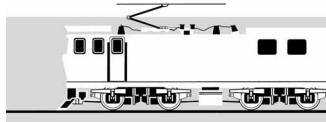
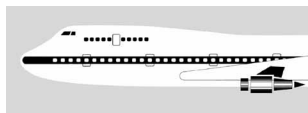


RAILWAY OCCURRENCE REPORT

04-107 express freight Train 237, derailment, near Kopaki

24 March 2004



TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

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Report 04-107
express freight Train 237
derailment
near Kopaki
24 March 2004

Abstract

On Wednesday 24 March 2004, at about 0149, USQ 7663, the 27th wagon on southbound express freight Train 237, derailed while negotiating a left-hand curve between Puketutu and Kopaki on the North Island Main Trunk. The wagon ran derailed for about 750 m until it struck the spreader bar on the north-end facing points at Kopaki, derailing the following 4 wagons and parting the train between the 29th and 30th wagons. The condition of the trailing bogie of wagon USQ 7663 was a significant contributing factor to the derailment.

Safety issues included:

- the fractured friction wedge springs
- the identification and correction of displaced bearing adaptors
- the assembly procedures for fitting wear liners to bolster wedge pockets
- the identification of individual bogie components.

Two safety recommendations were made to the Chief Executive of Toll NZ Consolidated Limited¹ to address these issues.

¹ New owner of Tranz Rail, effective 5 May 2004.



The derailment site

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Abbreviations

kg/m	kilograms per metre
km/h	kilometres per hour
m	metre(s)
mm	millimetre(s)
POD	point of derailment
t	tonne(s)
TIC	Train Inspection Certificate
Tranz Rail	Tranz Rail Limited
UTC	co-ordinated universal time

Data Summary

Train type and number:	express freight Train 237
Date and time:	24 March 2004, at about 0149 ²
Location:	near Kopaki
Persons on board:	one
Injuries:	nil
Damage:	substantial infrastructure and wagon damage
Operator:	Tranz Rail
Investigator-in-charge:	P G Miskell

² Times in this report are New Zealand Standard times (UTC+12) and are expressed in the 24-hour mode.

1 Factual Information

1.1 Narrative

- 1.1.1 On Tuesday 23 March 2004, Train 237 was a scheduled express freight service from Auckland to Wellington. The train departed from Te Rapa at about 2305 and consisted of EF locomotives 30134 and 30226 hauling 33 bogie wagons with a gross weight of 1151 t, and a total length of 509 m. The train was crewed by a locomotive engineer.
- 1.1.2 At about 0149 the following day, while the train was passing through Kopaki, the locomotive engineer noticed a sudden drop in brake pipe pressure, so he stopped the train. He contacted the train controller and suggested that the train may have burst a hose and that he would walk the train to investigate. The train controller replied that the problem may be more than a burst hose because he had lost points detection on his visual display unit screen.
- 1.1.3 The locomotive engineer secured the train, removed the portable radio from its cradle and proceeded to the rear of the train, checking the wagons on the way. He called the train controller when he was at the rear of the train and advised that the train had parted 4 wagons from the rear of the train, with a gap of about 80 m between the 2 portions. There were 3 wagons derailed at the rear of the front portion and 2 wagons derailed at the front of the rear portion. The last 2 wagons were not derailed (see Figure 1).

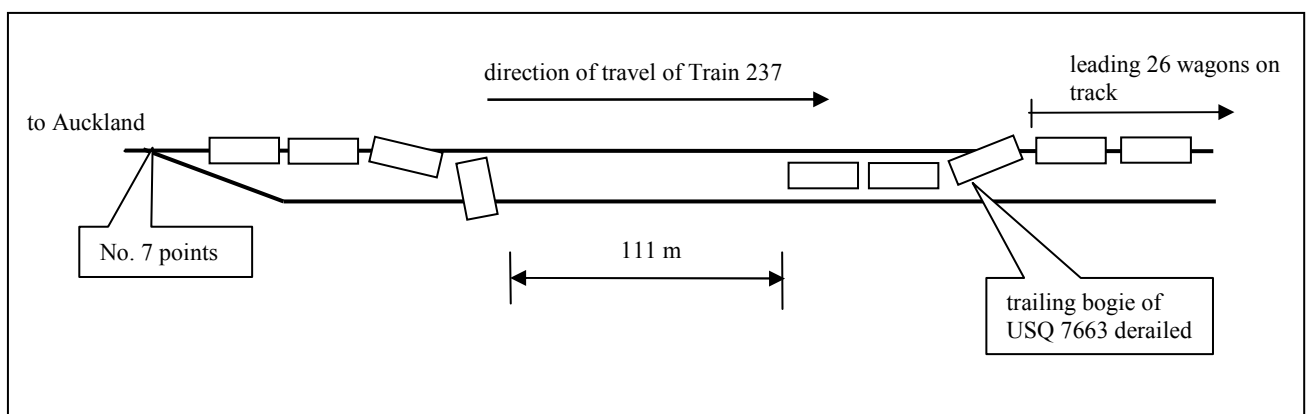


Figure 1
Kopaki crossing loop

1.2 Site information

- 1.2.1 The derailment occurred between Puketutu and Kopaki, on the North Island Main Trunk as Train 237 negotiated a 182 m radius left-hand curve on a rising grade of 1 in 70 (see Figure 2). The authorised curve speed was 50 km/h.

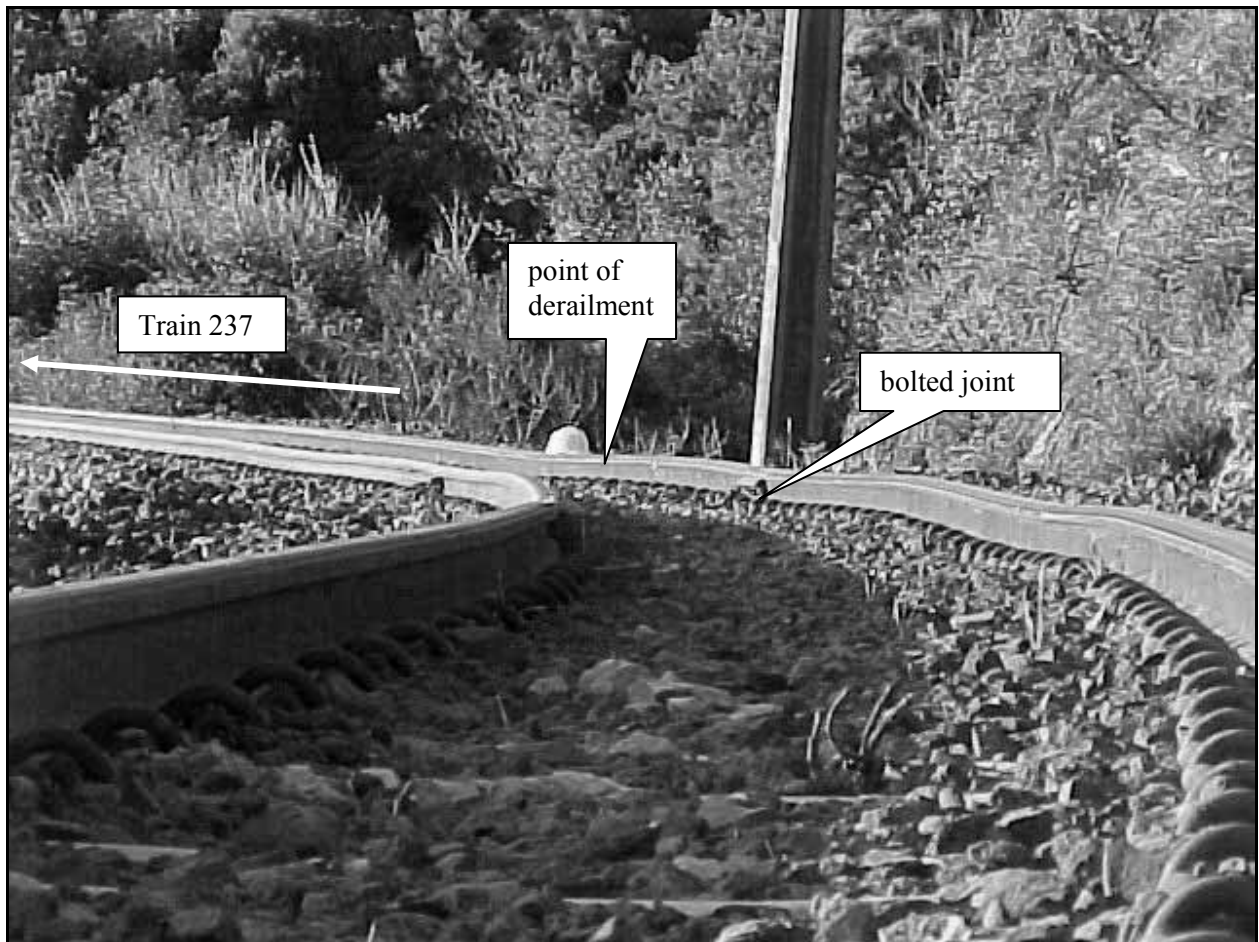


Figure 2
Track near point of derailment

- 1.2.2 A light, 4.7 m long wheel flange mark was visible across the railhead of the right rail (in direction of travel). This identified the point of derailment (POD) as 455.946 km, about 9 m past a bolted joint.
- 1.2.3 Wagon USQ 7663 (with handbrake trailing) was the first of the derailed wagons on the front portion of the train. Track and wheel set damage indicated that the wagon ran from the POD to the mainline turnout (No. 7 points) at the north end of Kopaki crossing loop, 455.200 km, with the leading axle of the trailing bogie derailed. As the train passed over these points, the next 4 wagons derailed and the train parted. Five bogies from the derailed wagons, including the trailing bogie from USQ 7663, finished under the last wagon to derail, UK 13376 (see Figure 3).

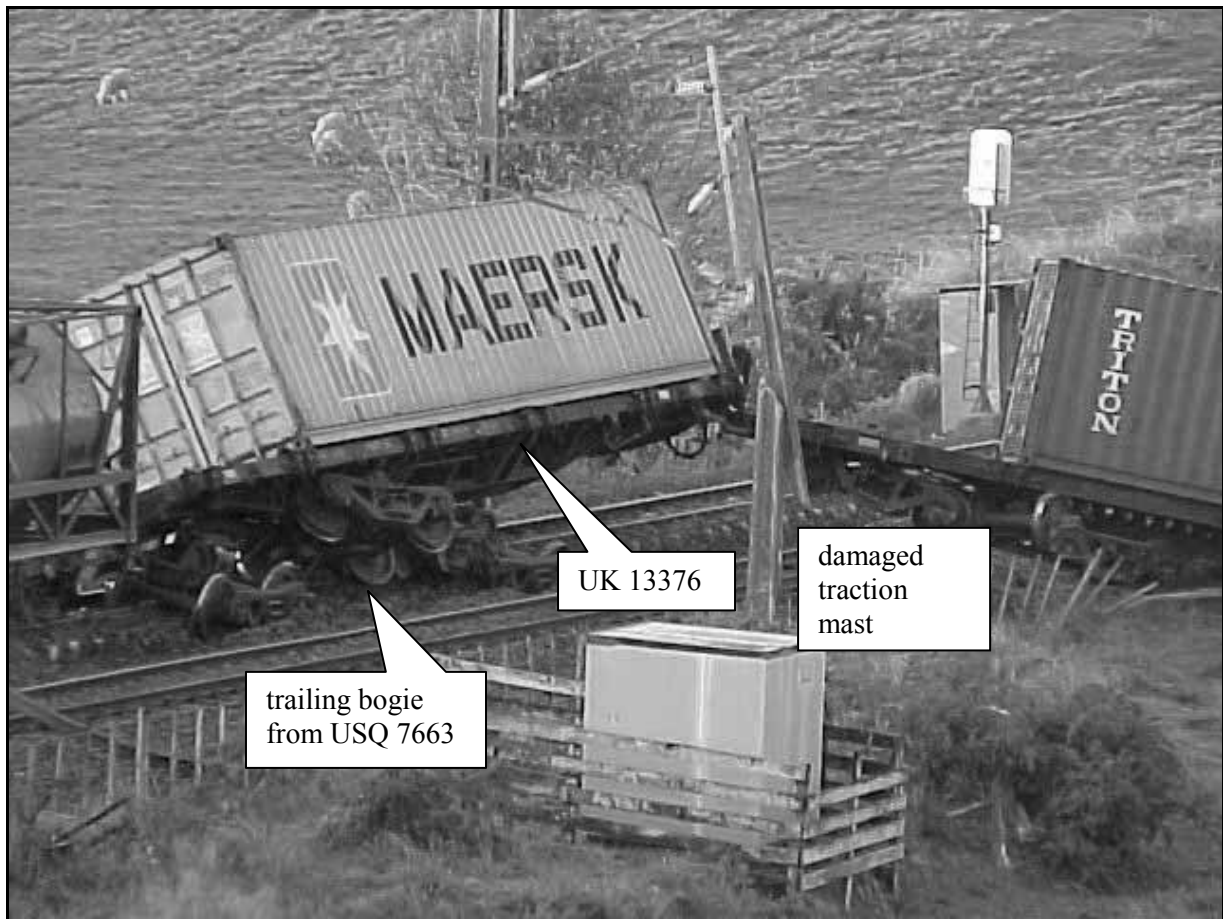


Figure 3
Derailed wagons at the rear of Train 237

1.2.4 When Train 237 stopped, the leading bogie of USQ 7663, the 27th wagon on the train, was at 454.921 km some 1026 m past the POD. There was a gap of 111 m between derailed wagons UK 20776 and IA 534. Although track damage from the POD to No. 7 points was relatively minor, the track was severely damaged from No. 7 points up to where USQ 7663 stopped. A concrete traction mast at 455.097 km on the loop side of the mainline was damaged in the derailment.

1.3 Locomotive engineer

1.3.1 The locomotive engineer had been an employee of Tranz Rail and its predecessors for about 25 years. He had more than 20 years' shunting experience before being accepted into the locomotive engineer training programme. After completing the 12-week locomotive engineer theory training at Woburn, he returned to Westfield in December 2001 to start his practical on-the-job training under the direction of a minder driver.

1.3.2 In July 2002, he transferred from Westfield to Te Rapa to continue his training and completed the minimum number of driving hours in August 2003. In the following month he attained his locomotive engineer mastery and certificate of competency.

1.3.3 On 23 March 2004, he arrived at work 10 minutes before his book-on time of 2300. He was rostered on a 9-hour 30-minute shift to take Train 237 from Te Rapa to Taumarunui and return to Te Rapa with Train 228. He read and signed for the daily train work orders before going into the yard to board his locomotive.

1.3.4 The locomotive engineer said that the train was travelling at about 45 km/h while climbing the 1 in 70 grade between Puketutu and Kopaki when it lost amperage for about 5 to 10 seconds. The train surged and the speed dropped to about 35 km/h. He moved the power handle to the

neutral position, pressed the reset button and then shifted the power handle back to the running position to restore power. He said that he had experienced a similar power loss and surge at about the same location the previous night. He was unable to confirm the exact location where the power loss happened but thought it was somewhere between 457 km and 456 km. Because he did not feel a run-in³ he continued southward towards his changeover point at Taumarunui.

- 1.3.5 He said the train picked up speed again and were travelling at about 45 km/h when it reached the summit of the grade and was drifting towards No. 7 points when there was a sudden reduction in brake pipe pressure.

1.4 Locomotive event recorder

- 1.4.1 Data from the event recorder on EF 30134 were downloaded and made available for analysis.

1.5 Track information

- 1.5.1 The 50 kg/m rail on the derailment curve was manufactured in 1986 and laid in 38 m lengths. The rail had been transposed⁴ in June 2002. The hi-leg rail had 2 points of top wear and zero side wear. The lo-leg rail had 2 points of top wear and zero side wear on the gauge side of the rail, although there were 11 points of side wear on the field side of the rail. The maximum wear limits for 50 kg/m rail were:

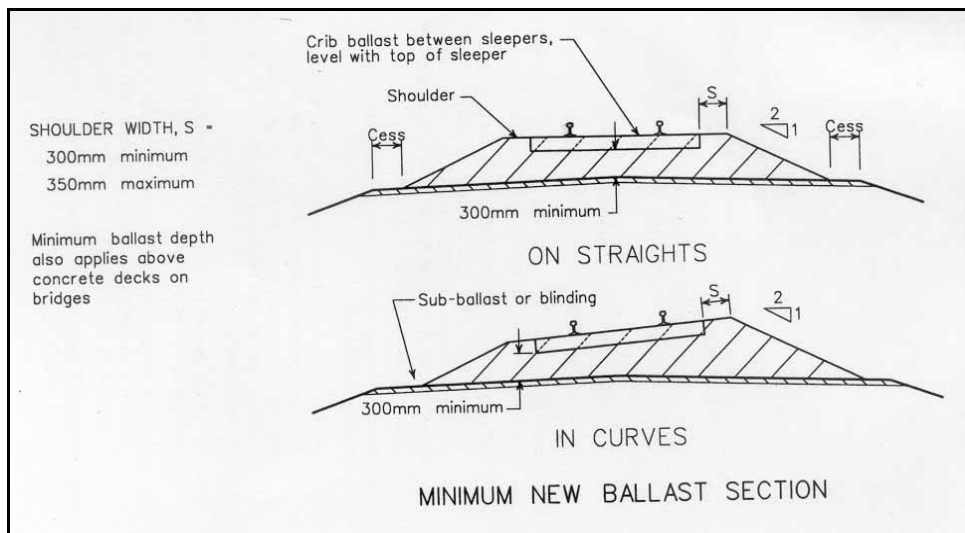
Top Wear	Side Wear
0-5	16
6-14	Maximum of 16 for combined top and side

When 50 kg/m rail had been transposed, side wear on the gauge side only was to be measured.

- 1.5.2 The concrete sleepers with Pandrol fastenings on the derailment curve were less than 2 years old and in near new condition. The sleepers were supported by clean ballast to a depth of 300 mm at the POD. The cribs were full and there was a 600 mm ballast shoulder at the sleeper ends. Tranz Rail's minimum ballast profile is shown in Figure 4. The track machine group last carried out tamping and lining on the derailment curve in June 2002 following the installation of the concrete sleepers.

³ When the rear section of a train is travelling faster than the forward section of a train.

⁴ The hi-leg and lo-leg rails were swapped over.



1.5.3

Figure 4

Minimum ballast profile

1.5.4 Two days before the derailment, the track inspector identified and marked up a maintenance item at 455.980 km, to lift and pack a 22 mm low joint. The maintenance item was about 34 m before the POD. There were no other outstanding Priority 1⁵ maintenance issues to be attended to on the derailment curve.

1.5.5 An exception report generated from the most recent track Evaluation Machine run on 5 November 2003 identified a Priority 2 top fault of 16 mm some 15 m prior to the POD. The magnitude of the exceedance was within operating parameters, but noted for completeness.

1.6 Wagon loading

1.6.1 USQ 7663 was conveying 2 loaded 20-foot containers from Auckland to Palmerston North. Each container carried resin granules inside a plastic bladder that assumed the shape of the container. The product had been consigned in a similar manner on a regular basis. Although the individual wheel loads on USQ 7663 were not recorded when Train 237 passed over the continuous-in-motion weighbridge at Westfield, similar load distributions had not previously been reported as being out of balance. The train list declared a gross weight of 47 t for USQ 7663. Tranz Rail limited the maximum gross weight for USQ class wagons to 54 t.

1.7 Three-piece bogie

1.7.1 Wagon USQ 7663 had a standard 3-piece bogie as used on most freight wagons worldwide. The 3 main “pieces” are one bolster and 2 side frames. The bolster was supported by 2 sets of coil springs. The larger diameter coil springs, known as primary suspension, provided vertical support. The smaller diameter coil springs, referred to as secondary suspension, loaded friction wedges to provide wagon damping.

1.7.2 On a high-speed rail network, wheel flanges do not generally touch the rails (see Figure 5). Flanges are only a last resort to prevent the wheels becoming derailed. The wheel tyre was coned at a 1 in 20 angle and the railhead was slightly curved. On curved track, the outer wheel has a greater distance to travel than the inner wheel and to compensate for this, the wheel set moves sideways in relation to the track. Thus a larger tyre radius on the inner edge of the wheel is in contact with the outer rail of the curve, and a lesser tyre radius on the outer edge of the wheel is in contact with the inner rail of the curve.

⁵ Priority 1 maintenance work must be fixed within 30 days.

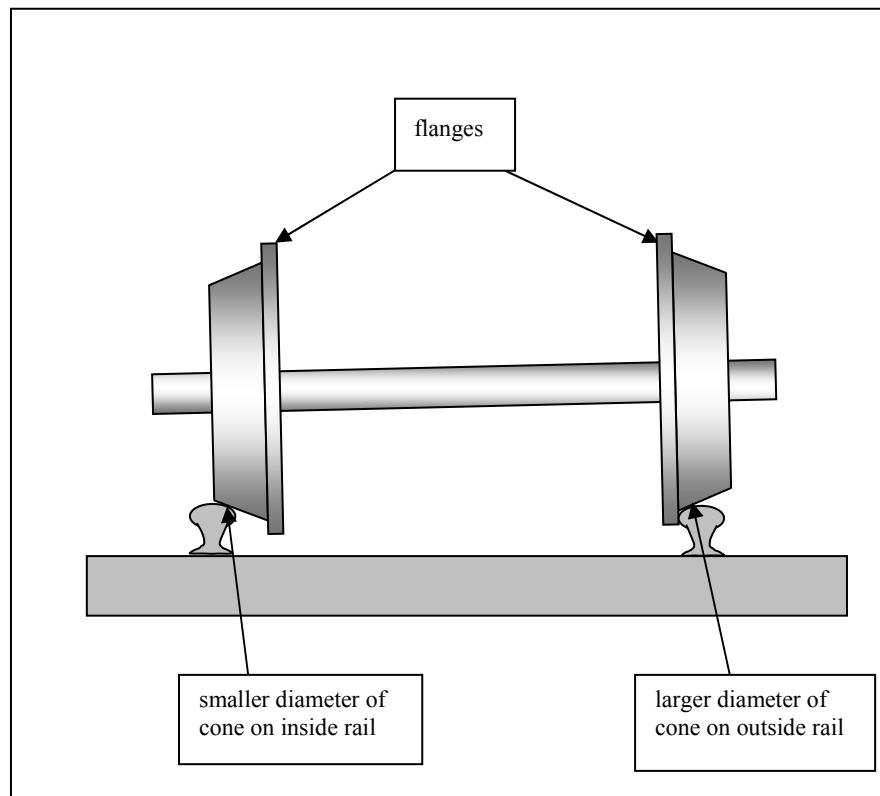


Figure 5
Wheel and rail interface (not to scale)

1.7.3 For the New Zealand situation, when a bogie negotiates a curve, the flange on the leading wheel on the hi-leg follows the rail running edge. When the curvature changes, the forces required to rotate the bogie and the wagon are generated by the flange pressing against the outer running rail.

1.8 Wagon inspection regime

1.8.1 During April 2002, Tranz Rail contracted out the mechanical inspection and maintenance of rolling stock to Alstom Transport New Zealand Limited⁶ (Alstom), to standards set by Tranz Rail.

1.8.2 The Tranz Rail Mechanical Code M2000 Issue 6 identified that all freight wagons must be inspected at the following frequency:

- a pre-departure check
- a B-Check, carried out when 2 or more brake blocks were changed, or after an incident
- a C-Check, carried out before a depot pass out but with an upper limit of 27 months
- a Brake Service Check, carried out every 10 years but with an upper limit of 11 years.

1.8.3 A pre-departure check was a thorough walk-around inspection undertaken by yard operating staff immediately before a train departed from a terminal and included checks on the condition of brake blocks and wheels and correct draw gear connections. The person carrying out the inspection signed a Train Inspection Certificate (TIC) to confirm that the train was in proper condition for safe running. The TIC was attached to the Train Work Orders and remained in the locomotive cab until the train reached its destination.

1.8.4 There were no wagon defects identified on the TIC before Train 237 departed Westfield.

⁶ Alstom was contracted to Tranz Rail to carry out the inspection and maintenance of wagons and locomotives.

1.8.5 The B-Check inspection requirements for the bogie suspension included these:

Springs	in place, secure and intact
Bearing keeps	held securely in place
Liners	secure and not broken
Wedge heights	within limits (use Snubber gauge if in doubt)
Bearing adapters	in place and no visual sign of damage
Dampers	secure
	no excessive oil leaks
Horns	not bent or loose
Bearings	no sign of overheating
	cap bolts in place
	backing rings secure
	no excessive grease leakage
Brake blocks	within wear limits.

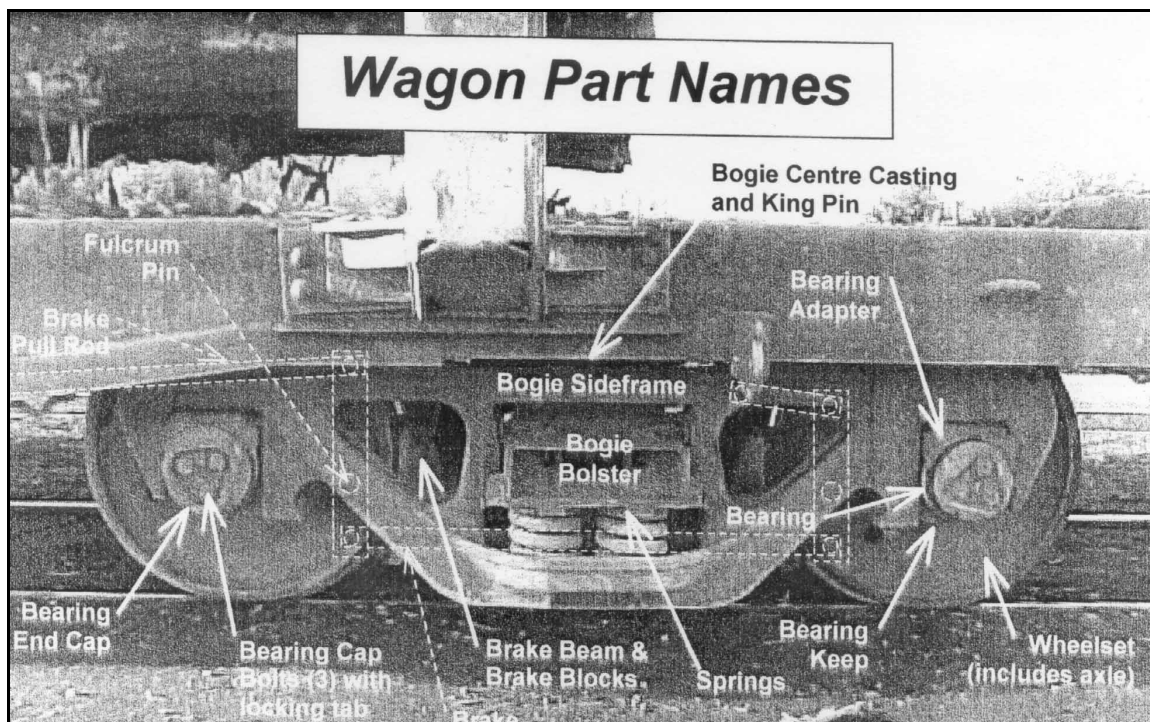


Figure 6
Identification of wagon parts

1.8.6 The most recent B-Check on wagon USQ 7663 was completed on 11 November 2003, as part of the higher order C-Check.

1.8.7 The C-Check inspection of the bogie suspension was the same as for a B-Check and included the following:

Liners	not worn more than 50% of the original thickness
Side bearer	not damaged or worn.

1.8.8 The most recent C-Check and 10-year Brake Service Check on wagon USQ 7663 were completed on 11 November 2003 when wheel sets 3 and 4 were replaced with second-hand stock. Repairs to the brake beam, a hand grab and an air leak on the VTA line and the replacement of 8 brake blocks were also completed.

1.8.9 A wagon wheel lathe report, dated 4 December 2003, confirmed that all wheels on the trailing (handbrake end) bogie of USQ 7663 were re-profiled to remove a flat spot on the tread of A1 wheel. All wheels on the trailing bogie were re-profiled using an under-floor lathe without the

need to remove the wheel sets from the bogie. A wheel profile gauge was used to record critical wheel dimensions of:

- flange sharpness (W)
- flange thickness (X)
- flange height (Y)
- rim thickness (Z).

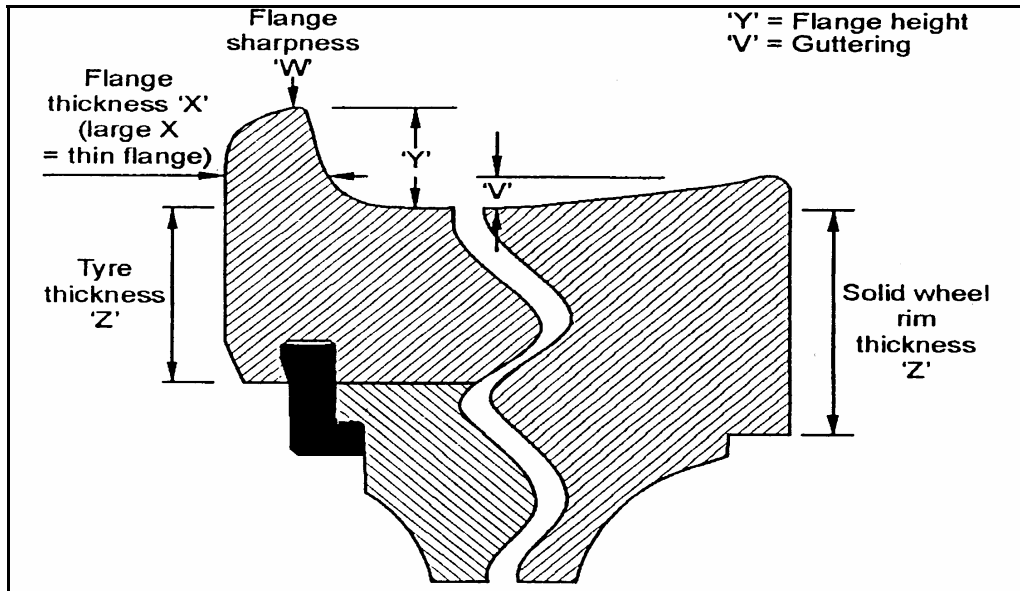


Figure 7
Wheel profile

1.8.10 Wagon axles were numbered from 1 to 4, starting at the handbrake end of the wagon. The handbrake side of the wagon was classified as the A-side and the non-handbrake side was the B-side. The wheel closest to the handbrake was therefore identified as A1 (see Figure 8). Axle No. 2 was the leading axle of the trailing bogie at the time of the derailment.

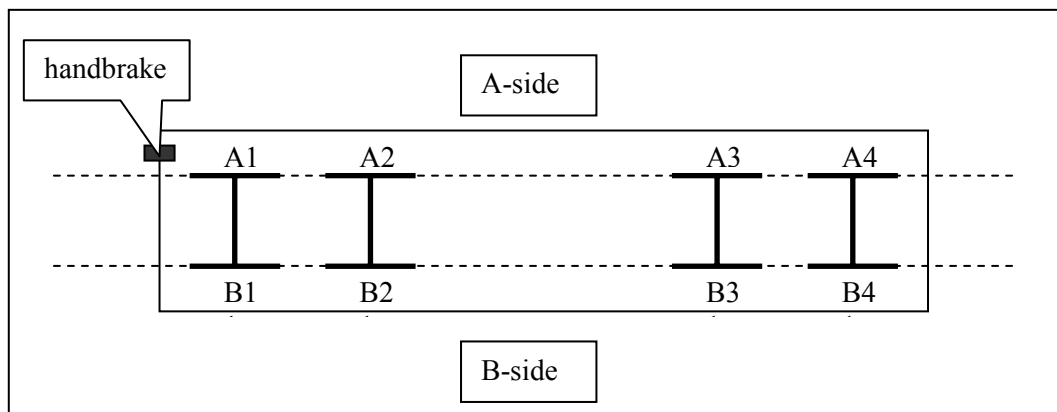


Figure 8
Wheel identification

- 1.8.11 The flange thickness dimensions recorded after re-profiling the wheels on the trailing bogie were as follows:

Axle Number	Tread Diameter	X A-side	X B-side
1	740	1	1
2	750	6	2

- 1.8.12 Tranz Rail's Wheelset Manual M6000 required that whenever a wheel set was removed from a bogie, the adapters must be checked for excessive wear, broken parts and cracking, wear on the bearing seat pads, wear on the bearing thrust faces and distortion. When the wheel sets on the trailing bogie of USQ 7663 were last removed could not be determined.

1.9 Post-derailment inspection of wagon USQ 7663

- 1.9.1 Standard 3-piece bogies were fitted to USQ 7663. The bogie types were widely used in New Zealand and overseas railways. Tranz Rail had no unique identification on the bogie and hence it was not possible to track either operational or maintenance history.
- 1.9.2 The tread on the leading wheel set of the trailing bogie (No. 2 wheel set) from USQ 7663 was the most pitted of all derailed wheel sets, indicating that this was the first wheel set to derail.
- 1.9.3 The containers on USQ 7663 were transhipped and a replacement bogie was fitted to the handbrake end of the wagon so that the wagon could travel back to Te Kuiti at reduced speed. The wagon and the derailed bogie were later transported by road from Te Kuiti to Te Rapa for examination.
- 1.9.4 The flange thicknesses on the wheels of the first bogie to derail were again measured and recorded as:

Axle Number	X A-side	X B-side
1	2	3
2	10	4

- 1.9.5 When the wagon was placed over the inspection pit at Te Rapa wagon repair depot, it became clear that the wagon frame had a noticeable hog. The drawgear at the handbrake end was 720 mm above rail level and 780 mm at the other end. Tranz Rail's Mechanical Code M2000 required the drawbar height to be between 725 mm and 767 mm above rail level.
- 1.9.6 The wagon corner heights above rail level were recorded as:
- handbrake end A-side 890 mm
 - handbrake end B-side 910 mm
 - non-handbrake end A-side 950 mm
 - non-handbrake end B-side 962 mm

The design deck height for USQ class wagons was 940 mm.

- 1.9.7 A more detailed examination of the derailed bogie of USQ 7663 was carried out on 11 May 2004, at the Alstom workshops at Hutt.
- 1.9.8 When the bogie frame was lifted off the axles it could be seen that the A2 wheel bearing adaptor was both damaged and distorted and had been running in a displaced position for some time. The locating lug was broken on the adaptor and there was a crack on the inside face (see Figure 9). When the adaptor was placed on the bearing, it could be slightly rotated about a vertical axis, and also rocked and slid backwards and forwards axially.

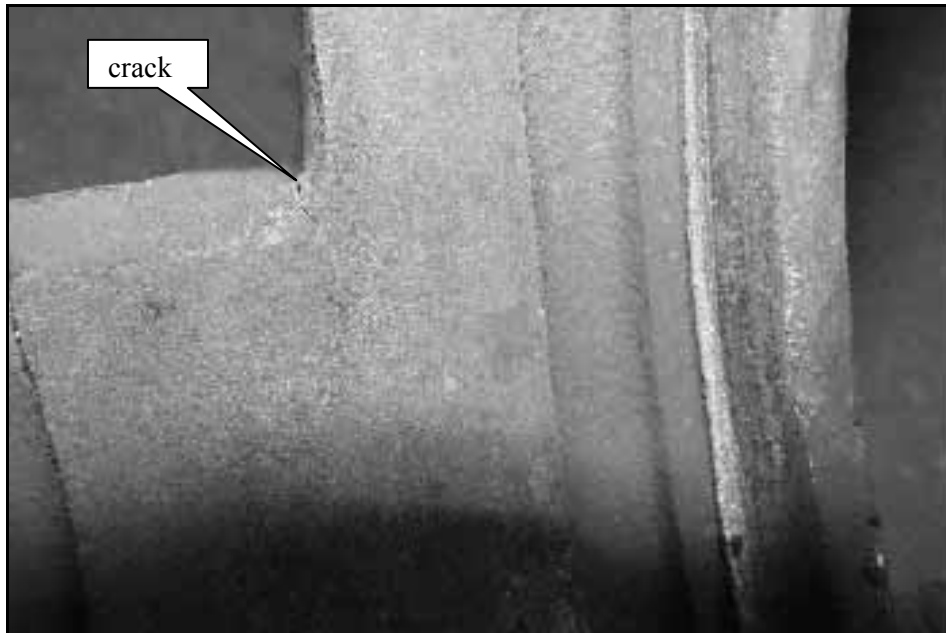


Figure 9
Crack on inside face of bearing adaptor

- 1.9.9 All bogie adaptor pockets were checked for dimensional compliance. All except that at A2 wheel were within the accepted tolerances. The A2 pocket was worn to an extent that it allowed 3 mm more longitudinal movement than the upper limit.
- 1.9.10 When the springs supporting the friction wedges were removed from the side frames, it was found that 2 of the inner springs on the B-side were broken at the same position, about one and a half turns from the bottom (see Figure 10).

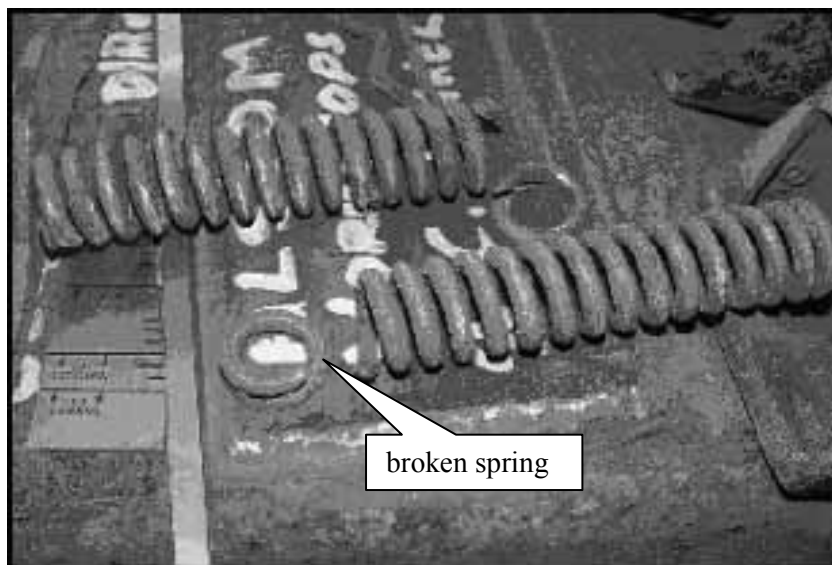


Figure 10
Broken springs

- 1.9.11 The welds attaching the wedge liner to the inboard side of the bolster wedge pocket near the 1B wheel had failed. The liner was displaced downwards and bent by the wedge.
- 1.9.12 The welds attaching the wedge liner to the inboard side of the bolster wedge pocket near the 2A wheel had partially failed and the lower two-thirds of the liner had broken off the bolster. The liner was displaced downwards and bent by the wedge.

2 Analysis

Train operation

- 2.1 The locomotive event recorder short-log provided details of speed, brake pipe pressure and throttle position at one-second intervals for 6 minutes before the completion of the recording. Analysis of this confirmed that 217 seconds before the train stopped at Kopaki, it was travelling at 38 km/h when the locomotive engineer moved the power handle from throttle position 2 to the neutral position. Five seconds later, the power handle was returned to its former setting. The recorded actions were consistent with the locomotive engineer's explanation that the locomotive lost amps and the train surged for about 5 to 10 seconds until he was able to restore power. The locomotive was still about one kilometre away from the POD when the locomotive engineer responded to the sudden power loss. The cause of the power loss could not be established but nevertheless, did not contribute to the derailment. The locomotive engineer's response to the train parting did indicate that he had the train under control at that time.
- 2.2 Analysis of the event recorder data confirmed that the train was travelling at about 40 km/h when the leading axle of the trailing bogie of USQ 7663 derailed in the body of the 182 m radius curve. The train speed was less than the authorised curve speed of 50 km/h and on its own did not contribute to the derailment. The cargo of resin granules that occupied most of the space within the two 20-foot containers on wagon USQ 7663 had a relatively high centre of gravity which in turn could accentuate wagon and track dynamic interaction. It was probable that the train speed of 40 km/h approximated the resonant speed for the wagon.

Track condition

- 2.3 From the post-derailment measure-up of the track geometry at one-metre intervals for 120 m leading up to the POD and the subsequent derailment analysis, there was no stand-out track condition which alone would have caused the derailment. The gauge, cant and curvature were reasonably regular within the body of the curve and within the Network Provider's⁷ established maintenance tolerance limits. However, there was evidence of some cyclic wavy top leading up to the POD. Although the track geometry at the POD was within maintenance tolerances the wavy top may have contributed to the derailment when combined with a wagon at the limit of acceptable maintenance tolerances.

Derailment

- 2.4 The derailment happened when the wheel flange of the leading axle on the trailing bogie of USQ 7663 climbed over the hi-leg rail when negotiating the left-hand curve. The fractured springs would have prevented the friction wedges being effective in damping out the rolling effect. Rolling oscillations would thus continue for longer durations, increasing the risk of these oscillations compounding should there be any small cyclic changes in track geometry.
- 2.5 The springs probably fractured before, rather than as a result of, the derailment. The springs were fitted in such a manner that it would not have been possible to identify the broken springs during a routine maintenance inspection, only when the bogie was dismantled.

⁷ New Zealand Railways Corporation assumed responsibility for the long-term operation and maintenance of the mainline and designated portions of operator-controlled territory on 1 September 2004.

Wagon condition

- 2.6 The deformation of the wagon frame of USQ 7663 that resulted in a lower buffer height at the trailing end and differing corner heights was probably a result of the derailment, rather than a pre-existing condition.
- 2.7 Although the bearing adapter was not a secure fit, and appeared to have been running in a displaced manner for some time, the condition of the adapter on its own was probably not sufficient to cause the bogie to derail.
- 2.8 In the 3 months that elapsed from the time the wheels were turned until the derailment, wheel set 2, the first to derail, had been experiencing more movement than wheel set 1.

		A-side	B-side
Wheel set 1	3 December 2003	1	1
	Post-derailment	2	3
	3-month wear	1	2
Wheel set 2	3 December 2003	6	2
	Post-derailment	10	4
	3-month wear	4	2

The wear pattern would suggest that the flange on wheel 2A had been bearing on the rail more heavily or more frequently than any other wheel on the bogie. In other words, there was a tendency for the bogie to run slightly skewed on the track. When wheel set 2 was leading, the 2A wheel would tend to drag back and steer into the rail. When the wagon was running in the opposite direction, the 2A wheel would drag the other way and steer into the rail. This would have the effect of skewing the bogie and steering 1B wheel into the rail. The heavier wear on the wheels was evident on the same 2 wheels that suffered from failure of the wear strips on the friction wedges.

- 2.9 The failed wear strips could not be easily identified during normal scheduled inspection. Therefore the welding standard and procedures must be clearly identified. Tranz Rail had no documented procedure for welding the wear strips and as a consequence the failed wear strips appeared to have been fixed with inadequate welds for their full circumference. A safety recommendation was made to the operator to address this issue.

3 Findings

Findings and safety recommendations are listed in order of development and not in order of priority.

- 3.1 Train 237 was being operated in accordance with Tranz Rail's operating rules and instructions at the time of the incident.
- 3.2 The momentary loss of power that the locomotive engineer corrected was not related to the derailment.
- 3.3 The derailment resulted after the leading axle of the trailing bogie on wagon USQ 7663 climbed the hi-leg rail when negotiating a left-hand curve.
- 3.4 The axle climbed the hi-leg rail because fractured springs within the bogie prevented the friction wedges providing sufficient damping and allowed excessive rolling to develop.
- 3.5 The track geometry at the POD was within Tranz Rail's maintenance standards. However, the cyclic wavy top before the POD, when combined with a wagon with inadequate damping, may have contributed to the derailment.

- 3.6 The A2 wheel bearing adaptor was damaged but did not cause the derailment. However, the small resulting movement, in combination with other factors, may have contributed to the derailment.
- 3.7 The wear strips failed due to inadequate welding around their full circumference. The failed strips would have exacerbated the lack of damping and, while this would not have caused the derailment, in combination with other factors, may have contributed to it.
- 3.8 The broken springs and failed wear strips could not be identified during normal maintenance inspections.
- 3.9 The lack of a unique identification number on each bogie prevented tracking of its operational and maintenance history

4 Safety Recommendations

4.1 On 9 February 2005 the Commission recommended to the Chief Executive of Toll NZ Consolidated Limited that he:

- 4.1.1 develop a documented procedure for fitting the wear liners to the bolster wear pocket. (093/04)
- 4.1.2 introduce a regime to provide unique identification of each bogie to enable the tracking of its operational and maintenance history. (094/04).

4.2 On 16 March 2005 the Chief Executive of Toll NZ Consolidated Limited replied in part:

093/04 the weld procedure [dated 20/08/02] forwarded to you on 10 February 2005 is the current procedure for attaching the wedge liners to the bogie frames.

094/04 for the last few years, both Hillside and Hutt workshops have been marking and recording serial numbers on bogies when they are overhauled. Subsequently we can trace when and where a bogie was last overhauled if it is involved in an incident. However it will be several years before all bogies have gone through a workshop for overhaul, to have a serial number assigned.

We are not recording which wagons these serialised bogies are going into, although bogies are checked at a two-yearly C-check and also whenever a bogie is swapped. At this time bogie wear limits are programmed into Alstom's computer system, which creates alerts for more regular checks as the bogie nears its limit.

As bogies are changed based on condition (rather than kilometres travelled or time in service), we are unsure how the serialisation of bogies would help prevent a similar incident.



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- 04-107 **express freight Train 237, derailment, near Kopaki, 24 March 2004**
- 04-102 motor trolley, derailment, Lepperton, 25 January 2004
- 03-113 diesel multiple unit, passenger Train 3366, passed conditional stop board without authority, Glen Innes, 30 October 2003
- 03-112 Investigation number and brief description
- 03-110 express freight Train 337, derailment, Kaimai Tunnel west portal, 9 August 2003
- 03-109 Investigation number and brief description
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