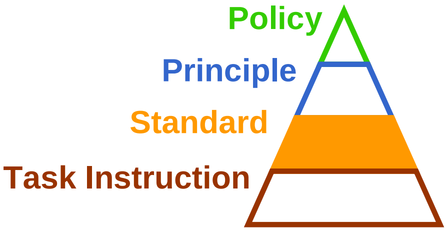

Track Standard

Track Geometry

Purpose

Track Geometry measurements of various track parameters, using a track recording vehicle and the subsequent analysis of the results provides KiwiRail with the means of determining track quality for each of its routes or sections of track within them. This standard details the process of monitoring the track geometry and the actions required of KiwiRail staff when the outputs are received from the inspection vehicle. It also details the required actions of track staff when they manually identify a track geometry fault in the field.

It also sets out the track quality (TQI) targets for each of KiwiRail routes which align the standard with the required outputs from the business plan.

Document Control

Document No.	T-ST-AM-5120	**Issue No.**	Issue 1.0
Date Effective	3/03/2017	**Author**	Section 9(2)(a) - Privacy [redacted]
Prepared (P) **Reviewed (R)** **Amended (A)**	Section 9(2)(a) - Privacy [redacted]	**Checked and Approved By**	Track – Technical Committee
		Authorised for Release By	Professional Head – Track

Copyright

1. Revision Procedure and History

This standards document will need to be reviewed every five years or earlier if required.

If changes arise from the review, this standards document will be reissued. If no changes arise from the review, the current version of this standards document will remain in force.

Refer to the **EM80 Exceedance Values by Speed Category**

(at the end of this document) for full document changes.

Issue No	Prepared (P) Reviewed (R) Amended (A)	Authorised for Release By	Date Effective

1.1 Changes in this issue

Issue No	Description	Page(s)

1.2 Withdrawn, closed and superseded

Old Reference	Title	Replaced by
Track Code T003 P91	EM80 Track Geometry Exceedances – Classification and Action	T-ST-AM-5120
Track Code T003 P148	Clearances in Overhead Electrified Areas	T-ST-AM-5120
Track Code Supplement Section 35	Track Monuments	T-ST-AM-5120
Track Code Supplement Section 36	EM80 Exceedance Values	T-ST-AM-5120
Track Code Supplement CSP 37	Track Geometry	T-ST-AM-5120
Track Code Supplement Section 50	EM80 Track Evaluation Car	T-ST-AM-5120

2. Associated Documents

Level	Number	Title
3	T-ST-IN-5109	Track Inspection (will be issued at a later date)
3	T-ST-DE-5200	Track Design
3	T-ST-AM-5121	Speed Restriction
3	T-ST-MM-5709	Use of Track Materials

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3. Acronyms and Definitions

Acronyms	Definition
Calibration	Control checks to ensure that track geometry measurements by the TEC or track gauges are accurate and repeatable
Exceedance	An output from the TEC showing locations where any of the track geometry parameters being measured exceeds the allowable limits
RAMP	Route asset management plans (work activities planned for a route to deliver safety and the business targets)
ROCOCD	Rate of change of cant deficiency
SD	Standard Deviation – the distance in mm away from a perfect mean (see explanation in standard)
TEC	EM80 Track Evaluation Car
TG	Track Geometry – the vertical and horizontal alignment of the track
TG parameters	The track alignment and design features that are measured as part of track geometry recording (eg vertical and horizontal track alignment ‘top’ and ‘line’)
TQ	Track Quality: A measure of the track’s roughness (Good track quality – very smooth ride, poor track quality – rough ride)
TQAT	Track quality analysis table shows the track quality degradation or improvement over each 100 m section of the track run on run
TQI	Track Quality Index – a numeric figure derived from several of the track geometry parameters which gives a measure of overall track condition. The TQI can be derived for any section of track
TRACE	An output from the track recording vehicle which shows details of the track geometry parameters being measured by the TEC
Track Gauges	Measuring devices used by KiwiRail staff to measure cant and gauge
TRI	Tamp Required Index – a value calculated from top, line and twist parameters, useful for determining priority tamping sites and to evaluate the quality of tamping performance

4. Scope

This standard covers the track geometry monitoring of the track infrastructure through the use of track recording vehicles or as measured during manual track inspection. It covers:

- what track geometry, track quality and standard deviation are.
- the management of the track recording vehicle and its outputs.
- the engineering tolerance levels by route for all track geometry parameters measured.
- what actions are required if track recording or track inspection measurements indicate the geometry is outside of these acceptable engineering tolerance levels.
- the roles and responsibilities of staff involved in track geometry / track quality management and asset management of the track infrastructure.

4.1 Use in the field

This document has been designed to be used in the field. It is expected that this document will be opened in an iPad via ‘Briefcase’ and used as reference to complete the task. Note as written on the front cover the controlled version is held on iKon. **Printed copies of this document are uncontrolled**.

5. Track Geometry and Track Quality

5.1 General

The term ‘track geometry’ describes the horizontal and vertical alignment of track including gauge, curvature, transitions and gradients.

The quality of track geometry is based on measurement of various track parameters including top, line, gauge, cant and derived values such as twist, ROCOCD and cyclic line. These are recorded by the TEC which provides an indication of track quality under load. Where measured values exceed maintenance limits, these are recorded as ‘exceedances’. Exceedance limits for the track geometry parameters are set for the various line speed categories as specified in section 6.4 TEC exceedance limits.

5.2 Track geometry and standard deviation

Track geometry is measured in terms of standard deviations (SD) from a mean and the value of these SD's, reflect the quality of a particular track section. This is explained in the figure below and shows that the further the measured value (in mm) from the mean, the rougher the track becomes. Note each measured parameter will have a different SD. The measurements are taken with the TEC at 250mm intervals along the track.

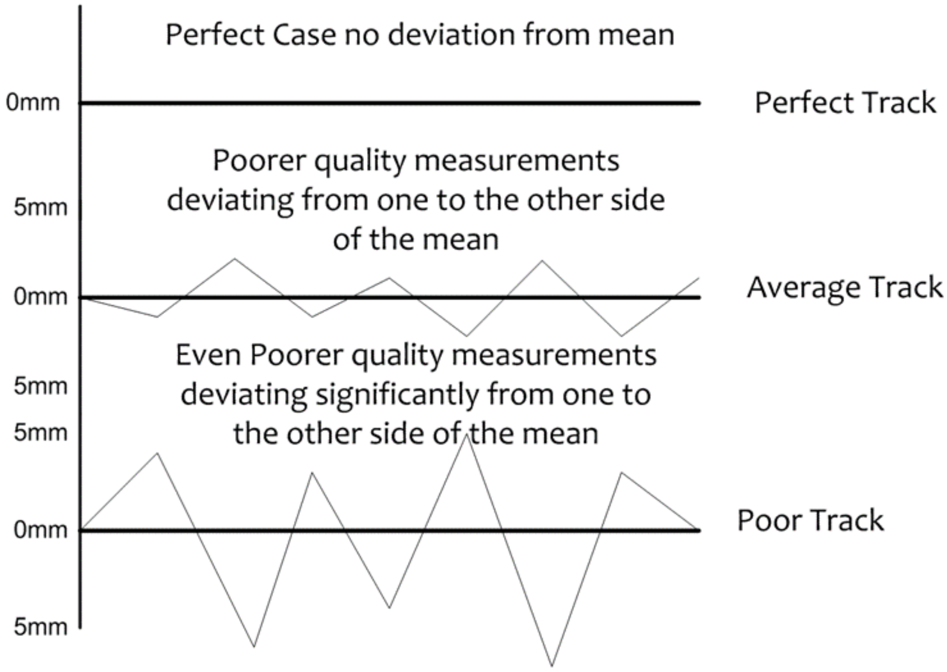

Figure 5.1 SD and track quality

For each of the line speed categories there is a SD limit (in mm) laid down for each parameter the TEC measures (eg twist, top, line). Figure 5.2 shows a measurement breaching the standard deviation limits creating an exceedance.

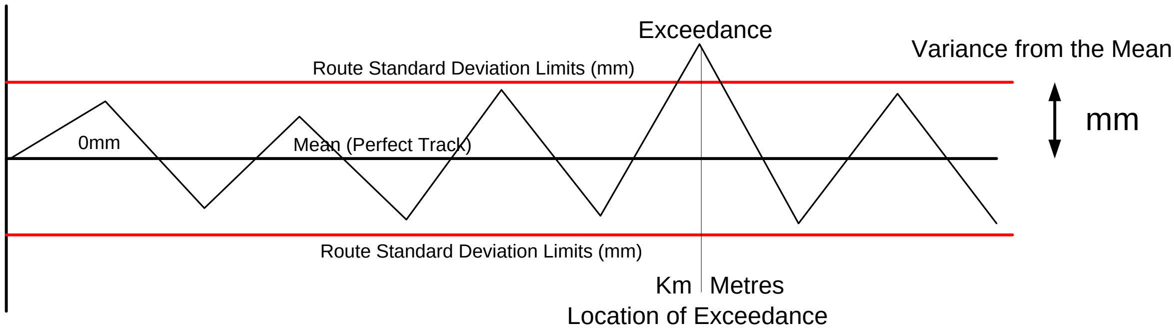

Figure 5.2 SD limits

5.3 Track quality explanation

Track quality is the roughness of the track as indicated by the track geometry parameters either in isolation or combined.

High quality track means track is generally smooth and provides a good ride for the passenger and lower rates of wear for the track and rail vehicles, thereby maximising the life cycle of each.

Conversely, poor track quality provides a rougher ride for the passenger and higher rates of wear for the track and rail vehicles increasing maintenance and renewals costs.

The track quality is calculated and expressed as a track quality index (TQI). This gives a quantitative figure for track quality; the lower the figure – the better the quality. The TQI can be calculated for any length of track and by route, refer to 5.4 for route targets.

5.4 Route TQI targets

Table 5.1 lists typical route TQI values for each line or line segment and corresponding target envelopes to guide maintenance and renewals plans. These are set by the Professional Head of Track and will be amended as changes in business plans occur.

Table 5.1 Example of target route TQI values by line segment

Line Segment	TQI Value	Acceptable Band
NAL - North Port	53.2	45 – 53
Auckland Metro	34.5	28 – 35
Auckland - Tauranga	30.3	28 - 35
NIMT – South of Hamilton	31.7	28 - 35
Forestry Routes	31.3	28 - 35
Milk Route	37.5	36 - 44
Whareroa – New Plymouth	42.0	36 – 44
Oringi – Napier	40.4	36 – 44
WL – Pahiatua to Woodville	45.3	45 – 53
Wellington Metro	43.3	36 - 44
MNL	34.2	28 – 35
Christchurch Urban Area	31.4	28 – 35
Coal Route – Midland	35.8	28 - 35
Coal Route – SNL	38.7	36 - 44
MSL	31.7	28 - 35
Dunedin Urban Area	43.7	36 – 44
Wairio	47.9	45 - 53

Line Segment	TQI Value	Acceptable Band
Bluff	49.5	45 - 53

It is the responsibility of the Asset Engineer to achieve the target values so that the route asset quality in TQ terms meets business targets for each route.

Note routes are not covered in the above must be maintained to be compliant with Track Engineering standards.

5.5 TRI and tamping

The TQI output by the TEC is based upon the standard deviation calculation of the track geometry parameters versine, top, twist, and gauge.

TRI provides an evaluation of track surface quality by omitting the gauge factor from the TQI calculation. It is therefore an indicator of the track condition which can be rectified by planned track surfacing activities.

5.5.1 Planning of tampers

The asset database can provide a TRI graph (Figure 5.3) which shows a distribution of TRI values for a selected line or line segment. From the graph, it can be seen that a certain percentage of the length of the selected line segment has a corresponding TRI value. This can be used to direct tamping intervention at the worst portions of the line, for example 20% highest TRI.

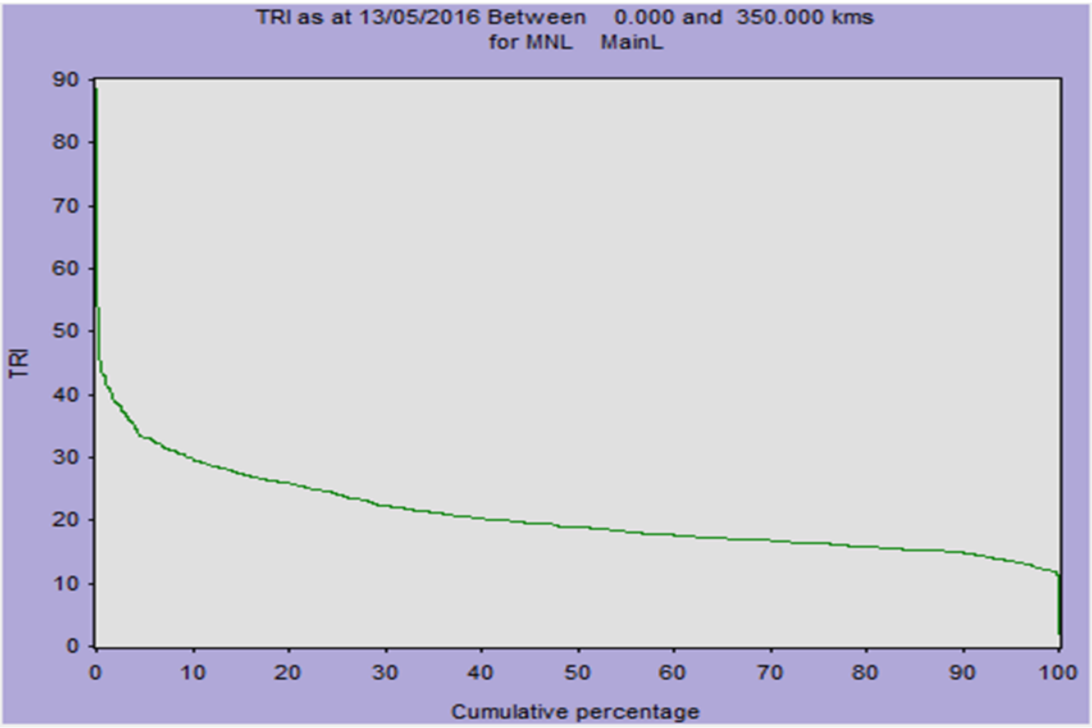

Figure 5.3 TRI graph

The example in this graph shows that the worst 20% of the MNL from a track surface quality perspective has a TRI value of approximately ≥25. This can be used to identify areas to be inspected for ballast and formation deficiencies and to plan restorative work with a tamper. Figure 5.4 lists sites between the 220 km and 260 km with TRI values greater than 25, which upon inspection may be included in a tamping programme.

TQI by GS												
19/10/2016												
Line	Track	From	To	Dist	Date	Type	Gauge	Twist	SF Av	AL av	TQI	TRI
MNL	MainL	221.382	221.403	21	19/10/2016	Turn	14.2	10.8	19.4	16.2	60.6	46.4
MNL	MainL	225.796	226.152	356	19/10/2016	Curv	10.2	9.7	7.8	7.7	35.4	25.2
MNL	MainL	226.873	227.697	824	19/10/2016	Curv	14.1	10.3	7.4	8.9	40.7	26.6
MNL	MainL	235.303	235.534	231	19/10/2016	Curv	8.8	8.9	9.9	6.9	34.5	25.7
MNL	MainL	235.534	235.699	165	19/10/2016	Tang	8.5	10.8	8.1	6.2	33.6	25.1
MNL	MainL	235.699	235.724	25	19/10/2016	Turn	9.2	9.2	13.1	15.8	47.3	38.1
MNL	MainL	236.804	236.828	24	19/10/2016	Turn	11.6	10.4	10.4	13.7	46.1	34.5
MNL	MainL	244.333	244.550	217	19/10/2016	Curv	9.8	11.8	6.2	8.9	36.7	26.9
MNL	MainL	245.752	246.060	310	19/10/2016	Curv	8.0	12.6	5.2	7.5	33.3	25.3
MNL	MainL	246.724	247.001	280	19/10/2016	Curv	13.5	11.1	10.5	13.3	48.4	34.9
MNL	MainL	247.001	247.018	17	19/10/2016	Tang	8.6	8.6	11.2	10.8	39.2	30.6
MNL	MainL	247.018	247.273	255	19/10/2016	Curv	21.7	11.2	7.9	8.6	49.4	27.7
MNL	MainL	247.349	247.529	180	19/10/2016	Curv	6.0	11.3	6.9	11.7	35.9	29.9
MNL	MainL	250.480	250.588	108	19/10/2016	Tang	3.7	13.5	6.7	5.7	29.6	25.9
MNL	MainL	250.588	250.731	143	19/10/2016	Curv	7.3	12.4	8.3	6.8	34.8	27.5
MNL	MainL	250.760	251.020	261	19/10/2016	Curv	14.5	11.4	6.0	10.6	42.5	28.0
MNL	MainL	256.599	256.699	100	19/10/2016	Tang	7.2	11.5	11.5	8.6	38.8	31.6
MNL	MainL	257.469	257.647	178	19/10/2016	Curv	12.0	11.1	7.6	9.5	40.2	28.2
MNL	MainL	257.647	257.668	21	19/10/2016	Turn	9.4	10.4	19.7	9.6	49.1	39.7
MNL	MainL	258.753	258.780	27	19/10/2016	Turn	7.4	8.4	13.3	12.2	41.3	33.9

Figure 5.4 TRI report

High TRI values are often identifiers of poor track conditions including mud spots or sections of poor jointed track. It is therefore important that before sections of track selected by this planning method are included on a tamping programme, sites must be checked to ensure 'tampability'. This will involve a check of formation and ballast profile and condition, and also integrity of the sleepers and fastenings.

The TRI can also be used to determine priorities for tamping requests.

5.5.2 Review of tamping operations

A review of track quality following maintenance and renewals works is required as described in section 11 Responsibilities for Managing Track Quality during Work Activities of this standard.

For tamping activities, this can be achieved by a visual check of the trace produced by the TEC. A more quantitative assessment is available through a review of the TRI values following tamping works as shown in the TRI report in Figure 5.4.

6. Track Evaluation Car

6.1 General

The EM80 Track Evaluation Car (TEC) is an automated track inspection vehicle running over designated routes at set frequencies. The TEC measures several geometric parameters of the track without obstructing normal railway operations. Measurement of these parameters is based on laser scanning systems, transducers, accelerometers and camera systems.

The train operates at a maximum recording speed of 60 km/h.

6.2 Frequency of recording by route

The Professional Head of Track will determine the frequency of runs based on the criticality of each route to the business, the risk on each and general track infrastructure condition.

This frequency will be reviewed at least every three years or when there is:

- An alteration to the business plan objectives affecting traffic flows on a route.
- A proposed change to heavier axle weight loading on a route.
- A proposed change to line speed.
- A need to carry out special analysis on a route due to track assembly, track component or substructure conditions.
- A change of rolling stock or locomotive type on a route.

Table 6.1 TEC run frequency

Line Class	Description	Run Frequency	Tolerance
Class A Metro	Auckland and Wellington Metro	Once every four months	Four weeks
Class A Non–Metro	Class A Lines and Lines with regular passenger services (Non–Metro)	Once every six months	Six weeks
Class B	Class B Freight Lines	Once every eight months	Eight weeks
Class C	Class C Freight Lines	Once every 12 months	Eight weeks
All	Loops and Yard Main Arrival/Departure Roads	Once every 12 months	Eight weeks

The above frequencies are minimum requirements and testing more than that specified is acceptable, including other roads in yards and terminals.

Notes:

1) The run frequency shown above does not include any runs required to carry out alternative mechanised track inspections.

2) Line classifications for all lines are listed in document T-ST-MM-5709 Use of Track Materials.

6.3 Parameters measured by the TEC

Table 6.2 Parameters measured by the TEC

Parameters	Description
Cant	The height of one rail above the other. Also known as 'cross level' or 'super elevation'.
Cyclic Line	Repeat alignment faults that have similar wavelengths.
Gauge Wide or Tight	The distance between the inside faces of the rail heads measured 16 mm below the running surface.
Line	The horizontal or lateral position of the track measured on both rails.
ROCOCD	The difference (rate of change) in the cant deficiency over a length of track.
Top	The longitudinal level of the running surfaces of the rail measured on both rails.
Twist	The variation in cross level over a base length of four metres.

Additional Parameters that may be measured / calculated by future TEC's	Description
Additional Camera Views of Infrastructure	Improves inspection and asset management capabilities.
Cyclic Top	Dips in the vertical profile that repeat at regular lengths along the track
Long Wheelbase Twist	Normally measured around 12 m wavelengths.
Rail Profile	Measurement of the rail head profile to track wear patterns.
Short Bogie Twist	Normally measured around two metres wavelengths.

6.4 TEC exceedance limits

Exceedances recorded by the Track Evaluation Car (EM80) are classified in Table 6.3.

- Class 1** is defined as at or above the maximum allowable limit and must be planned as detailed in section 0.
- Class 1 is defined as below the maximum allowable but above the maintenance tolerance limit and must be planned as detailed in section 0.
- Class 2 is defined as at the acceptable maintenance tolerance limit and should be planned as a normal maintenance activity to bring within tolerance.

Table 6.3 EM80 Exceedance values for all classes of faults

EM80 Exceedance Values All Classes							
Curve Radius	Speed Category	1	2	3	4	5	Class Value
	Line Speed	over 71	51-70	41-50	26-40	25 and under	
All track	Gauge Wide	1095	1095	1096	1097	1097	1**
		1092	1092	1093	1094	1094	1
		1088	1088	1089	1090	1090	2
> 250 m	Gauge Tight	1054	1054	1054	1054	1054	1**
		1056	1056	1056	1056	1056	1
		1058	1058	1058	1058	1058	2
< 250 m	Gauge Tight	1056	1056	1056	1056	1056	1**
		1058	1058	1058	1058	1058	1
		1060	1060	1060	1060	1060	2
< 800 m	Cant	24	24	26	28	30	1**
		19	19	21	22	24	1
		17	17	18	19	21	2
> 800 m	Cant	24	24	26	28	30	1**
		19	19	21	22	24	1
		17	17	18	19	21	2
All track	Top	22	27	31	35	40	1**
		18	22	26	31	36	1
		16	19	23	27	32	2
All track	Twist	24	24	25	26	28	1**
		18	19	20	21	24	1
		16	17	18	18	20	2
> 499 m	Versine	27	30	34	40	50	1**
		18	20	25	30	36	1
		16	18	23	27	32	2
451 m to 499 m	Versine	27	27	34	40	50	1**
		20	20	25	30	36	1

EM80 Exceedance Values All Classes							
Curve Radius	Speed Category	1	2	3	4	5	Class Value
	Line Speed	over 71	51-70	41-50	26-40	25 and under	
		16	18	23	27	32	2
275 m to 450 m	Versine Radius dependent	27-36	27-41	34-46	40-51	50-62.5	1**
		20-27	20 -30	25-34	30-38	36-45	1
		16	18	23	27	32	2
< 275 m	Versine	36.5	40.5	46.2	50.7	62.5	1**
		27	30	34	38	45	1
		16	18	23	27	32	2
All track	ROCOCD	340	340	340	340	340	1**
		280	280	280	280	280	1
		200	240	240	240	240	2
All track	CYCLIC Line	5	5	5	5	5	1**
		4	4	4	4	4	1
		3	3	3	3	3	2

Notes:

1) The radius bands for versine tolerances vary for each speed category.
2) EM80 Exceedance Value tables for each speed category are included in Appendix 1 of this standard.

6.5 Actions to be taken when the TEC runs

6.5.1 Mandatory attendance on the TEC

Asset Engineers or one of their delegated representatives must attend all TEC runs. This is to ensure large exceedances are prioritised for correction and all traces and exceedance reports are forwarded to production staff for action (normally the Ganger in charge of the section) within 24 hours of the run. When only loops are being recorded, it is not necessary for a representative to be on board the car. However, for any unattended run, it is important that Asset Engineers ensure that arrangements are made with the car operator for the Ganger to receive the exceedance reports within 48 hours. Class 1** gauge and twist exceedances recorded during an unattended run, which are classified as U1 or P1 priority as per Table 6.1 and Table 7.1, must be advised in writing to the Asset Engineer when the TEC completes the days run or completes the track section any Asset Engineer is responsible for.

6.5.2 Inspection and prioritisation of exceedances

The appropriate track interventions are to be determined following a detailed inspection of the exceedance within the timeframes specified in Figure 6.1. Work will be prioritised if necessary by the Asset Engineer. Prioritisation may be required when there are multiple exceedances reported of the same class.

The highest priority is to be placed on repairing Class 1** exceedances. Generally twist and wide gauge are to be programmed for corrective action first and Asset Engineers must take appropriate action to ensure this work is undertaken.

Asset Engineers must also review Class 1 exceedances for twist and wide gauge as these exceedances may only be 1–2 mm below the threshold for a Class 1** exceedance. Appropriate action must be taken with these exceedances to ensure timely programming for the work to be done.

6.5.3 Actions to be taken where exceedances cannot be repaired within required timescales

If it is not possible to achieve the repair on a Class 1** or Class 1 exceedance within the required timescales, it is the responsibility of the Asset Engineer to ensure that mitigations are in place until the repair is completed. This will be through routine or special inspections, as directed by the Asset Engineer and is to ensure that the track is still suitable for the passage of trains under any operating restriction that may be in place. Inspections are to continue until the exceedance is corrected.

This process is to be recorded on the M91 form.

Where the number of exceedances is so excessive that all exceedances cannot be individually checked, a representative sample must be checked.

In the case of a route having a significant amount of exceedances reported that are unlikely to be rectified within the required timescales, the Asset Engineer must undertake the following actions (also refer to Figure 6.1).

Within seven days:

- Develop a prioritised action plan with the Production Manager to remove all exceedances as soon as reasonably practical.
- Ensure this is prioritised so that serious exceedances are removed in a sequence based on the risk at each site.
- Ensure speed restrictions are appropriately imposed, lengthened or blanketed along the route dependant on the action plan to maintain the safety of trains.
- Ensure additional inspections are undertaken regularly where necessary to manage risk.
- Report on overdue Class 1** exceedances in the quarterly M120 compliance report to the Professional Head – Track, stating mitigations taken and proposed rectification plans.

All outstanding exceedances not corrected prior to a subsequent run will become null and void if not re-detected. For remedial action priorities, the date of the latest run is deemed to be the date the exceedances are recorded.

6.5.4 Review of TEC exceedance reports

Asset Engineers must review exceedance reports and compare with past recordings to identify trends for appropriate action and potential changes in the RAMP plan. Repeat exceedances must be given special attention. Where previous repairs have proven to be ineffective, the Asset Engineer should seek technical advice from Track Engineering.

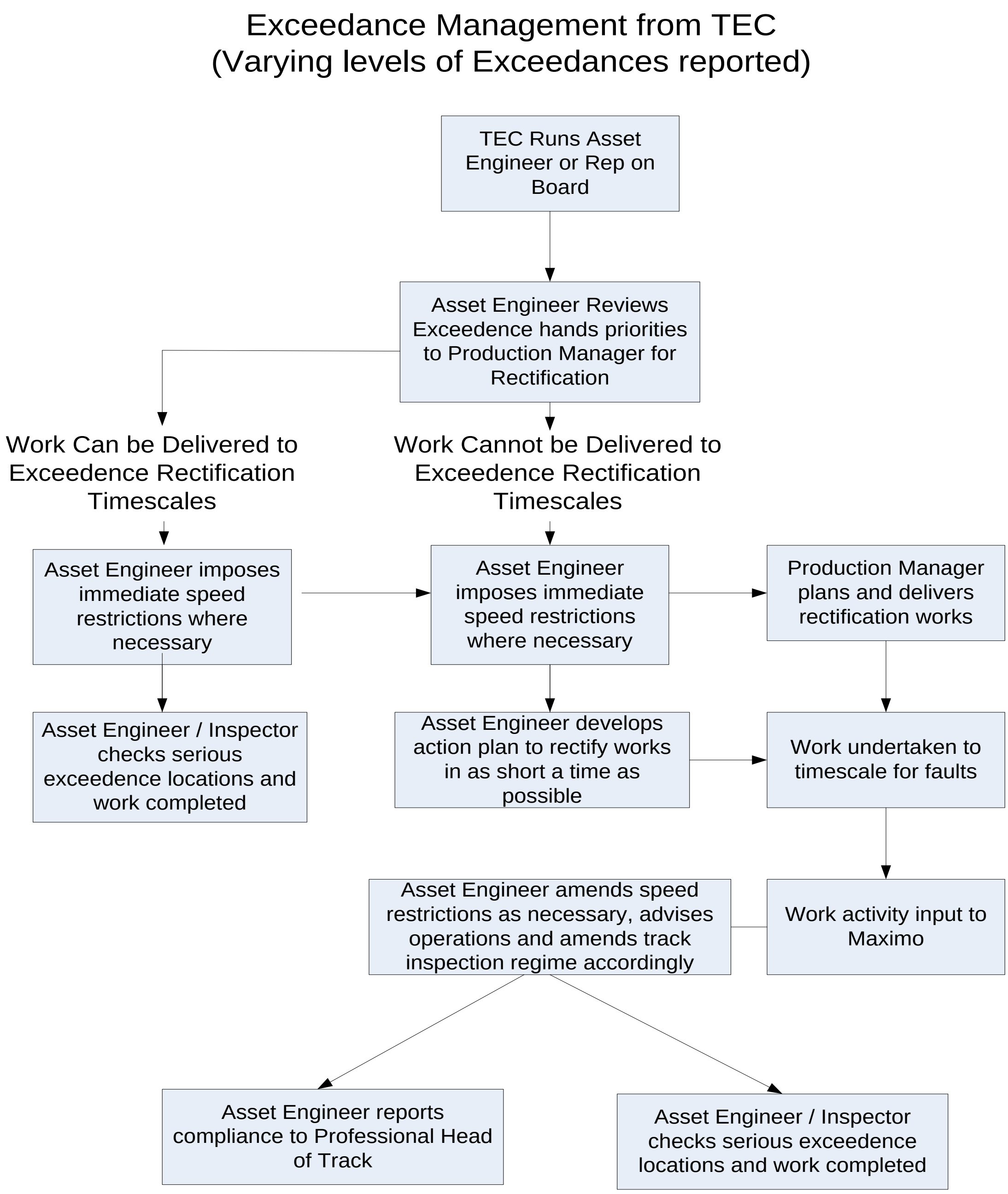

Figure 6.1 TEC exceedance management

7. Repair and Safety Actions for TEC Track Geometry Exceedances

7.1 TEC response categories and TSR's required

Table 7.1 indicates the response categories for the various classes of exceedance, the timescales for inspection and repair, and the required safety actions.

In the case of Class 1** wide gauge and twist exceedances (priorities U1, P1 and P2), the TSR's are to be imposed **immediately** following notification from the TEC.

All other prescribed safety actions are to be implemented following a detailed inspection of the exceedance within the timescales stated in Table 7.1.

Table 7.1 TEC Repair and safety actions

Response Category	Class	Maximo Pty	Inspect and Verify Response	Safety Action	Repair Action
Immediate - U1	1**	1	Before next train	Close line until repaired	Before next train
Priority 1 - P1	1**	3	Within 24 hours	TSR of 25	Within two days
Priority 2 - P2	1**	6	Within three days	TSR of 40	Within seven days
Priority 3 - P3	1	10	Within 14 days	TSR of 60[1]	Within four weeks
Priority 4 - P4	2	16	Within three months	Nil	Within six months
Normal (N)	-	-	Routine Inspection	Nil	Routine Inspection
[1]P3 gauge, twist, and cant exceedances require a safety action of 40 km/h. **Note for speed category 3, 4 and 5 lines**					
Priority 1 - P1#	1**	6	Within 24 hrs	TSR of 25	Within seven days
Priority 2 - P2#	1**	8	Within three days	TSR of 40	Within 14 days

7.2 Assessment of repair and safety actions

Inspection of exceedances reported by the TEC must be done by a competent person to determine the correct response.

The following guidelines and assessment tables are to be used to determine the correct repair and safety actions.

7.2.1 Guidelines

The detailed inspection will take into account the condition of track components and the existence of other track exceedances in the immediate vicinity. The stability of the track and the potential for rapid deterioration of the fault should be taken into account in determining the required mitigation. Where further deterioration is eminent, a more urgent response or lower speed restriction may be warranted until repairs are completed.

This is particularly relevant where for example:

- gauge exceedances are caused by failure of fastenings
- a twist is recorded at a mudhole or poorly drained area of formation
- large top exceedances occur at short plated joints and
- cant run-out is steeper than the maximum allowable limit.

7.2.2 False readings

The TEC may give readings that, on initial examination, appear to be larger than expected. In this instance, action is required to inspect and verify the exceedance in the field. TEC geometry traces must also be reviewed to verify false recordings. This is particularly important where the exceedance is at Class 1** level. Exceedances which have been verified as false by the process described above may be managed out of the work bank database in accordance with established processes. This can be relevant to tight gauge and line exceedances recorded in turnouts.

7.2.3 Assessment tables

The following assessment tables are to be used to determine the correct repair and safety actions for each of the track geometry parameters.

Table 7.2 Response to twist exceedances found by TEC

Twist	Line Speed Category				
4 m	5	4	3	2	1
	< 26	26 - 40	41 - 50	51 - 70	71 - 110
<16	N	N	N	N	N
16-17	N	N	N	P4	P4
18-19	N	P4	P4	P3	P3
20	P4	P4	P3	P3	P3
21-23	P4	P3	P3	P3	P3
24	P3	P3	P3	P2	P2
25	P3	P3	P2#	P2	P2
26-27	P3	P2#	P2#	P2	P2
28-31	P1#	P1#	P1#	P1	P1
32-34	P1#	P1#	P1#	U1	U1
>34	U1	U1	U1	U1	U1

Table 7.3 Response to wide gauge exceedances found by TEC

Gauge	Line Speed Category				
	5	4	3	2	1
	< 26	26 - 40	41 - 50	51 - 70	71 - 110
<1088	N	N	N	N	N
1088	N	N	N	P4	P4
1089	N	N	P4	P4	P4
1090-1091	P4	P4	P4	P4	P4
1092	P4	P4	P4	P3	P3
1093	P4	P4	P3	P3	P3
1094	P3	P3	P3	P3	P3
1095	P3	P3	P3	P2	P2
1096	P3	P3	P2#	P2	P2
1097	P2#	P2#	P2#	P2	P2
1098-1104	P1#	P1#	P1#	P1	P1
>1104	U1	U1	U1	U1	U1

Table 7.4 Response to tight gauge exceedances found by TEC

GaugeT	Line Speed Category				
Rad<250	5	4	3	2	1
	< 26	26 - 40	41 - 50	51 - 70	71 - 110
>1060	N	N	N	N	N
1059-1060	P4	P4	P4	P4	P4
1057-1058	P3	P3	P3	P3	P3
<1057	P2#	P2#	P2#	P2	P2
Rad>250	5	4	3	2	1
	< 26	26 - 40	41 - 50	51 - 70	71 - 110
>1058	N	N	N	N	N
1057-1058	P4	P4	P4	P4	P4
1055-1056	P3	P3	P3	P3	P3
<1055	P2#	P2#	P2#	P2	P2

Table 7.5 Response to line exceedances found by TEC

Line	Line Speed Category				
	5	4	3	2	1
	< 26	26 - 40	41 - 50	51 - 70	71 - 110
Class 2	P4	P4	P4	P4	P4
Class 1	P3	P3	P3	P3	P3
Class 1 **	P2#	P2#	P2#	P2	P2

Note For curves less than 499 metres radius, absolute line exceedance values vary with a change in radius as shown in Table 6.3. Therefore, safety and repair actions are to be determined from the simplified table above.

Table 7.6 Response to top exceedances found by TEC

Top	Line Speed Category				
	5	4	3	2	1
	< 26	26 - 40	41 - 50	51 - 70	71 - 110
<16	N	N	N	N	N
16-17	N	N	N	N	P4
18	N	N	N	N	P3
19-21	N	N	N	P4	P3
22	N	N	N	P3	P2
23-25	N	N	P4	P3	P2
26	N	N	P3	P3	P2
27-30	N	P4	P3	P2	P2
31	N	P3	P2#	P2	P2
32-34	P4	P3	P2#	P2	P2
35	P4	P2#	P2#	P2	P2
36-39	P3	P2#	P2#	P2	P2
>39	P2#	P2#	P2#	P2	P2

Table 7.7 Response to cant exceedances found by TEC

Cant	Line Speed Category				
	5	4	3	2	1
	< 26	26 - 40	41 - 50	51 - 70	71 - 110
<17	N	N	N	N	N
17	N	N	N	P4	P4
18	N	N	P4	P4	P4
19-20	N	P4	P4	P3	P3
21	P4	P4	P3	P3	P3
22-23	P4	P3	P3	P3	P3
24-25	P3	P3	P3	P2	P2
26-27	P3	P3	P2#	P2	P2
28-29	P3	P2#	P2#	P2	P2
>29	P2#	P2#	P2#	P2	P2

Table 7.8 Response to ROCOCD exceedances found by TEC

ROCOCD	Line Speed Category				
	5	4	3	2	1
	< 26	26 - 40	41 - 50	51 - 70	71 - 110
<200	N	N	N	N	N
200-239	N	N	N	N	P4
240-279	P4	P4	P4	P4	P4
280-339	P3	P3	P3	P3	P3
>339	P2#	P2#	P2#	P2	P2

Table 7.9 Response to cyclic line exceedances found by TEC

Cyclic Line	Line Speed Category				
	5	4	3	2	1
	< 26	26 - 40	41 - 50	51 - 70	71 - 110
<3	N	N	N	N	N
3	P4	P4	P4	P4	P4
4	P3	P3	P3	P3	P3
5	P2#	P2#	P2#	P2	P2

8. Manual Track Geometry Maintenance Tolerances

8.1 Response categories for manually found faults

Track staff such as Track Inspectors, Gangers, Engineers and Managers may observe and measure track geometry faults as they undertake field operations.

These must be measured with a track gauge, or observed (when measurement cannot be undertaken) as track geometry faults and recorded on a M125 form. All faults must be given an appropriate priority action as specified in

Table 8.1.

Table 8.1 Priority action table

Response Category	Maximo	Action
P1	Maximo 3	Apply immediate 25 km/h TSR and repair within 48 hours.
P2	Maximo 6	Apply immediate 40 km/h TSR and repair within seven days.
P3	Maximo 10	Consider need for TSR and repair within four weeks.
P4	Maximo 16	Consider need for TSR and repair within 26 weeks.
P5	Maximo 17	Repair within 52 weeks.

8.2 Tolerances for manually found faults

Apply the tolerances in Table 8.2 for all mainline track and yard faults according to the speed category (SC) of the line.

Consideration has to be made for the additional vertical and lateral loading when compared to static measurements. For example if the twist is measured as 23 mm (priority P2 in the table), expect it to be worse and significantly so, if the track substructure is poor (eg in a mud spot).

Table 8.2 Priorities of manual track geometry maintenance tolerances

	P1	P2	P3	P4	P5
Twist					
SC1	24	18	16	14	12
SC2	24	19	17	15	13
SC3	25	20	18	16	14
SC4	26	21	19	17	15
SC5 and Yards	26	24	20	17	15

Top

	P1	P2	P3	P4	P5
SC1	22	19	16	13	10
SC2	27	22	19	16	13
SC3	31	26	23	20	17
SC4	35	31	27	24	21
SC5 and Yards	40	36	32	28	24
Cant					
SC1	24	19	17	15	13
SC2	24	19	17	15	13
SC3	26	21	18	16	14
SC4	28	22	19	17	15
SC5 and Yards	30	24	21	18	16
Wide Gauge					
SC1	1095	1092	1088	1085	1082
SC2	1095	1092	1088	1085	1082
SC3	1096	1093	1089	1086	1083
SC4	1097	1094	1090	1087	1084
SC5 and Yards	1097	1094	1090	1087	1084
Tight Gauge (all speed categories) Construction standard					
1074 mm	1054	1056	1058	1060	1062
1068 mm	1052	1054	1056	1058	1060

Note any approved manual track recorder, for example, the Amber Trolley shall use the values shown in the above table.

8.3 Guidelines to assessing priority

8.3.1 Twist

The priority is to be worsened by one level (eg P2 to P1) if the twist fault is measured where there are poor substructure conditions (eg mud spots), poor track condition (eg poor sleepers at a joint), or where multiple faults can be seen and the twist is likely to be far more severe than as measured statically. Void meters should be used to determine actual deflection values under load which will be added to measured values.

8.3.2 Top

The priority is to be worsened by one level (eg P2 to P1) if the top fault is observed where there are poor substructure conditions (eg mud spots, poor drainage), poor track condition (eg a low joint), or where multiple faults can be seen and the impact of rough riding on rail traffic suspension systems is likely to be severe.

Top faults are significant where dip angles at short fishplated joints are high – this can lead to bolthole cracking and failure of fishplates.

Void meters should be used to determine actual deflection values under load which will be added to measured values.

It is often difficult to determine the size of a top fault found during manual inspection. Where the fault cannot be accurately measured, the priority can be determined as follows:

P5 Deformation minor, track surfacing optional

P4 Deformation moderate, track surfacing necessary

P3 Deformation significant, some ballast contamination or a low joint, further deterioration likely. Track repairs to programme

P2 Rough top, heavy ballast contamination or significant rail end batter, further deterioration certain, TSR required. Track repairs essential

P1 Very poor top, muddy ballast or badly dipped joints, significant voiding under traffic. Immediate action required, maximum speed of 25 km/h

8.3.3 Wide Gauge

The priority is to be worsened by one level (eg P2 to P1) if the gauge is measured where there are clear signs of bedplate pushing or punching over three or more consecutive timber sleepers or where there are signs of insulator failure on concrete sleepers. In determining the correct priority, the inspection must ascertain whether further deterioration is likely – in other words, is the track well secured against further widening? Where wide gauge readings are a result of high leg railwear, the wear limits must also be within the rail wear standard.

If a dynamic track gauge is used the response categories are to be the same as those shown in

Table 7.3 Response to wide gauge exceedances found by TEC.

8.4 Track geometry faults above P1 tolerances

When an inspection reveals track geometry at or above P1 tolerances, record the non-compliance and advise the Asset Engineer of the issue. Take one of the actions shown in the table below depending on the conditions of the track.

Step	Action
1.	Place a more restrictive TSR over the affected track section
2.	Pilot trains over the affected track section until track is repaired, also applying action 1
3.	Stop all train movements over affected track until track is repaired. **Note this applies to twist faults over 35 mm and gauge faults over 1105 mm no matter what Speed Category line.**

9. Outputs from TEC and Required Actions

The Track Evaluation Car outputs track exceedances and traces for the track geometry parameters it measures. It also analyses and produces a report of track quality indices at 100 m intervals. These TQI values can be incorporated into a Track Quality Analysis Table (TQAT).

Track Exceedances and their rectification are explained in sections 6 and 7.

9.1 Track geometry traces

Track Geometry traces show the trace line for each of the parameters the TEC measures. Figure 9.1 shows a typical trace output.

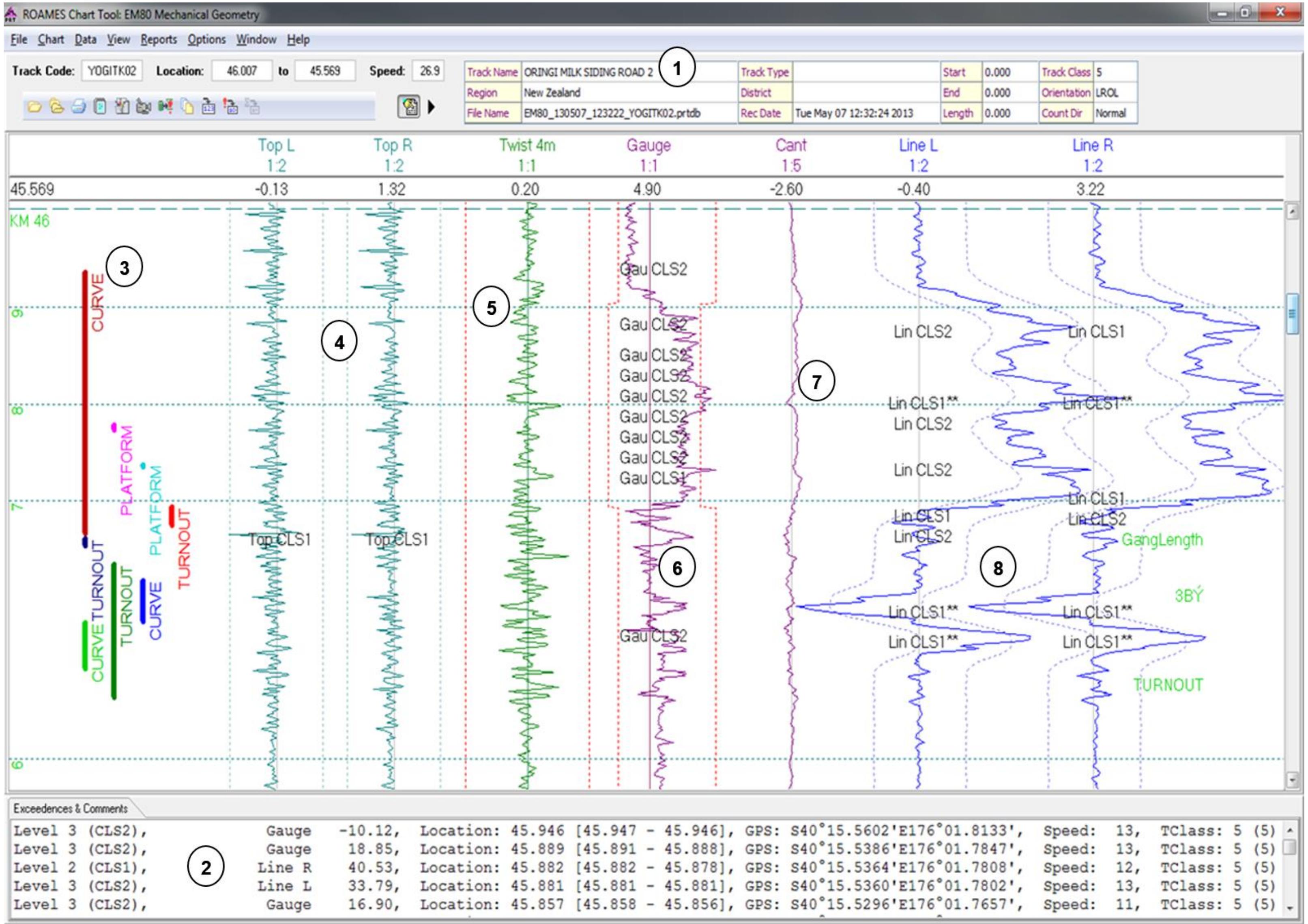

Figure 9.1 Example of EM80 trace output

1) Run Details
Top of the trace indicates line speed, class, date of run track sections and track reference.
2) Exceedances found
Bottom of the page, a list of exceedances is given with location and what parameter they cover.
3) Track Attributes
Left hand side of the trace indicates physical attributes of the track (eg turnouts) and the alignment of the track (eg location of curves)
4) Top recording
First two vertical lines show the 'top' (vertical alignment) for left and right rails.
5) Twist recording
Next line shows the trace line for "twist". The Class 1** limit lines are shown as dotted red lines. On this section of track the peaks are all within the Class 1** limits so there are no exceedances.
6) Gauge recording
Next vertical line indicates the gauge of the track. The graph shows gauge exceedances are present where the graph cuts the Class 1** limit lines.
7) Cant recording
Followed by the cant readings. It can be seen by observing the full trace above that the track is on a curve however the track design has not canted the track.
8) Line recording
The final two vertical trace lines cover the horizontal alignment measured for each rail. Exceedances are noted on the graph (Class 1** where the lines cut the dotted blue limit lines).

The Asset Engineer or their delegate must review these traces within four weeks of receiving them and initiate changes to RAMPs or carry out further detailed investigation where required.

The ROAMES visualisation system is to be used for the analysis of the track sections identified as blue or red on the TQAT.

9.2 Track quality analysis table (TQAT)

Figure 9.2 shows an example of the TQAT that is to be used by the Asset Engineer and staff for reviewing movements in the track quality trends and refining the route asset management plans.

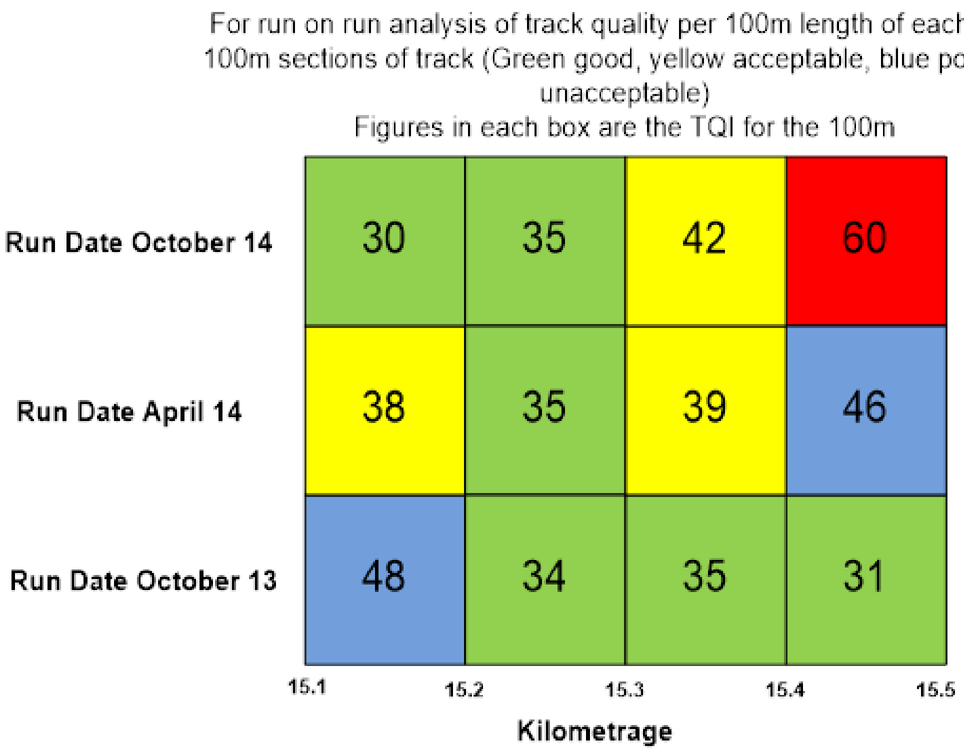

Figure 9.2 Track quality analysis table (TQAT)

Figure 9.2 shows that the track between 15.4 and 15.5 km/h has deteriorated badly and that it requires urgent intervention to address the risk.

Conversely it shows that the track condition between 15.1 and 15.2 km/h has improved in condition due to track interventions.

The Asset Engineer must review the deterioration and improvement shown on the analysis table and:

- input or amend work held in the RAMP
- review the risk and instigate measures, as applicable, where emerging track degradation rates are either showing or moving towards high TQI values
- review the impact of intervention like track renewals or heavy maintenance activities such as formation repair on TQI levels.

10. Responsibilities for Managing Track Geometry Recording and Outputs

10.1 Key responsibilities

Table 10.1 identifies the key responsibilities for the management of track geometry and track quality.

Table 10.1 Roles and responsibilities

Responsibility	When	Action Required
Professional Head of Track	Every three years	Review TEC run frequencies in light of business plan changes and risk. Advise National Planning Resource Service Manager of the required recording frequencies.
Professional Head of Track	Annually	Set and review TQI limits for red, blue, yellow and green bands in TQAT's.
National Planning Resource Service Manager	Annually	Prepare detailed programme as per required frequency for each route and run the TEC to this programme.
National Planning Resource Service Manager	As required	Undertake calibration of the TEC and report validation findings to Professional Head of Track.
Asset Engineer and Production Manager	Immediately after TEC results received	Programme production staff to remove exceedances prioritised on severity and type of exceedance and the criticality of location.
Field Asset Engineer / Track Inspector	Immediately after TEC results received	Develop scope for each EM80 exceedance site such that repair activities remove not only the symptom but the underlying cause of each fault.
Asset Engineers / Field Asset Engineer	Within four weeks of receipt	Review traces and identify work activities that need to be entered into RAMP and/or where prioritisation of work already entered requires changing.
Asset Engineer	Within four weeks of TEC run	Review route TQI figure against target and undertake TQI analysis of at risk track sections to determine degradation rates and necessary interventions.
Asset Engineer	Within four weeks of TEC run	Review TQAT for track degradation / improvement and amend RAMP plans / risk mitigation actions as necessary
Field Asset Engineer	Within four weeks of TEC run	Review TQI over major maintenance work activities undertaken to check quality improvements (eg tamping / mud spot repairs).
Professional Head of Track	Within audit schedule	Monitor compliance to this standard.

10.2 Vehicle management and calibration

10.2.1 Vehicle management

The TEC will be managed by the National Planning Resource Service Manager to develop the outline programme from the run frequency advised by the Professional Head of Track.

10.2.2 Calibration

The TEC must undergo a calibration check prior to each recording run. This is carried out on a selected track section with outputs checked and verified against manual measurements and previous outputs.

Any errors found during calibration are to be rectified by the EM80 Technical Officer.

Records of calibration tests are to be kept on the TEC with errors found and rectification measures undertaken clearly stated. These records are to be retained for 36 months.

Serious faults found during operation or calibration must be reported to the Professional Head of Track if they are going to affect the proposed run frequency.

The Professional Head of Track will audit the TEC's calibration regime to ensure the reliability and repeatability of the vehicle outputs are robust and confidence in the results can be maintained.

10.3 Monitoring of track quality and degradation rates

Monitoring of track quality and its degradation will be the responsibility of the Asset Engineers and their staff.

Monitoring and analysis of track quality and its degradation / improvement rates will be achieved by:

- reviewing the numbers and locations of exceedances.
- detailed analysis of repeat track exceedance sites (through track geometry and site analysis).
- analysis of the track geometry traces from the TEC.
- analysis of the TQAT's to determine key risk areas and plan improvement interventions.
- Analysis of the current route TQI values against business plan targets.
- Comparisons of previous runs.

The Professional Head of Track will also monitor track quality for analysis and business planning / reporting purposes.

10.4 Actions to plan and execute work on sections of track approaching TQI safety limits

It is the responsibility of the Asset Engineer and their staff to analyse, scope and plan track interventions as appropriate to ensure safety of traffic is maintained in red track sections that are approaching the maximum set TQI limit. These actions are to be planned into the RAMP wherever possible.

Actions may consist of one or combinations of the following as appropriate to the site conditions and the TQI degradation rate:

- Blockage of the line, until rectification works have been undertaken.
- The imposition or enhancing of a temporary speed restriction.
- Urgent re-prioritisation of intervention works in the RAMP to allow interventions on the affected site.
- Immediate action (eg improve drainage systems if this is a major cause of the track problems).
- Increase inspection frequencies to monitor degradation and the impact of intervention work.

11. Responsibilities for Managing Track Quality during Work Activities

The Production Manager must ensure that the track design is established during all work activities and that all relevant standards for construction activities have been met.

This includes the technical supervision of excavation works and the reinstatement of the track and its substructure to the necessary design.

This is to ensure that work activities realise a significant improvement in track quality.

11.1 Review of track quality before work commences and at completion

The key aim of track interventions is that once made, the track will be returned to a much higher quality and that further interventions will not be required for a significant period.

Most track interventions will require a design and it is expected that the design will improve the track geometry across each site.

To assist with the scoping and design of track intervention works, the Asset Engineer must review the current track geometry using TEC geometry traces, TQAT's and site analysis as necessary. Recommendations for improvements from this analysis will be built into the design.

Following the track intervention the Asset Engineer will check the quality of the intervention following the next TEC run and assess the quality improvement. For track surfacing activities, a review of the TRI values is required (refer to section 5.5.2). If the track quality has not been improved, the underlying reasons for this will be analysed by the Asset Engineer and the Production Manager.

11.2 Requirement to maintain / improve TQ during maintenance interventions

Maintenance interventions must be aimed at improving track quality on track sections where this is an issue. Specification of works must ensure vertical and horizontal alignment is improved and that the design cant, where appropriate, is provided.

11.3 TQ requirements for renewals and life extension interventions

11.3.1 Track renewal operations

The track quality requirements for a track renewal activity involving re-sleepering, re-railing and or re-ballasting (and combinations of these) will be expected to return the track sections affected by the renewal to a green category (good track quality).

11.3.2 Life extension operations

The track quality requirements from a medium or heavy track life activity involving multiple maintenance treatments, such as replacement of fastenings, will be expected to return the track sections affected by the renewal to at least a yellow category (satisfactory track quality).

11.4 TQ design for bridges, level crossings and turnouts

It is imperative that track quality on the approaches to and over bridges, level crossings, and turnouts is of a high standard so that additional dynamic forces are not imposed on these structures leading to premature failure of components.

The Asset Engineer must monitor these locations through TQAT, trace and visual observation and ensure that all substandard approaches to structures have the necessary work identified and planned within the RAMP.

12. Gauges and Equipment for Measuring Track Geometry

12.1 Measuring equipment to be held

The Asset Engineer and Production Manger must ensure that staff has correctly calibrated measuring equipment to monitor track geometry and condition.

The list of equipment to be maintained should include:

- Track Gauges for measuring cant and gauge.
- Dynamic track gauges for measuring gauge when trains are passing suspected gauge problem areas.
- Rail head profile gauges.
- Rail gauges for switch blades and frogs.
- Straight edges for the monitoring of welding.
- Sighting boards for the measurement of vertical track alignment[1].
- Void meters for measuring voiding of the track assembly.
- Hallade measurement sets.
- An electronic measurement trolley for recording track geometry parameters (used for maintenance activities and proving track quality on completion of renewals, such as Amber Trolley).
- Calipers or sliding calipers for the measurement of the railhead, web and foot.
- Measuring wheel for measuring longitudinal distances along the track.
- Nylon tape measures of varying lengths (metal tapes are prohibited).
- Rail thermometers for measuring rail temperatures.

12.2 Calibration

Asset Engineers are responsible for ensuring that all track gauges are calibrated and that other measuring equipment is not damaged and is fit for purpose. Calibration requirements for all gauges and equipment are specified in document T-ST-AM-5600 Calibration of Measurement Equipment.

[1] Repair of 'top' without the use of gauges and sighting boards is prohibited.

13. Track Geometry Management

13.1 Curve records

For each curve on the network the Asset Engineer must ensure that the following curve records are maintained in the asset database:

- Kilometrages of 'S' and 'CTP' points (marking the start and end) for all transitions. Note CTP points may be excluded if transition length shown.
- Radius.
- Actual cant.
- Length of transitions.
- Run off of cant.
- Authorised curve speed.

The Asset Engineer must update these records whenever any alterations are made to the track. Updated copies of curve lists must be made available to and held by Production Managers and Gangers. Checks of existing records must be made.

The position of each 'S' and 'CTP' should be marked at the appropriate track locations.

Where realignment of track, or alteration to cant on curves is being considered, particular attention is required to ensure that side and overhead clearances to electric overhead, structures and other physical features are not impaired.

13.2 Managed track

13.2.1 Definition

'Managed Track' is a classification where the position of ballasted track is strictly controlled so that close tolerance clearances to the overhead lines equipment system (OLE) can be maintained. These areas are monumented by data plates and the area affected listed in the asset database.

In addition to the OLE, all tunnels, platforms and other restricted areas such as those with limited overhead clearance and or side clearance reduced to 2.6 m from centreline (eg overbridge, are regarded as 'Managed Track').

Track must be maintained to specified tolerances in this standard and no work in these areas altering the alignment or track level shall take place without the approval of the Asset Engineer.

13.2.2 Track tolerances

The permissible variations from line (horizontal position), level (vertical position) and cant shown on track data plates (TDP's) attached to the adjacent traction poles are shown in

Table 13.1.

Table 13.1 Track tolerances for managed track

Track Parameter	Normal Track Tolerance	Tolerances for 'Managed Track'
Line (horizontal position) - straights and curves above 800 m radius	25 mm to TDP	25 mm to TDP
Line (horizontal position) - curves less than 800 m radius	50 mm to TDP	10 mm to TDP
Level (vertical position) (set to low rail on curves)	25 mm to current tamped level	25 mm to TDP
Cant	15mm to TDP	10 mm to TDP

13.2.3 Track maintenance allowance

The design of the traction overhead has a built in 'track maintenance allowance' for heavy track maintenance including tamping which allows the track to be lifted up to a maximum of 150 mm from the 'Design Rail Level' (level at which track is initially laid, or design level as determined by Track Engineering) for normal open ballasted track. When the track maintenance allowance of 150 mm has been reached and further tamping is required, the track must be re-instated to the 'Design Rail Level' as shown on the TDP.

For 'Managed Track' the track may only be lifted to a maximum of 50 mm. When this track maintenance allowance of 50 mm has been reached and further tamping is required the track must be re-instated to the 'Design Rail Level' as shown on the TDP.

13.2.4 Level crossings

At level crossings, track must not be lifted or lowered more than 25 mm without prior consultation with the Traction Supervisor Overhead who will ensure the required clearances to the roadway can be maintained. Once the planned track lift is completed there may be a need to re-adjust the overhead contact wire height to retain the required clearances.

13.2.5 Variations to specified standards

All proposed or 'as installed' variations to these standards must be referred to Track Engineering who will consult with Traction Engineering before approving or otherwise.

Where out of tolerance situations are found, or changes are proposed to a track position that exceeds the specified tolerances, the Traction Supervisor Overhead must be consulted so that traction lines staff can assess the situation and take appropriate action.

13.3 Track data plates

Track data plates are to standard plan ET60050[2] (refer to Figure 13.1) and the information contained on them must be engraved.

TDP's are mounted on all traction poles in the NIMT, Auckland, and Wellington electrified areas and are also used on trackside monuments where required (refer to section 13.4).

Information contained on the TDP's is recorded in the asset database.

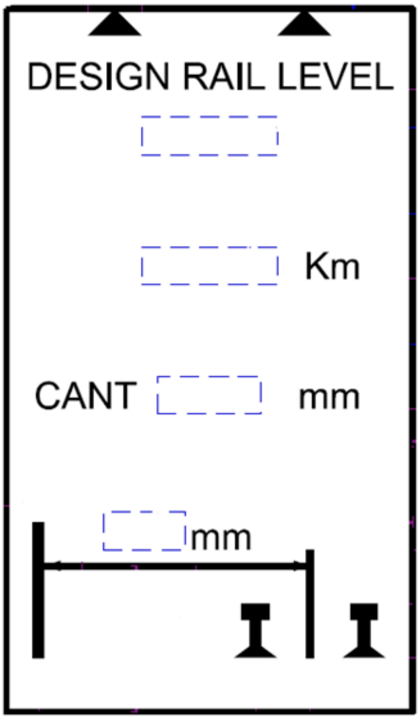

Figure 13.1 Track data plate

13.4 Track monuments

13.4.1 Requirement

Trackside monuments are required wherever CWR has been formed on curves of 400m radius or less. The monuments are an important aid in the monitoring and recording of lateral track movement and are to be installed prior to or in conjunction with de-stressing.

The installation and maintenance of monuments shall be certified as completed on the M153 Trackside Monumenting Return and recorded in the asset database.

13.4.2 Location of monuments

Track side monuments to measure lateral or sideways shift in the track, must be installed on curves with radius of 400 m or less. The monuments shall be located at intervals no greater than 30 m.

[2] Alternative designs are utilised in the Auckland and Wellington electrified areas.

Wherever possible the monuments are to be positioned at a consistent offset from the track.

The standard offset is to be 2.500 m from the nearest outer edge of the rail and preferably located on the high side of the curve.

This standard offset of 2.500 m may be varied by up to + or - 0.500 m if the formation profile requires a variation.

Traction Poles may be used as monuments in electrified areas.

13.4.3 Construction of monuments

To ensure permanency, monuments are to be constructed from half round ground treated timber posts painted white with the flat side to the rail. A concrete foundation is required for all monuments.

Monuments must be vertical (any off vertical monument will indicate damage and will need to be restored to vertical and offsets re-measured and records corrected).

The minimum and maximum dimensions are shown in Figure 13.2.

Monuments need to be protected from damage or interference. The timber monuments do not require specific protection measures but need to be located clear of potential damage from road vehicles and rail maintenance machines such as ballast regulators.

A check for underground services must be done before installing monument posts.

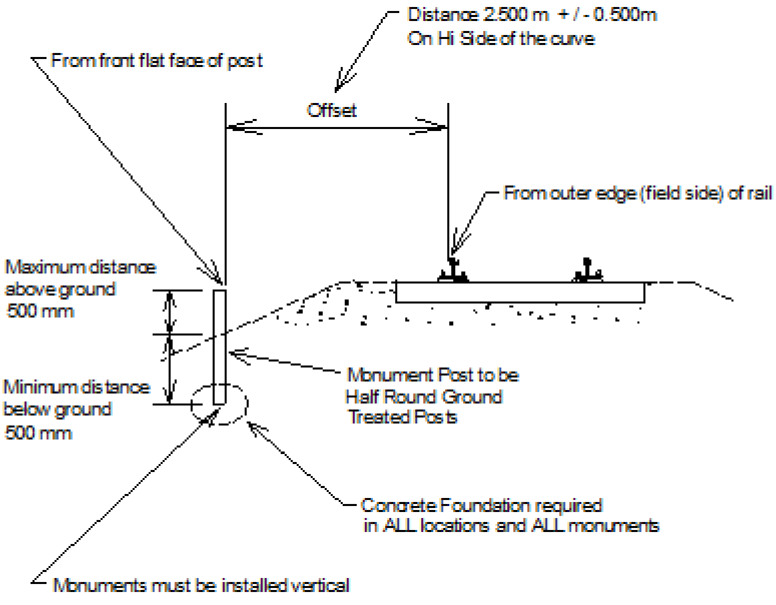

Figure 13.2 Siting of shift monuments

13.4.4 Site measurements

The monuments shall be positioned so that the measuring point of the monument is at the offset of 2500 m from the nearest outer edge of rail head. Future monitoring of the monuments shall be by measuring to the same points and the difference from the original offset recorded as shift of the track.

Each measurement shall be perpendicular from the back of the rail head in a horizontal plane. Where necessary a plumb bob shall be used to locate the front face of the timber post (refer to Figure 13.2). This will eliminate any discrepancy in rail height that may occur between measurements.

It is essential to re-measure the trackside monuments after installation, to reconfirm their location. Measurements should be taken to an accuracy of the nearest 5 mm.

13.4.5 Track data plates

Punched aluminium plates as described in section 13.3 Track data plates with the original offset measurement recorded on them are to be attached securely to each shift monument. Reference may also be made to the distance the rail level is from the top of the tag.

The plates are to be fixed to the flat face of the timber post with two galvanised screws.

13.4.6 Disturbed track

When track is disturbed through re-sleepering, tamping or other such work, the track alignment must be reinstated to the alignment provided by the monuments. If the alignment changes then the rail must be de-stressed and the data plates amended to suit the new alignment.

13.5 Management of track markers

The Asset Engineer is responsible for ensuring that track alignment is maintained as specified in section 13.2 Managed track and in section 13.4 Track monuments.

In addition to these sites, attention must be given to:

- curves with poor track conditions
- curved track that is designed towards the maximum limits of cant and deficiency or where transition lengths are sub optimal
- curved track on sharp curves approaching an open decked bridge
- curves that regularly move and
- curves with obvious alignment faults like over / undershooting of curves.

Where track markers are considered non-reliable or are missing, the Asset Engineer must have a programme of work to achieve the correct design.

Appendix 1 EM80 Exceedance Values by Speed Category

Appendix 1.1 Speed category 1 – 71 km/h and over

Parameter	Sub	Class CL1	Ratio 1–2	Class CL2	Ratio 1–1**	Paint CL1**	Standard		Radius Radius Limits		
Gauge	A	18.0	0.778	14.0	1.167	21.0	1074	mm	Under	->	150
Wide	B	18.0	0.778	14.0	1.167	21.0	1074	mm		->	250
	C	24.0	0.833	20.0	1.125	27.0	1068	mm		->	400
	D	24.0	0.833	20.0	1.125	27.0	1068	mm			Over
Gauge	A	16.0	0.875	14.0	1.125	18.0	1074	mm	Under	->	150
Tight	B	16.0	0.875	14.0	1.125	18.0	1074	mm		->	250
	C	12.0	0.833	10.0	1.167	14.0	1068	mm		->	400
	D	12.0	0.833	10.0	1.167	14.0	1068	mm			Over
Cant	A	19.0	0.895	17.0	1.263	24.0			Under	->	800
	B	19.0	0.895	17.0	1.263	24.0					Over
Top	A	18.0	0.889	16.0	1.222	22.0					
Twist	A	18.0	0.889	16.0	1.333	24.0					
Versine	A	20.0	0.800	16.0	1.350	27.0			Under	->	499
	B	18.0	0.889	16.0	1.500	27.0					Over
Versine	A	a =	0.700	b =	1.000	c =	0.000		Max=		27.00
Formula	B	a =	0.700	b =	1.000	c =	0.000		Max=		30.00
Cyclic	A	Ratio =	0.450	Limit =	2.500		Dist.	=	12.50		
	B	Ratio =	0.450	Limit =	2.500		Dist.	=	12.50		
ROCOCD		Speed 50.0 km/h			Limit =	200.0	mm/sec				
Radius		Confidence Value		= 5.000	M	TQI Ratio	1.500				

Appendix 1.2 Speed category 2 – 51 to 70 km/h

Parameter	Sub	Class CL1	Ratio 1–2	Class CL2	Ratio 1–1**	Paint CL1**	Standard		Radius Radius Limits		
Gauge	A	18.0	0.778	14.0	1.167	21.0	1074	mm	Under	->	150
Wide	B	18.0	0.778	14.0	1.167	21.0	1074	mm		->	250
	C	24.0	0.833	20.0	1.125	27.0	1068	mm		->	400
	D	24.0	0.833	20.0	1.125	27.0	1068	mm			Over
Gauge	A	16.0	0.875	14.0	1.125	18.0	1074	mm	Under	->	150
Tight	B	16.0	0.875	14.0	1.125	18.0	1074	mm		->	250
	C	12.0	0.833	10.0	1.167	14.0	1068	mm		->	400
	D	12.0	0.833	10.0	1.167	14.0	1068	mm			Over
Cant	A	19.0	0.895	17.0	1.263	24.0			Under	->	800
	B	19.0	0.895	17.0	1.263	24.0					Over
Top	A	22.0	0.864	19.0	1.227	27.0					
Twist	A	19.0	0.895	17.0	1.263	24.0					
Versine	A	20.0	0.900	18.0	1.350	27.0			Under	->	499
	B	20.0	0.900	18.0	1.500	30.0					Over
Versine	A	a =	0.700	b =	1.000	c =	0.000		Max=		30.00
Formula	B	a =	0.700	b =	1.000	c =	0.000		Max=		30.00
Cyclic	A	Ratio =	0.500	Limit =	2.500		Dist.	=	12.50		
	B	Ratio =	0.500	Limit =	2.500		Dist.	=	12.50		
ROCOCD		Speed 50.0 km/h			Limit = 240.0 mm/sec						
Radius		Confidence Value = 5.000m				TQI Ratio = 1.500					

Appendix 1.3 Speed category 3 – 41 to 50 km/h

Parameter	Sub	Class CL1	Ratio 1–2	Class CL2	Ratio 1–1**	Paint CL1**	Standard		Radius		Radius Limits
Gauge	A	19.0	0.789	15.0	1.158	22.0	1074	mm	Under	->	150
Wide	B	19.0	0.789	15.0	1.158	22.0	1074	mm		->	250
	C	25.0	0.840	21.0	1.120	28.0	1068	mm		->	400
	D	25.0	0.840	21.0	1.120	28.0	1068	mm			Over
Gauge	A	16.0	0.875	14.0	1.125	18.0	1080	mm	Under	->	150
Tight	B	16.0	0.875	14.0	1.125	18.0	1074	mm		->	250
	C	12.0	0.833	10.0	1.167	14.0	1068	mm		->	400
	D	12.0	0.833	10.0	1.167	14.0	1068	mm			Over
Cant	A	21.0	0.857	18.0	1.238	26.0			Under	->	800
	B	21.0	0.857	18.0	1.238	26.0					Over
Top	A	26.0	0.885	23.0	1.192	31.0					
Twist	A	20.0	0.900	18.0	1.250	25.0					
Versine	A	25.0	0.920	23.0	1.360	34.0			Under	->	499
	B	25.0	0.920	23.0	1.360	34.0					Over
Versine	A	a=	0.860	b=	1.000	c=	0.000		Max=		34.00
Formula	B	a=	0.860	b=	1.000	c=	0.000		Max=		34.00
Cyclic	A	Ratio =	0.500	Limit =	2.500		Dist.	=	12.50		
	B	Ratio =	0.500	Limit =	2.500		Dist.	=	12.50		
ROCOCD		Speed = 50.0km/h			Limit = 240.0 mm/sec						
Radius		Confidence Value = 5.000 m				TQI Ratio = 1.500					

Appendix 1.4 Speed category 4 – 26 to 40 km/h and loops

Parameter	Sub	Class CL1	Ratio 1–2	Class CL2	Ratio 1–1**	Paint CL1**	Standard		Radius Radius Limits		
Gauge	A	20.0	0.800	16.0	1.150	23.0	1074	mm	Under	->	150
Wide	B	20.0	0.800	16.0	1.150	23.0	1074	mm		->	250
	C	26.0	0.846	22.0	1.115	29.0	1068	mm		->	400
	D	26.0	0.846	22.0	1.115	29.0	1068	mm			Over
Gauge	A	16.0	0.875	14.0	1.125	18.0	1074	mm	Under	->	150
Tight	B	16.0	0.875	14.0	1.125	18.0	1074	mm		->	250
	C	12.0	0.833	10.0	1.167	14.0	1068	mm		->	400
	D	12.0	0.833	10.0	1.167	14.0	1068	mm			Over
Cant	A	22.0	0.864	19.0	1.273	28.0			Under	->	800
	B	22.0	0.864	19.0	1.273	28.0					Over
Top	A	31.0	0.871	27.0	1.129	35.0					
Twist	A	21.0	0.857	18.0	1.238	26.0					
Versine	A	30.0	0.900	27.0	1.333	40.0			Under	->	499
	B	30.0	0.900	27.0	1.333	40.0					Over
Versine	A	a =	0.860	b =	1.000	c =	0.000		Max=		38.00
Formula	B	a =	0.860	b =	1.000	c =	0.000		Max=		38.00
Cyclic	A	Ratio =	0.500	Limit =	2.500		Dist.	=	12.50		
	B	Ratio =	0.500	Limit =	2.500		Dist.	=	12.50		
ROCOCD		Speed = 40.0 km/h			Limit =	240.0 mm/sec					
Radius		Confidence Value = 5.000 m				TQI Ratio = 1.500					

Appendix 1.5 Speed category 5 – 25 km/h and yards

Parameter	Sub	Class CL1	Ratio 1–2	Class CL2	Ratio 1–1**	Paint CL1**	Standard		Radius		Radius Limits
Gauge	A	20.0	0.800	16.0	1.150	23.0	1074	mm	Under	->	150
Wide	B	20.0	0.800	16.0	1.150	23.0	1074	mm		->	250
	C	26.0	0.846	22.0	1.115	29.0	1068	mm		->	400
	D	26.0	0.846	22.0	1.115	29.0	1068	mm			Over
Gauge	A	16.0	0.875	14.0	1.125	18.0	1074	mm	Under	->	150
Tight	B	16.0	0.875	14.0	1.125	18.0	1074	mm		->	250
	C	12.0	0.833	10.0	1.167	14.0	1068	mm		->	400
	D	12.0	0.833	10.0	1.167	14.0	1068	mm			Over
Cant	A	27.0	0.889	24.0	1.222	33.0			Under	->	800
	B	27.0	0.889	24.0	1.222	33.0					Over
Top	A	36.0	0.889	32.0	1.111	40.0					
Twist	A	24.0	0.833	20.0	1.167	28.0					
Versine	A	36.0	0.889	32.0	1.389	50.0			Under	->	499
	B	36.0	0.889	32.0	1.389	50.0					Over
Versine	A	A=	1.000	b=	1.000	c=	0.000		Max=		45.00
Formula	B	A=	1.000	b=	1.000	c=	0.000		Max=		45.00
Cyclic	A	Ratio =	0.500	Limit	= 2.500		Dist.	=	12.50		
	B	Ratio =	0.500	Limit	= 2.500		Dist.	=	12.50		
ROCOCD		Speed = 25.0 km/h			Limit =	240.0mm/sec					
Radius		Confidence Value = 5.000 m				TQI Ratio = 1.500					

The following are to be used when assessing the required action for these defect types.

Defect	Class 2	Class 1	Class **
ROCOCD Speed Category 1	200 - 279	280 - 339	340 or more
ROCOCD Speed Categories 2 - 5	240 - 279	280 - 339	340 or more
Cyclic Line	3	4	5 or more

Briefing Note(s) for T-ST-AM-5120 Track Geometry

Date Effective 03/03/2017 **Issue No.** Issue 1.0

Background

This document details track geometry measurements of various track parameters, using a track recording vehicle and the subsequent analysis of the results provides KiwiRail with the means of determining track quality for each of its routes or sections of track within them. It details the process of monitoring the track geometry and the actions required of KiwiRail staff when the outputs are received from the inspection vehicle. It also details the required actions of track staff when they manually identify a track geometry fault in the field.

It also sets out the track quality (TQI) targets for each of KiwiRail routes which align the standard with the required outputs from the business plan.

Key changes / compliance

This is the first issue of a new document outlining the above procedure for Track geometry

Implementation

This document should be cascaded down to all field staff impacted by this standard in the field. All documents will have the Briefing Note inserted to each document during the next review process or next published version iteration, whichever comes first.

Applicability (select relevant boxes)	**General**	**Asset Engineers**	**Field Asset Engineers**	**Production Managers**	**Field Production Managers**	**Gangers**
All	☐	☐	☐	☐	☐	☐
Signals and Telecommunications	☐	☐	☐	☐	☐	☐
Structures	☐	☐	☐	☐	☐	☐
Network Access	☐	☐	☐	☐	☐	☐
Civil	☐	☐	☐	☐	☐	☐
Track	☒	☒	☒	☒	☒	☒
Traction and Electrical	☐	☒	☐	☐	☐	☒