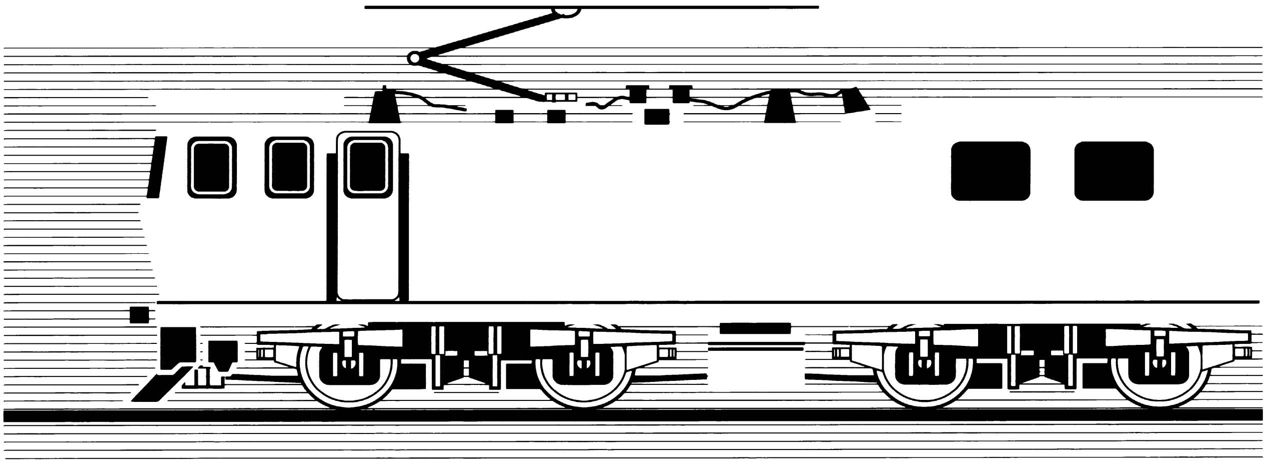

RAILWAY OCCURRENCE REPORT

05-126 express freight Train 246, derailment, South Junction 30 October 2005

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

Report 05-126

express freight Train 246

derailment

South Junction

30 October 2005

Abstract

On Sunday 30 October 2005 at about 1820, wagon UKR84 on Train 246, a Wellington to Auckland express freight service, derailed at 32.08 km, South Junction, between Pukerua Bay and Paekakariki, on the North Island Main Trunk. The wagon derailed as its leading bogie passed over a set of trailing points.

The left-hand leading bogie side frame had fractured through the top end pedestal and collapsed at about 28.733 km. The underside of the wagon then rested on the flange of the wheel and the brake rigging beneath the wagon dropped until the brake shoe rested on the head of the rail until the wagon derailed some 3.35 km further on. The derailed wagon was then dragged an additional 3.3 km before the train stopped at 35.38 km.

The collapsed bogie side frame damaged trackside structures at Pukerua Bay (30.295 km) and Muri (31.300 km) and, after the wagon derailed at 32.08 km, damaged the track from there to 35.38 km.

Safety issues identified included:

- the reporting and tracking of bogie component replacement
- the non-visual inspection of bogie components.

A previous safety recommendation covering the reporting and tracking of bogie components arising from another derailment has already been made to the Chief Executive of Toll NZ Consolidated Limited. A new safety recommendation has been made regarding the non-visual inspection of bogie components.

Contents

Figures

Abbreviations

DED	dragging equipment detector
m	metre(s)
t	tonne(s)
Toll Rail	Toll NZ Consolidated Limited
POD	point of derailment
MPa	Mega Pascals
Psi	Pounds per square inch

Data Summary

Train type and number:	express freight Train 246
Date and time:	30 October 2005, at about 1815[1]
Location:	32.08 km, South Junction, North Island Main Trunk
Persons on board:	crew: 1
Injuries:	nil
Damage:	wagon bogie destroyed and extensive track damage
Operator:	Toll NZ Consolidated Limited (Toll Rail)
Investigator-in-charge:	D L Bevin

[1] Times in this report are New Zealand Daylight Times (UTC + 13) and are expressed in the 24-hour mode.

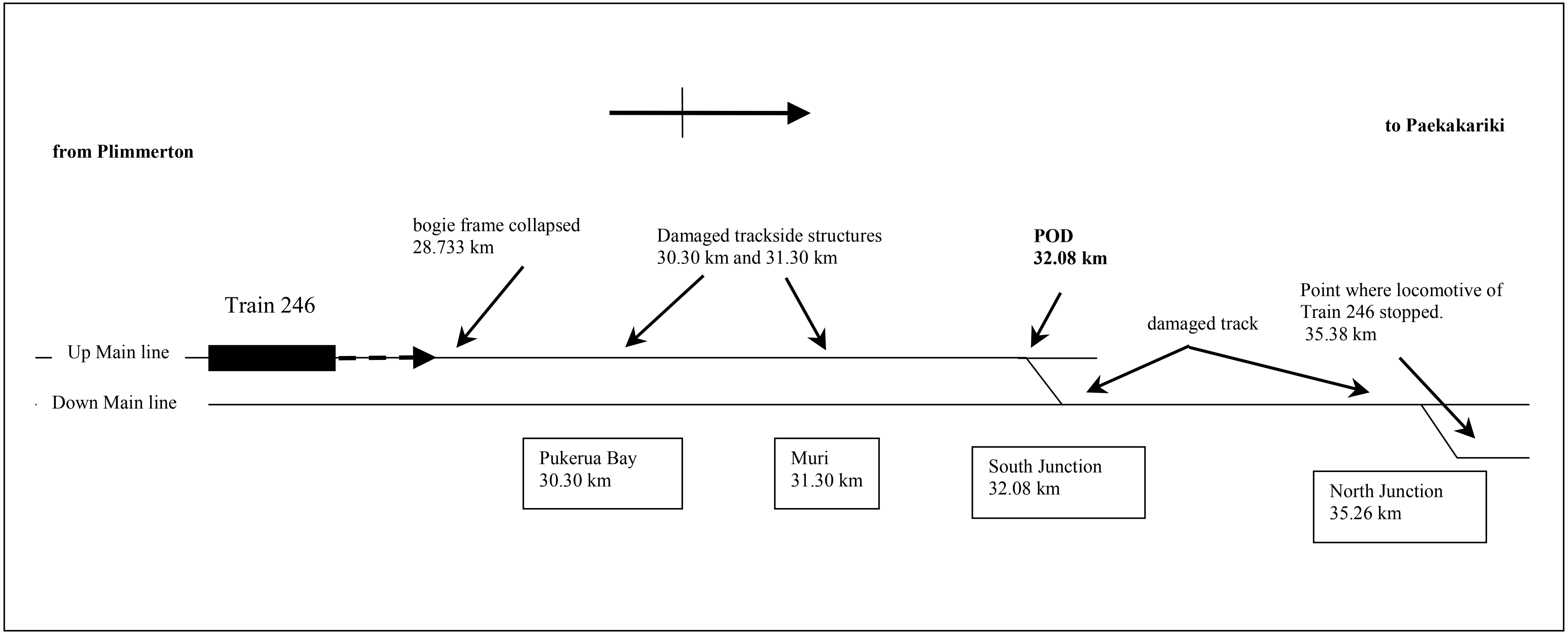

Figure 1
Derailment site plan (not to scale)

1 Factual Information

1.1 Narrative

1.1.1 On Sunday 30 October 2005, Train 246 was a Wellington to Auckland express freight train and consisted of one DX class and one DC class locomotive in multiple and 28 wagons with a gross weight of 862 t and a total train length of 474 m. The train was crewed by a locomotive engineer.

1.1.2 At about 1813, as Train 246 approached 28.733 km on the Up Main line between Plimmerton and Pukerua Bay, on the North Island Main trunk, the leading left-hand bogie side frame of UKR84 collapsed, causing the deck of the wagon to drop onto the flange of the wheel and the brake shoe to drop onto the head of the rail. The wagon continued in this state for another 3.35 km until it crossed over from the Up Main line to the single line at the trailing points at South Junction, at which point the bogie derailed.

1.1.3 The train continued with UKR84 derailed for a further 3 km to Up Home Signal 10R at North Junction, where it stopped while the locomotive engineer received authority from train control to proceed on to the Down Main line.

1.1.4 Once the locomotive engineer had received this authority he started to move Train 246 forward, and was just crossing the points onto the Down Main line when the train came to a stop. He saw that the train had lost air brake pressure and, on inspecting the train, he found that UKR84 had derailed.

1.1.5 The track was closed to all train movements for about 48 hours while the derailment was cleared and the track repaired.

1.2 Site information

1.2.1 The track from Wellington to South Junction and from North Junction to Paekakariki was double line with automatic signalling.

1.2.2 The track from South Junction to North Junction was single line. The signalling and interlocking was remotely controlled from the train control centre in Wellington.

1.2.3 The track from Plimmerton to Pukerua Bay was a climb of 5.8 km, at a ruling grade[2] of 1 in 57. Train 246 was about 4.2 km into the climb when the bogie side frame on UKR84 collapsed.

1.2.4 The track north of Pukerua Bay descended on a ruling grade of 1 in 66 for 5 km through Muri and South Junction and on to North Junction. Between South Junction and North Junction, a distance of 3.18 km, there were 12 curves and 5 tunnels, with cliff walls close to the locomotive engineer's side of the cab. The left-hand side dropped steeply towards State Highway 1 and the coast.

1.2.5 A broken bond wire on the outside of the left-hand running rail of the Up Main line at 28.733 km, and gouge marks on the head of the rail, were the first signs of the collapsed bogie side frame contacting the head of the rail. Figure 2 shows the next broken bond wire, at 28.771 km, with gouge marks visible on the head of the rail approaching and beyond the broken bond wire.

[2] The steepest part of the gradient.

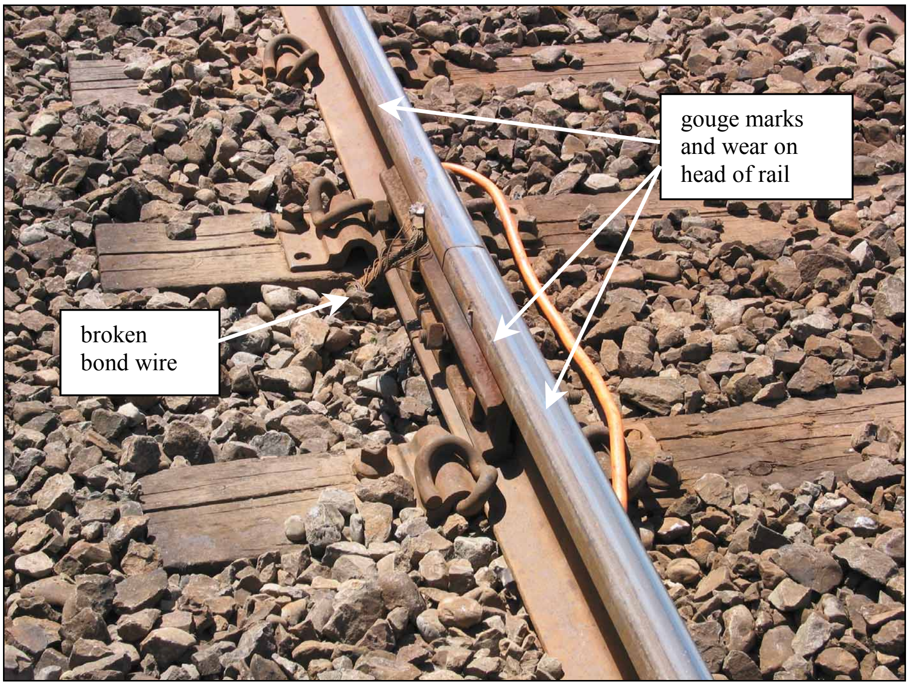

Figure 2
Broken bond wire at 28.771 km

1.2.6 A hi-rail vehicle (HRV) off-tracking stand at 30.285 km (see Figure 3) and a pedestrian level crossing at 30.300 km, both on the Up Main line at Pukerua Bay, showed evidence of strikes by the underside of the dropped bogie side frame.

Figure 3
Hi-rail vehicle off-tracking stand at Pukerua Bay

1.2.7 The tarmac on the left-hand side of the pedestrian level crossing on the Up Main line at 31.300 km at Muri showed further evidence of a strike by the dropped bogie side frame hanging over the left running rail (see Figure 4). The width of the gouge in the seal corresponded with that of the underside of the dropped frame.

Figure 4
Pedestrian level crossing at Muri

1.2.8 The first impact mark from the derailed right-hand wheelset was on a bolt on the inside of the right-hand running rail, about 500 mm past the point of derailment (POD). The first impact mark from the derailed left-hand wheelset was on a screwspike on the outside of the left-hand running rail, about one metre beyond the POD (see Figure 5). The bearing adaptor and the broken-off portion of the side frame were found adjacent to the points.

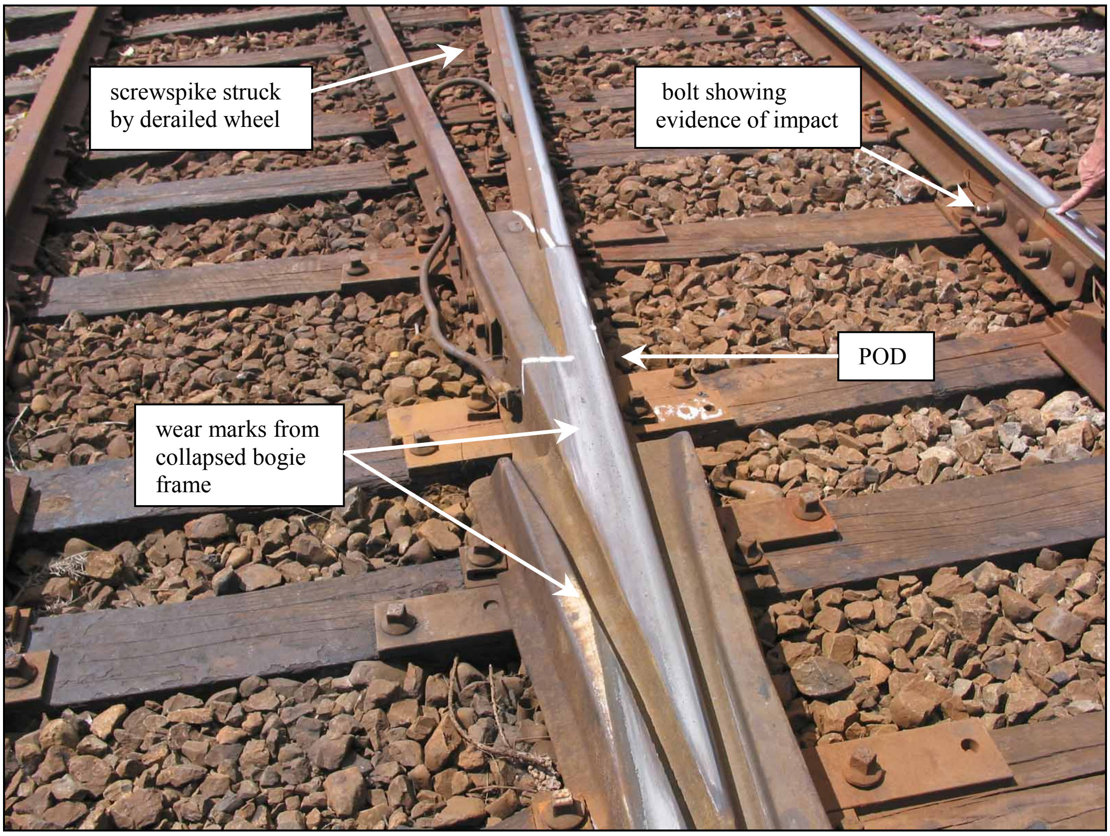

Figure 5
Point of derailment, facing points South Junction

1.2.9 The derailed wheelset had struck the foot of a rail weld at 32.40 km, about 320 m north of South Junction, and had broken the weld.

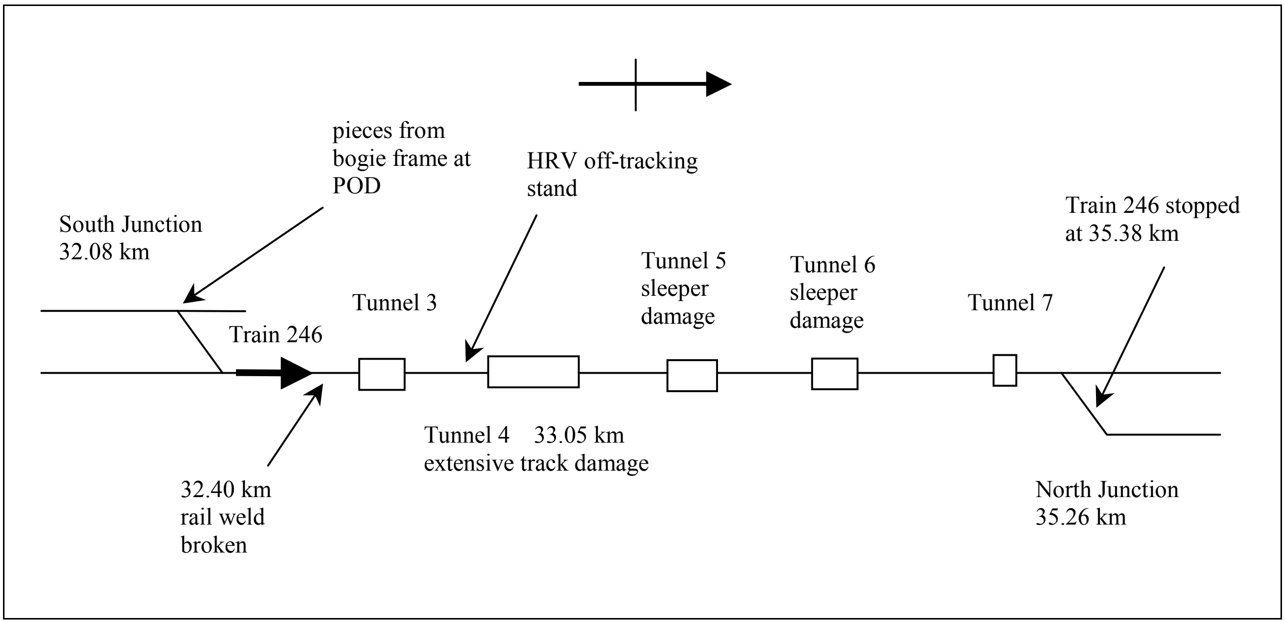

Figure 6
Site diagram South Junction to North Junction (not to scale)

1.2.10 As Train 246 approached Tunnel 4 at 33.05 km, the derailed wheelset struck another HRV off-tracking stand. About 80 sleepers were damaged in Tunnel 4, and the tunnel walls at the south end showed rubbing marks from the side of the wagon body.

1.2.11 About 12 sleepers were damaged in Tunnel 5, and a further 12 in Tunnel 6. About 40 sleepers and numerous pandrol clips and fastenings between the north end of Tunnel 6 and Tunnel 7 were destroyed.

1.3 Signalling and work area information

1.3.1 On Sunday 30 October a concrete sleeper lay was being carried out on the Up Main line between North Junction and Paekakariki. The work area extended from 32.25 km, between South Junction and North Junction, to 48.53 km at Paraparaumu. South Junction was outside the southern boundary of the work area.

1.3.2 During the work period, Tranz Metro[3] electric multiple unit (EMU) services between Wellington and Paraparaumu had been terminated at Pukerua Bay and returned to Wellington on the Down Main line via the points at South Junction. Up Departure Signal 8R was fixed at stop to prevent the entry of trains to the South Junction to North Junction section without authority. A shunting signal had been installed that allowed EMU services to pass Signal 8R and proceed for a short distance into the section before returning on the Down Main line. Northbound freight trains passing through the area, such as Train 246, required from train control a Mis 59 authority to pass Signal 8R at stop.

1.3.3 To enable Train 246 to travel around the work area, the train controller diverted the train to the Down Main line at North Junction, referred to as wrong line running (see Figure 7), as far as Paekakariki and then re-routed it back to the Up Main line.

[3] Tranz Metro was the group within Toll Rail with responsibility for the operation of suburban train services in Wellington.

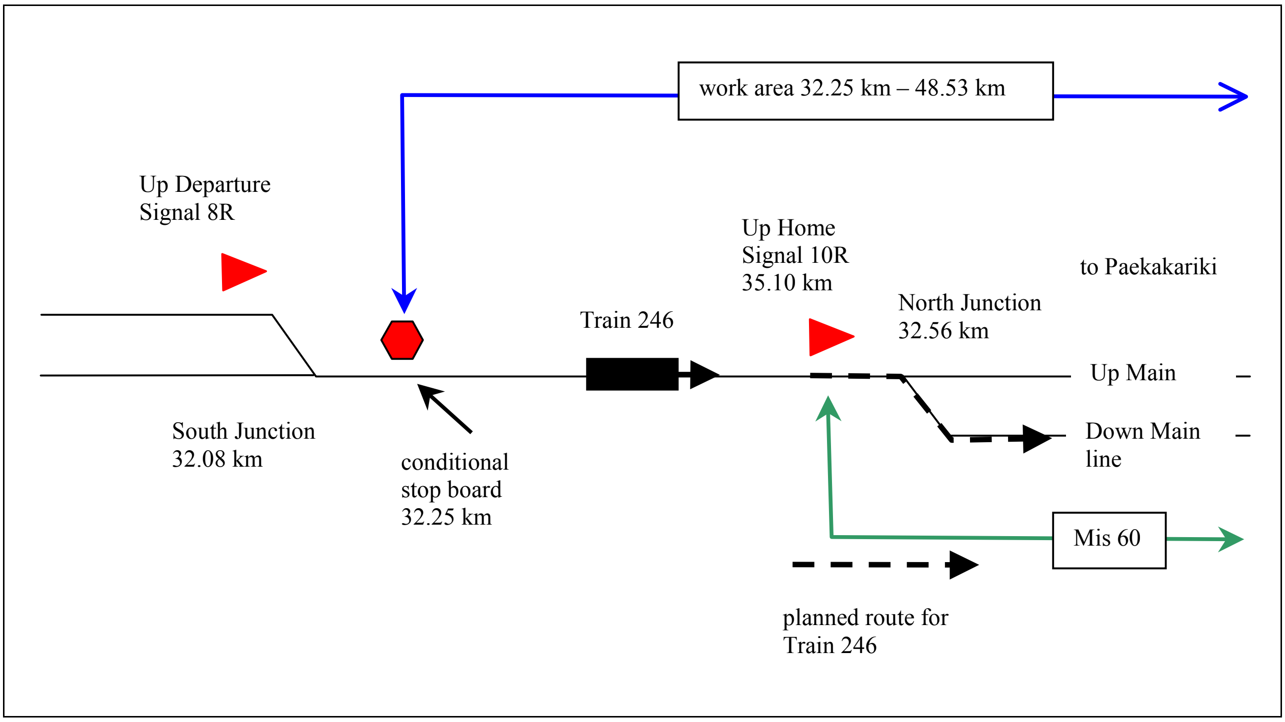

Figure 7
Signalling and work site arrangements in place (not to scale)

1.3.4 The locomotive engineer of Train 246 stopped at Up Home Signal 10R at North Junction (see Figure 7) to receive from train control the Mis 60, authorising him to run up the Down Main line from North Junction to Paekakariki.

1.4 Personnel

1.4.1 The locomotive engineer had 40 years' driving experience with Toll Rail and its predecessors and was qualified for express freight services.

1.4.2 The locomotive engineer said that he had stopped his train at the departure signal at South Junction to obtain authority to pass the signal at stop, then stopped at the conditional stop board between South Junction and North Junction to get permission to enter the work area and finally at the home signal at North Junction where he received his Mis 60 from train control. After each stop he said the train had moved away without any indication that anything was wrong.

1.4.3 He first became aware of the derailment after the train lost brake pipe pressure and stopped as he negotiated the set of points at North Junction and moved towards the Down Main line. He walked back along the train and found that UKR84 had derailed.

1.5 Locomotive event recorder

1.5.1 The locomotive event recorder data was not requested for analysis because train handling was not considered to have contributed to this accident.

1.6 Dragging equipment detectors

1.6.1 Since 1993 a number of dragging equipment detectors (DED's) had been installed on the rail network. Dragging equipment was detected by frangible plates mounted in 5 sections, 3 between the rails and one on either side (see Figure 8). This bar formed part of an electrical circuit that provided an alarm output if any section of the bar no longer provided electrical continuity, for example if it was broken by dragging equipment.

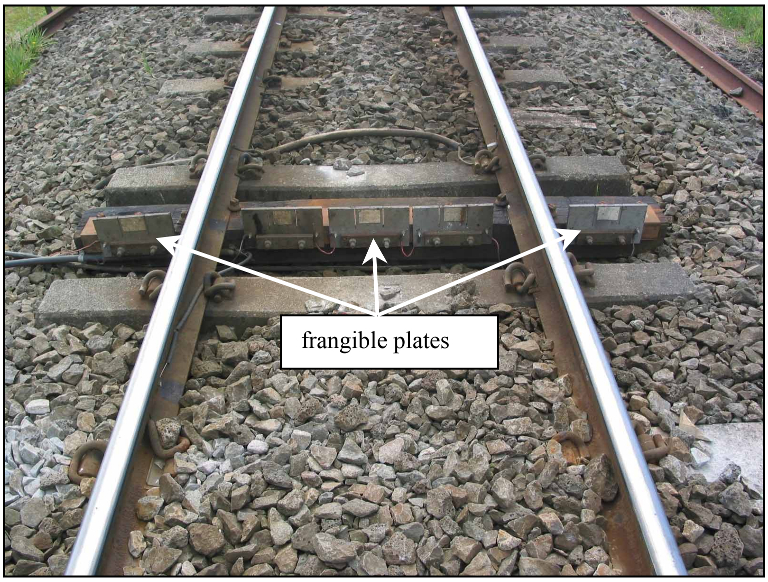

Figure 8
Example of a dragging equipment detector

1.6.2 The dragging equipment alarm was fed into a radio controller that performed the following functions:

- sent an alarm message to train control – this alarm continued at regular intervals until acknowledgement was received from the train control radio computer
- activated a voice message over the local radio channel (channel 1) for immediate advice to any trains in the immediate vicinity. This voice message was heard twice.

1.6.3 The nearest DED was at 49.83 km, between Paraparaumu and Waikanae, about 17.75 km north of the POD.

1.6.4 ONTRACK advised that DED's were installed to provide network protection by ensuring trains detected as having dragging equipment could be stopped before causing too much damage to the infrastructure. Historically there was no policy to determine sites for installing dragging equipment detectors. Usually sites were incorporated with heat detection sites or were installed at sites where additional capacity was available through the centralised traffic control signalling cables for communicating with train control. These latter installations were mostly on the North Island Main trunk between Hamilton and Auckland.

1.6.5 Although there was no fixed plan for the ongoing installation of dragging equipment detector sites, ONTRACK had identified the Kaimai Tunnel as a potentially vulnerable area and was working towards installing the equipment at the approaches to the Tunnel.

1.7 Wagon inspections

1.7.1 Mechanical Code M2000, Wagon and Inspection Manual, required that all freight wagons 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.

1.7.2 A pre-departure check was a thorough walk-around inspection undertaken by yard operating staff before a train departed from a terminal and included the following below wagon-deck items:

- observe the condition of the brake blocks
- confirm that the handbrakes were released and the lever was in the crotch
- rectify any leaking brake hoses or replace burst hoses
- check the wheels/tyres
- check bogie springs
- check for loose/hanging brake gear and rigging.

The code required a Train Inspection Certificate to be signed off by a qualified person confirming that the train had been inspected and was in a proper condition for safe running. The completed Certificate was then attached to other train documentation and retained in the locomotive cab until the train reached its destination.

The B-Check and C-Check requirements listed in M9202 were:

<u>B-Check – Bogie/suspension</u>

Springs:	In place, secure and intact.
Bearing keeps:	Held securely in place.
Liners:	Secure. Not broken.
Wedge heights:	Within limits (use Snubber Gauge if in doubt).
Bearing adapters:	In place. No visual signs 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.
VTA valve	Gap setting correct. (WM.T. only).
	Plunger and stop in line.
	Air supply hoses in place.

<u>C-Check – Bogie/suspension</u>

Springs:	In place, secure and intact.
Bearing keeps:	Held securely in place.
Liners:	Secure. Not broken. Not worn more than 50% original thickness.
Wedge heights:	Within gauge limits.

Bearing adapters:	In place. Not damaged or worn.
Side bearer:	Not damaged or worn.
Dampers:	Secure No excessive oil leaks.
Horns:	Not bent.
Bearings:	No sign of overheating. Cap bolts in place. Cap bolts secure. Backing rings secure. No grease leakage.

1.7.3 Details of the last four B-Checks and C-Check carried out on UK17032/UKR84 were:

Work Order	Work completed	Description	Date
501929	WORN AND 2 FUSE BLOCKS, A1, B2, 4 SLIPPERS	Wagon B Check	05-Aug-05
439928	4 BRAKE BLOCKS	Wagon B Check	10-Dec-04
173931	12214 – 2 Year Wagon C Check	2 Year Wagon C Check	14-Jul-03
240314	UK17032-B CHECK INSPECTION/AIR TEST	Wagon B Check	14-Jul-03
224684	WORN BRAKE BLOCKS	Wagon B Check	15-May-03

1.8 Wagon UKR84

1.8.1 Toll Rail's records showed that UKR84 had originally entered service as UK17032 in May 1986 but had later been modified and converted for the conveyance of refrigerated containers and reclassified. UKR wagons were semi-permanently coupled together in 5-wagon packs. The centre wagon had a power generator, which powered the containers' refrigeration equipment on all 5 wagons.

1.8.2 UKR84 had standard 3-piece bogies, known as T14 bogies, as used on most freight wagons worldwide. The 3 main "pieces" were 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, known as wedge springs, applied pressure to the friction wedge to provide wagon damping[4].

1.8.3 There were no markings on the bogie side frame to indicate the age of the casting, and no markings to indicate where or when it was last overhauled. However, records showed both bogies had been fitted to UKR84 on 9 October 2003.

1.9 The failure

1.9.1 When the leading end of the left-hand bogie side frame supporting the leading wheelset fractured, it dropped about 130 mm, resulting in the underside of the wagon deck resting on the flange of the left-hand wheel (see Figure 9). The brake rigging beneath the wagon also dropped until the brake shoe, attached to the brake beam and immediately behind the leading wheel, came in contact with the head of the rail.

[4] Damping reduced oscillation of wagons while in motion.

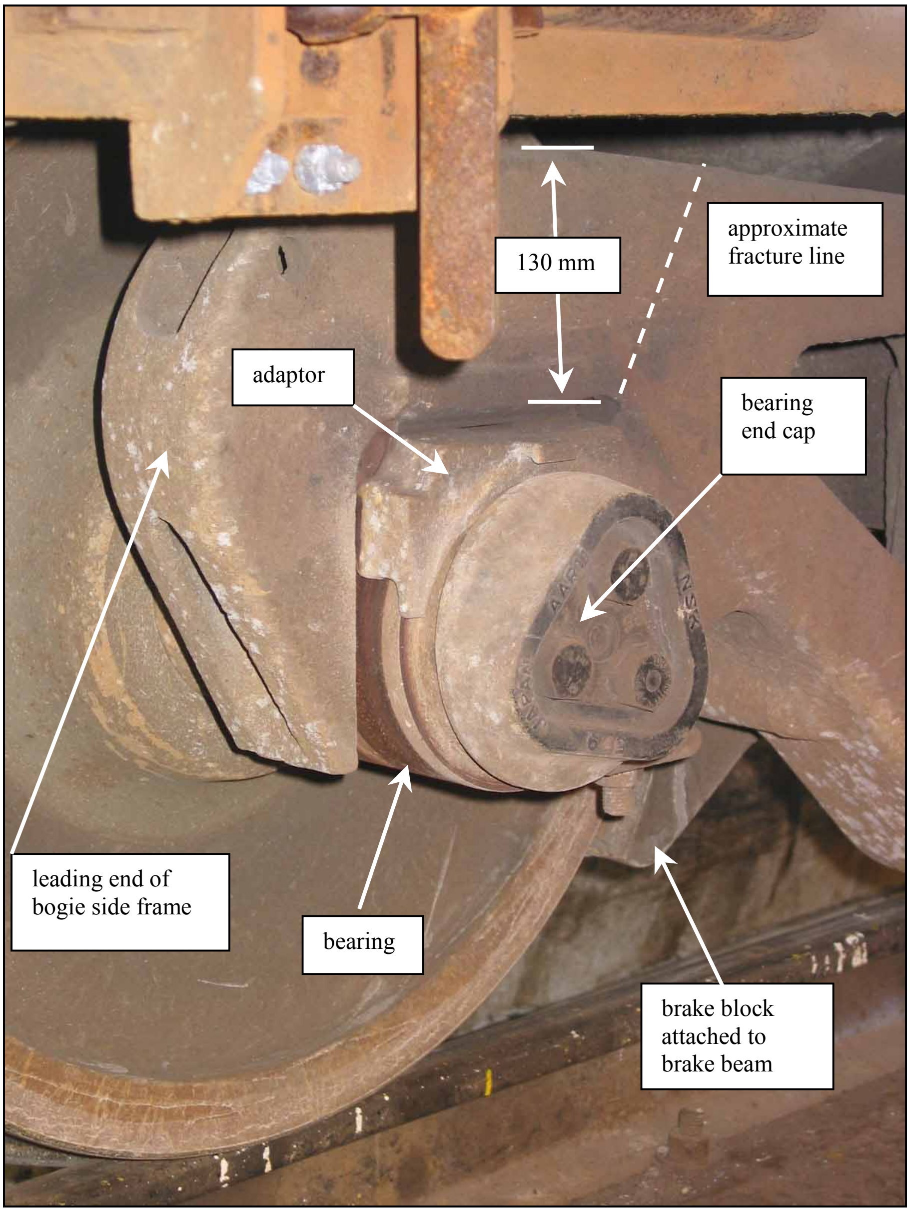

Figure 9
Identification of wheel set parts

1.9.2 When the bogie side frame collapsed, it dropped until the gussets on the underside were below the head of the rail. The side frame was then overhanging the head of the rail and below rail level. Figure 10 shows an undamaged assembly, and Figure 11 shows the worn gussets and other damage to the underside of the side frame of UKR84. Figure 11 was taken from the rear of the bogie side frame; the gussets would have been outside the left-hand rail in the direction of travel, as shown in Figure 9.

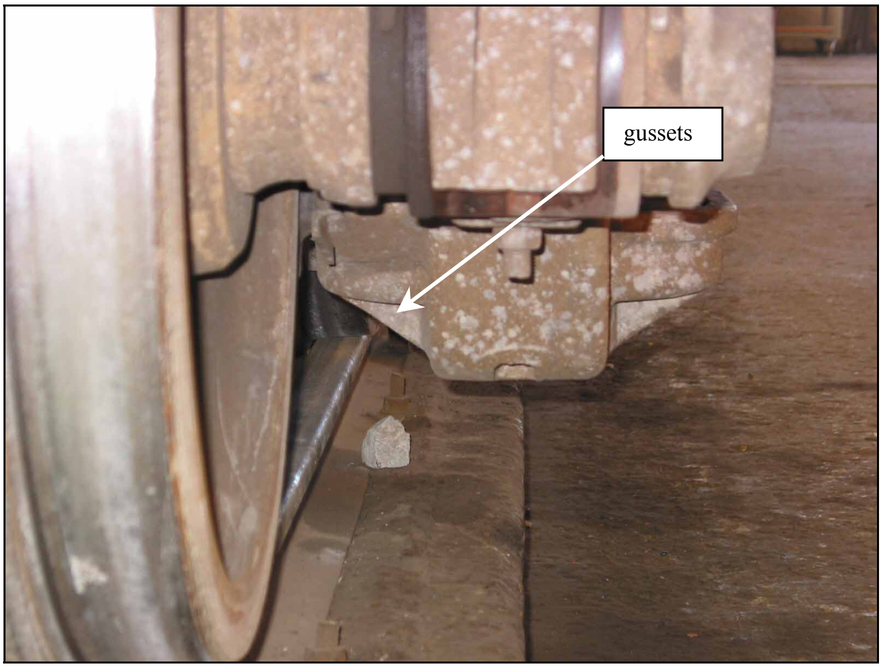

Figure 10
Front view of an undamaged bogie side frame assembly

Figure 11
Worn away gussets

1.10 The failed bogie side frame

1.10.1 The failed bogie parts were taken to the United Group Limited[5] wagon depot in Wellington where they were examined as part of the investigation. Figure 12 shows the bogie side frame after it was recovered from the derailment site.

[5] Contracted in 2005 to undertake the inspection and maintenance of rolling stock to standards set by Toll Rail.

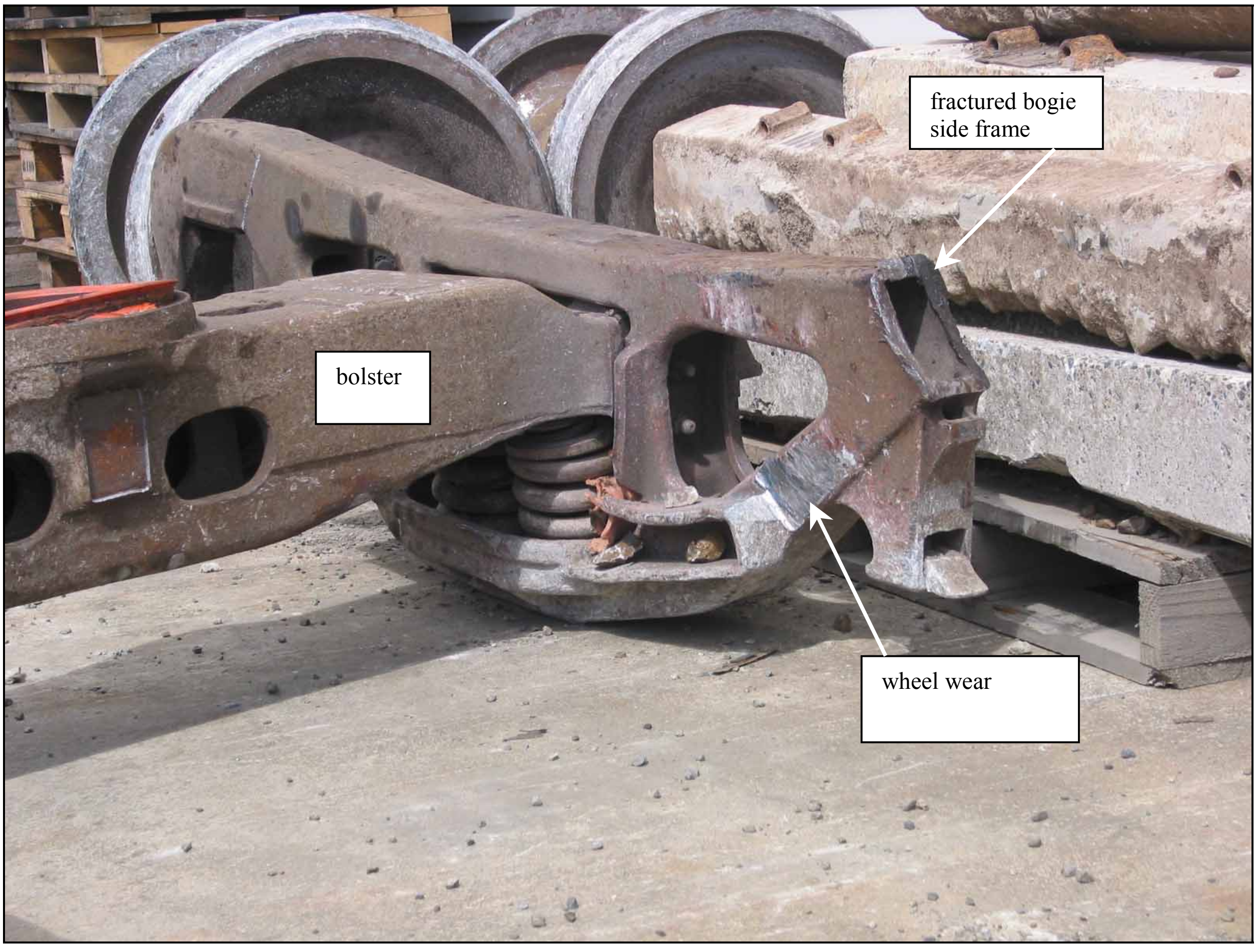

Figure 12
Failed left-hand side of the bogie side frame

1.10.2 The fractured left-hand leading end of the bogie side frame was recovered from the POD at South Junction.

Figure 13
Fractured bogie side frame left-hand leading end

1.11 Examination of the failed bogie side frame

Introduction

1.11.1 The separated portion of the front left-hand leading side of the bogie frame was taken for independent metallurgy testing and analysis. Figure 14 shows the failed bogie side frame with the fracture area circled.

Figure 14
Failed bogie side frame

1.11.2 The age of the bogie side frame was unknown. The bogie had been fitted to UKR84 on 9 October 2003 but it was not known if it was new or used at that time. Also it was not known when the bogie side frame was last serviced or visually checked for cracks.

Visual examination

1.11.3 The fractured part of the bogie side frame was visually examined using a stereoscopic microscope. The side frame included a box section to which was welded a wear plate (see Figure 15). The blue arrow indicates an axial direction view of castellations in the prepared metallographic section.

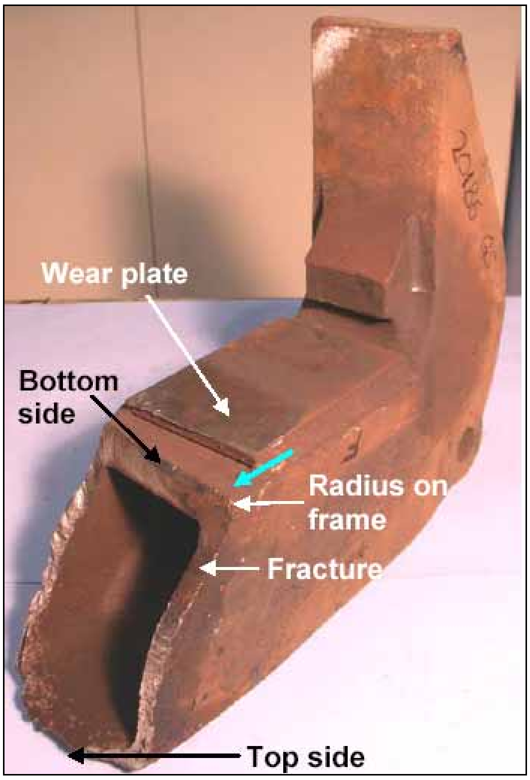

Figure 15
Fractured section of bogie side frame

1.11.4 A fatigue fracture was present and had propagated completely through the bottom side and across about two-thirds of adjacent sides of the box section area. Ductile overload fracture was visible below the yellow arrows as was a deformation lip on the topside of the box section (see Figure 16).

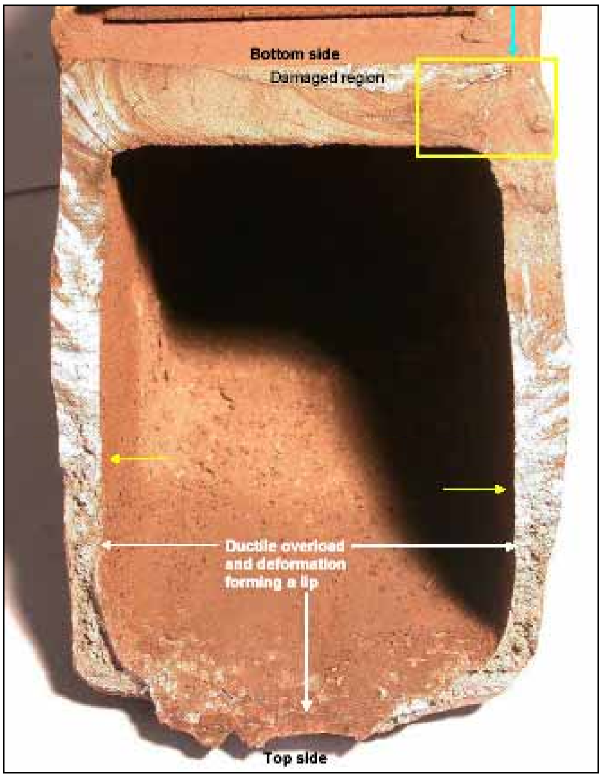

Figure 16
Box section

1.11.5 Fatigue initiation occurred at a corner in a radius on the bottom side of the box section. The radius appeared to have been part of the original frame geometry (see Figures 15 and 16). Some edge damage sustained after the failure had obliterated evidence in part of the fatigue initiation region, although considerable evidence of fatigue was present beyond this. Several fatigue cracks had initiated at significantly different positions on the radius and led to castellations with significant steps. One of these castellations appeared to have been masked by damage sustained after the failure (see Figure 17).

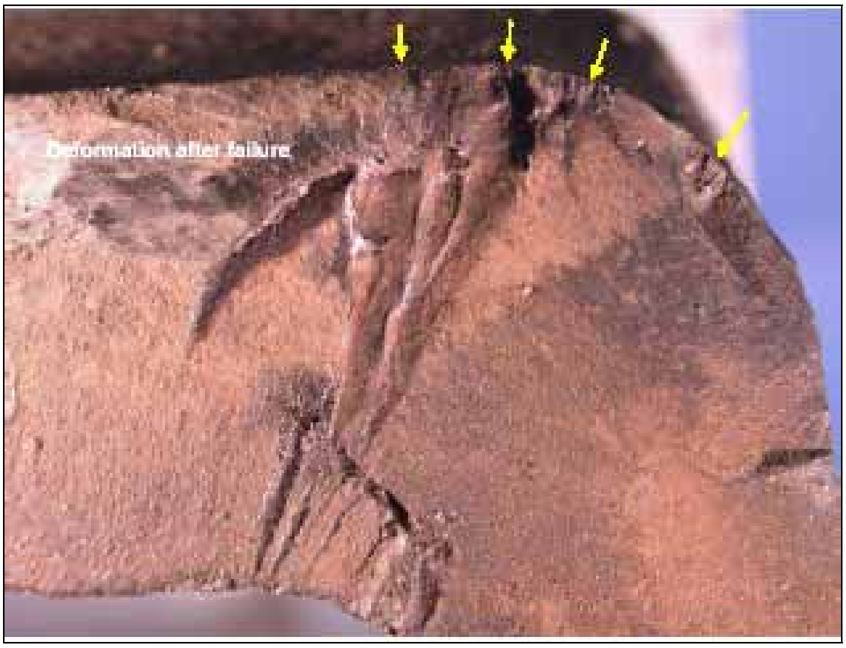

Figure 17
Initiation region of fatigue crack exhibiting castellations (arrowed)

1.11.6 The fatigue crack exhibited a considerable area of smooth, relatively flat crack propagation along the bottom side of the box section. Within this area, at least 40 arrest or beach marks were present, many of which were very close together. This was consistent with a fairly high number of changes in service condition. As the crack propagated the beach marks gradually became further apart.

1.11.7 The wear plate exhibited fairly evenly distributed and typical wear on its surface. No cracking was observed next to the wear plate welds and the origin of the fatigue crack was not associated with the welds.

1.11.8 No defects were observed at the fatigue origin.

1.11.9 Superficial corrosion product was observed on the fracture surface.

Microscopic examination

1.11.10 A section was removed from the initiation region and metallographically examined. The sample was mounted in bakelite so that during grinding and polishing, the castellations could be approached and examined from behind, in the axial direction indicated by the blue arrows in Figures 15 and 16.

1.11.11 There was no evidence of any welding to suggest that the frame had been repaired in this region and no significant porosity, non-metallic inclusions or other defects were observed near the surface in the crack initiation region.

1.11.12 Decarburisation [6] near the surface of the material was observed under the microscope in the decreasing amount of the darker phase (pearlite) in the microstructure, and can lead to a reduction in strength in the surface layer (see Figure 18). This was typical of annealed[7] cast steel structures and was not considered to be a contributing factor.

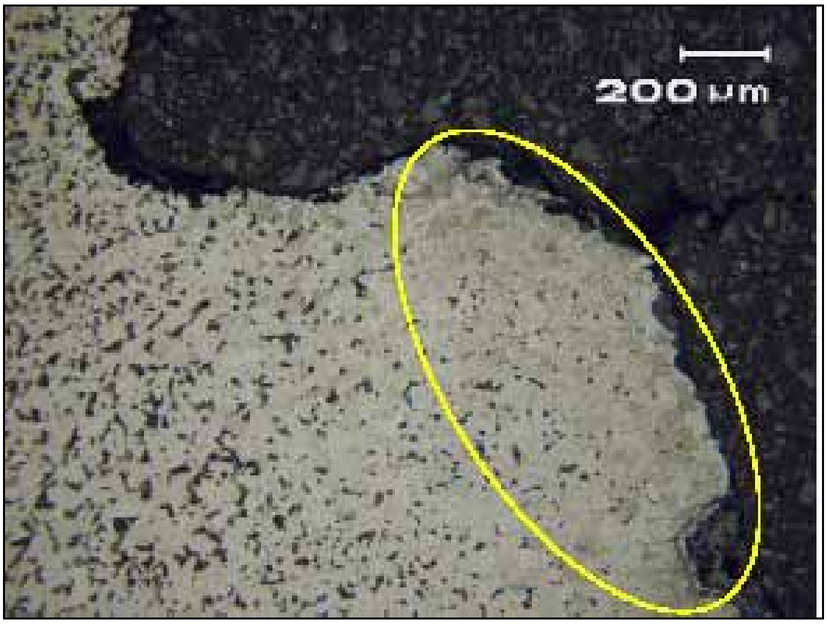

Figure 18
Region of initiation near a castellation. Decarburisation is present (circled) near the surface of the bogie frame

1.11.13 The structure was typical of cast steel. However, the microstructure was consistent with annealed carbon steel, indicating a typical heat treatment after casting (see Figure 19).

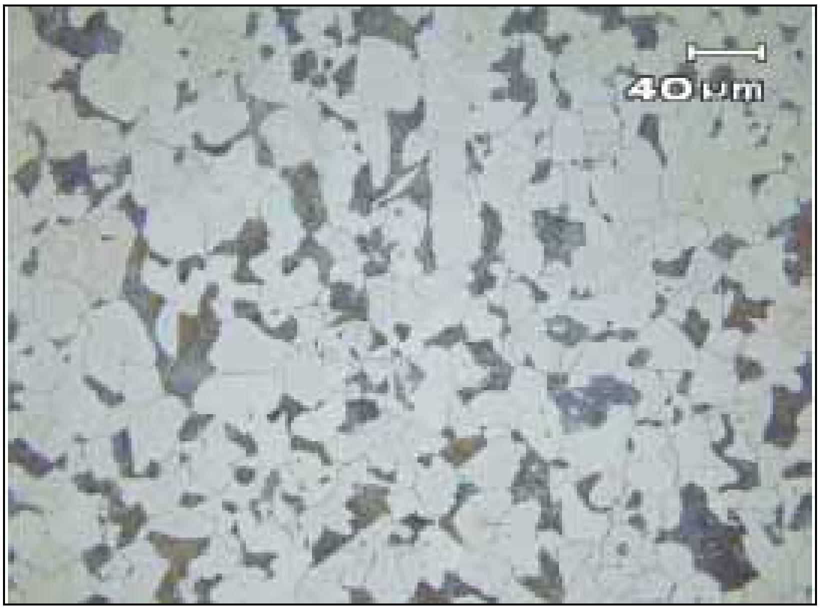

Figure 19
Microstructure of surface area

[6] Decarburisation occurs during casting and, more so, subsequent heat treatment of the item. Carbon is lost to the surrounding atmosphere due to diffusion and oxidation.
[7] Heated and allowed to cool slowly to toughen it.

Hardness

1.11.14 Vickers hardness tests were performed on the prepared section using a 10 kg load. Five hardness values were consistent in the range 121 – 135 HV 10. The hardness values were indicative of steel with a tensile strength of about 393 - 441MPa (57 000-64 000 psi).

1.12 T14 bogies

1.12.1 The T14 bogie was an old design, dating from the late 1960's, so the current American Association of Railroads (AAR) material standards were not relevant.

1.12.2 The original Australian design/manufacture of the T14 specified that the side frame material was to have a tensile strength of 460Mpa minimum with a maximum carbon content of 0.30%. The original New Zealand manufacturing specification required nothing more than a "cast steel 0.2% - 0.22% of carbon content A steel of this carbon content would have a tensile strength of 450 – 460 MPa.

1.12.3 Although manufactured from a slightly lower carbon steel than the original Australian design, the New Zealand version of this bogie was used at a lower axle load than the bogie side frame was nominally designed for.

1.12.4 The bogie side frames were designed to carry a load equal to the rated load of the bearing with which they were fitted. The T14 used the Class C AAR package bearing, rated at 15.2 tonnes per axle. In service in New Zealand the T14 bogie was rated at 14.3 tonnes per axle, 6% below the bogie side frame nominal rating.

1.12.5 Toll Rail confirmed that AAR standards had not initially applied in New Zealand but were now used for convenience. However, this was not the case in the 1960's and compliance with AAR standards was not relevant.

1.13 Previous relevant occurrences investigated by the Commission

Occurrence report 04-107, express freight Train 237 derailment, near Kopaki, 24 March 2004

1.13.1 On Wednesday 24 March 2004, USQ7663, 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 USQ7663 was found to be a contributing factor to the derailment.

1.13.2 The report noted that Tranz Rail[8] had no unique identification on the bogie and it had therefore not been possible to track either its operational or maintenance history.

1.13.3 On 9 February 2005, as a result of this incident, the Commission recommended to the Chief Executive of Toll Rail that he:

> introduce a regime to provide unique identification of each bogie to enable the tracking of its operational and maintenance history.
> (094/04)

[8] The predecessor to Toll Rail.

1.13.4 On 16 March 2005 the Chief Executive of Toll Rail replied in part:

> 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.

Occurrence report 04-130, covering four derailments due to axle bearing failures, various locations, 5 November 2004 – 21 March 2005

1.13.5 Between 5 November 2004 and 21 March 2005 there were 4 express freight train derailments where the cause was attributed to a bearing failure. Because of the similarities of the incidents, investigations into them were combined into one report, although each incident was dealt with separately. The incidents were:

- **Occurrence 04-130**: on Friday 5 November 2004, wagon ZH1812 on express freight Train 237 travelling from Auckland to Wellington derailed between Kakahi and Owhango. The derailed wagon activated a dragging equipment detector unit that sent an alert to train control. The train controller contacted the locomotive engineer and the train was stopped about 4 km past the point of derailment
- **Occurrence 05-106:** on Friday 4 February 2005, wagon UKR137 on express freight Train 221 travelling from Auckland to Wellington derailed at Kaiwharawhara. A shunter saw the derailed wagons as the train was berthing at Wellington freight yard
- **Occurrence 05-110:** on Monday 21 February 2005, wagon UK18837 on express freight Train 247 travelling from Auckland to Wellington derailed about 20 m before the north end main line points at Te Kauwhata. The derailed wagon caused significant damage to the main line points and associated signalling equipment
- **Occurrence 05-114:** on Monday 21 March 2005, loaded coal wagon CB10558 on unit freight Train 842 travelling from Ngakawau to Lyttelton derailed at Jackson on the Midland Line. Six other loaded coal wagons derailed as a consequence of derailment damage to the track. There was significant damage to both track and rolling stock.

1.13.6 On 7 December 2005, as a result of these incidents, the Commission recommended to the Chief Executive of Toll Rail that he:

> develop a system for recording and tracking both new and reconditioned key components used on bogies. (111/05)

1.13.7 On 19 December 2005 the Chief Executive of Toll Rail replied in part:

> It will take 10 years for the implementation to be complete, as bogies can have up to 10 years life between overhauls.

1.13.8 While the causes of the derailments in Occurrence reports 04-107 and 04-130 and that in the derailment at South Junction were different, they were all related to bogie failures or defects. The inability to track bogie maintenance and operational history was considered to be an issue in all the investigations because such a history may have been able to better identify causes of those failures. Therefore, the safety recommendation is equally applicable to this investigation.

2 Analysis

2.1 When the leading left-hand end of the leading bogie side frame collapsed, the wagon deck fell until the underside was resting on the flange of the left-hand leading wagon. The underside of the wagon deck, together with the weight bearing down, would have slowed the wheel but it probably continued to turn until the POD. This downward pressure would have kept the flange of the wheel against the rail, and probably prevented an immediate derailment by assisting with steering the bogie through to South Junction.

2.2 The gouging on the head of the rail was probably caused by the sharp edge of the brake block shoe, which came in contact when the side frame dropped. The side frame probably broke the bond wires because it overlapped the head of the rail after the initial collapse.

2.3 Impact marks at the hi-rail vehicle off-tracking stand at Pukerua Bay indicated the bogie side frame had grazed the timber, rather than made direct head-on impact, which confirmed that the under side of the side frame was then riding high. Likewise the paving at the pedestrian level crossing at Pukerua Bay, a few metres further on, had disintegrated, but there was no evidence of gouging at ground level either approaching or beyond the crossing. However, the pedestrian level crossing at Muri, one kilometre beyond that at Pukerua Bay, did have evidence of a direct strike with a deep gouge taken out of the paving. The width of this gouge corresponded with the width of the under side of the side frame.

2.4 The under side of the side frame, rather than the leading edge, bore most of the markings from strikes with line-side structures, although there were significant ballast abrasions on the leading edge, probably incurred between the POD at South Junction, and North Junction.

2.5 The derailment occurred when the leading left-hand wheel failed to negotiate the points at South Junction. The wagon was then dragged to North Junction where Train 246 stopped when the air brake pipe pressure was lost and the locomotive engineer became aware of the train parting. From the time the bogie side frame had collapsed until the derailment was discovered, the air brake pipe had remained coupled throughout the train and the locomotive engineer would not have had any indication that a wagon had derailed.

2.6 The topography of the countryside, together with the track geometry, would have prevented the locomotive engineer seeing the derailed wagon from his side of the cab, although it may have been visible at times from the opposite side. However, he had no reason to cross the cab to view his train and again, the countryside he was driving through, particularly as he was approaching a complex work area, meant that he needed to focus his attention fully on his driving duties.

2.7 The bogie side frame was made from steel of slightly less strength than the AAR standard for the time. However, it was used to carry a load 6% less than the AAR specified load. In terms of material strength the bogie was probably fit for purpose and the years of generally satisfactory service confirmed that its fundamental strength was adequate.

2.8 The bogie side frame probably failed in high cycle fatigue followed by ductile overload. The presence of a relatively smooth, flat region of fracture with "arrest" marks along the bottom side of the box section indicated that the cracking had been present for some time. Each "arrest" mark indicated a significant change in the loading conditions, probably related to each time the wagon was loaded or unloaded and each time the wagon was moved.

2.9 The presence of a number of castellations showed that the fatigue cracking had occurred at a stress level well in excess of the fatigue limit, which suggested that the cracking probably occurred in thousands or tens of thousands of cycles rather than tens of millions of cycles.

2.10 The cracking was probably initiated due to heavy loading conditions such as those that caused the "arrest" marks. Once the crack had formed, it would have propagated at progressively lower stress levels until the propagation occurred during normal operation. Once this occurred the rate of cracking probably accelerated. From this it could be concluded that the smooth fracture along the bottom side was probably present for some time, but the remainder of the fracture could have occurred within the last 2 trips.

2.11 The inspection of UKR84 before Train 246 departed from Wellington probably would not have detected the fracture in the bogie side frame. Although the crack on the bottom side of the box section had propagated to the outside of the frame, it was probably camouflaged by the grime and discoloration of the surrounding surface and would not have been visible to the person carrying out the inspection. Although the inspection did cover items beneath the deck of the wagon, the overall condition of the bogie side frame was not one of those items. The wagon was stationary at the time of the inspection but once it started moving again, the additional stresses created by the movement probably speeded up the fracture process.

2.12 Neither the age of the bogie nor its operational and maintenance history could be determined. However, it was likely to be of a similar age to other bogies in service and may therefore have experienced service over a period of about 30 to 40 years. In this case, the bogie was likely to have experienced thousands of trips with a variety of loading conditions.

2.13 Toll Rail advised that it is now marking and recording serial numbers on bogies when they are overhauled to enable tracing of the history of a bogie should it be involved in an incident. However, it is accepted that in the interim such historic information will not be available for all bogies. Because of this, no safety recommendation covering this issue has been made.

2.14 The presence of a crack in the bogie side frame at the time it was installed on UKR84 in 2003 could not be discounted, as there was no evidence to suggest the bogie side frame had been inspected for cracks prior to its installation. The lack of prior service history of the bogie also meant it was not possible to determine if the bogie had been involved in a previous incident resulting in overstress of the side frame. Had this happened, it could possibly have been the cause of the crack initiation.

2.15 B-Check and C-Check inspections of the bogies were visual only and, unless the crack was obvious, there was a possibility it could be missed and a potentially defective bogie returned to service. Often the B-Check or C-Check does not involve a wheel change so the visual inspection of the bogie side frame would be done with the wheels still in place, further reducing the opportunity for the inspecting staff to identify a crack. A safety recommendation covering enhancements to existing bogie frame inspection regimes has been made to the Chief Executive of Toll Rail.

2.16 Had a dragging equipment detector been positioned on the Up Main line near Pukerua Bay, the collapsed bogie side frame on UKR84 would have been detected and arrangements made for the train to be stopped before it entered the single line section at South Junction. This would have prevented the derailment, the resulting major track damage and the disruption to traffic.

2.17 The DED located at 49.83 km north of Wellington was the first such unit which could have detected any potential dragging equipment on the train. While the location at which wagon equipment could start to drag, or a derailment occur, was somewhat random, consideration should be given to the positioning of a network protection facility, such as a DED, near the operationally critical single-line section between South Junction and North Junction and a safety recommendation covering this issue has been made to the Chief Executive of ONTRACK.

3 Findings

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

3.1 UKR84 derailed after the left-hand bogie side frame fractured and collapsed and the wagon was unable to negotiate a set of points in that condition about 3 km further on.

3.2 The bogie side frame failed due to high cycle fatigue followed by ductile overload.

3.3 No metallurgical evidence of defects was found at the fatigue origin.

3.4 The steel used for the manufacture of the bogie met New Zealand specifications and was typical of such an application.

3.5 Hardness tests did not indicate a significant reduction in strength that could have contributed to the initiation of a fatigue crack.

3.6 The lack of a unique identification number on each bogie prevented tracking of its operational and maintenance history.

3.7 B-Check and C-Check procedures required only visual inspections of bogies.

3.8 No track geometry issues were identified that could have contributed to the derailment.

3.9 Operating procedures in place for the planned work were appropriate and did not contribute to the derailment.

3.10 The actions of the locomotive engineer did not contribute to the derailment.

3.11 Had a dragging equipment detector been positioned on the Up Main line in the vicinity of Pukerua Bay the derailment, subsequent damage and network disruption would have been avoided.

4 Safety Recommendations

4.1 On 13 March 2006 it was recommended to the Chief Executive of Toll NZ Consolidated Limited that he:

> include within the existing procedure for overhauling bogies, an inspection other than visual only, to confirm the structural integrity of specified components before a bogie is returned to service. (007/06)

4.2 On 2 April 2006 the Chief Executive of Toll NZ Consolidated Limited responded:

> Toll Rail intends to formally implement this recommendation.
>
> The "Overhaul Manual for Bogies" will be amended specifying bogie components that will require other than visual inspections. The inspection method will also be specified.
>
> It is expected this change will be formally promulgated, following final Technical Committee approval, by end of April 2006.
>
> However, it should be noted that specific testing is now being applied to side frames, bolsters and specified areas pf brake beams in anticipation of this Code change.

4.3 On 13 April 2006 it was recommended to the Chief Executive of ONTRACK that he:

> review the network protection at operationally critical locations such as but not limited to North and South Junctions (019/06).

4.4 On 20 April 2006 the Chief Executive of ONTRACK responded in part:

> ONTRACK accept this recommendation, and anticipates commencing this review in 2006.

Approved on 27 April 2006 for publication

Hon W P Jeffries
Chief Commissioner

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