features which can assist with the interpretation of the track charts and reports.
- Receiving the production outputs including the Track Chart and Exception Reports as soon as possible following the measuring run Track and Rail Condition Monitoring Contractor responsible for operation of the Track Geometry Vehicle.

5.7.2.8 Assessment of Curves with High Cant Deficiencies

On curves with designed superelevation deficiencies exceeding:

- 75 mm for traffic classes T2, T3, T4 and T5
- 100mm for traffic class T1
- Following each run, the superelevation output as recorded by TRV's shall be checked against Table 5.2b.