Report 06-111, express freight Train 237, derailment, Utiku, 20 October 2006

Report 06-111

express freight Train 237

derailment

Utiku

20 October 2006

Contents

Figures

Abbreviations

km	kilometre(s)
km/h	kilometre(s) per hour
m	metre(s)
mm	millimetre(s)
NIMT	North Island Main Trunk
t	tonne(s)
Toll Rail	Toll NZ Consolidated Limited
UTC	universal coordinated time

Data Summary

Train type and number:	express freight Train 237	
Date and time:	20 October 2006**,** at about 0640[1]	
Location:	Utiku	
Persons on board:	crew:	one
Injuries:	crew:	nil
Damage:	substantial damage to wagons and infrastructure	
Operator:	Toll NZ Consolidated Limited (Toll Rail)	
Investigator-in-charge:	P G Miskell	

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

Executive Summary

At about 0640 on 20 October 2006, the sixth wagon on express freight Train 237 derailed and entered a crossing loop at Utiku, derailing 9 other wagons and bringing down a section of the overhead electric traction line as well.

The derailment was caused by the dynamics of a permanently coupled pair of wagons and the design of the modified solid drawbar arrangement when the wagons behind bunched and "ran-in" while the train was under braking on a descending gradient.

A safety issue identified was the incomplete process for approving a new design of coupling and monitoring its performance in service.

No new safety recommendations have been made in this report as the safety issue has been raised in previous reports and safety recommendations are still currently open pending corrective action.

1 Factual Information

1.1 Narrative

1.1.1 Train 237 was a scheduled southbound express freight service travelling from Auckland to Wellington. The train had departed from Hamilton at about 0010 on 20 October 2006 with 2 EF-class electric locomotives hauling 32 wagons with a total gross weight of 1356 tonnes (t) and 519 metres (m) long. The train was marshalled in accordance with Toll Rail's procedures.

1.1.2 A Palmerston North-based locomotive engineer changed to Train 237 at National Park. He had been driving freight trains and long-distance passenger trains on the North Island Main Trunk (NIMT) for almost 32 years. His certification was current at the time of the derailment.

1.1.3 The locomotive engineer said that he entered Taihape using regenerative[2] braking to keep the train below a 40 kilometre per hour (km/h) posted curve speed. After exiting the cutting at the south end of Taihape, the locomotive engineer released the regenerative braking down the grade, which allowed the train speed to reach the maximum authorised speed of 80 km/h. The train drifted in idle for a few seconds until the locomotive engineer re-applied regenerative braking to maintain the train speed throughout the 6.5-kilometre (km) long, gentle, descending grade towards Utiku. The locomotive engineer was aware of a 40 km/h temporary speed restriction on the approach to Utiku, so had the train travelling at about 38 km/h when it entered the speed-restricted zone at about 0640.

1.1.4 The locomotive engineer said that before the train cleared the speed restriction he felt what he thought was a slight "run-in", so he looked out his side window and saw the overhead traction line shaking violently. He said that a few seconds later the train lost air pressure and came to a stop without a brake application being made. He looked towards the rear of the train again and saw 2 wagons derailed across the crossing loop and the overhead traction line on the ground. The locomotive engineer followed procedures to secure the locomotive he was driving before making a radio base-call to train control to report the derailment. The train controller had anticipated the radio call because his mimic screen was showing an abnormal track circuit occupation at the north end of Utiku.

1.1.5 The train controller used the emergency switch to cut the overhead power to the Utiku section, but he instructed the locomotive engineer to remain in the locomotive cab until traction field staff confirmed that the overhead line at Utiku was earthed and isolated.

1.1.6 When the train stopped, 10 wagons from the front portion, the fifth to the 14th wagon, had derailed. The last derailed wagon, ZH1207, was about 30 m past the north-end mainline points. All wagons were coupled. The trailing end of the sixth wagon PKH34 and the leading end of the seventh wagon PKH21 were straddling the crossing loop and had brought down the traction poles between the mainline and loop. The other derailed wagons were upright beside the main line.

1.2 Operating and track information

1.2.1 The track between Palmerston North and Hamilton on the NIMT was single line, with the movement of trains controlled under centralised traffic control regulations from the national train control centre in Wellington. The overhead electric traction system between Palmerston North and Hamilton was commissioned in 1987.

[2] Regenerative braking is when energy is fed back into the catenary during braking by using traction motors as generators. In the case of freight trains, only a small fraction of the kinetic energy can be recovered, since tractive force is supplied only by the locomotive and (mechanical) braking force is distributed along the entire train.

1.2.2 The maximum authorised line speed between Hamilton and Palmerston North for express freight trains was 80 km/h. However, on the day of the derailment there was a 40 km/h temporary speed restriction in place between 243.90 km and 244.10 km NIMT, over the Utiku Road level crossing. The southbound approach to the level crossing was on a descending gradient averaging about 1 in 150.

1.2.3 The point of derailment was determined as 244.075 km NIMT, within the speed restriction, on a 500 m radius right-hand curve in the direction of travel (see Figure 1). The track within the derailment curve consisted of 50-kilogram-per-metre continuous welded rail fixed to treated Pinus radiata sleepers with Pandrol elastic-type fastenings. Both the rail and the sleepers were about 25 years old. The derailment curve had been tamped and lined in August 2004 and the curve had been de-stressed in 2005.

Figure 1
Track formation at the point of derailment

1.2.4 The most recent track inspection between Utiku and Taihape had been carried out on 17 October 2006, 3 days before the derailment. The track inspector had not identified any track condition outside of code standard, nor had he undertaken any minor track maintenance work near the derailment site.

1.2.5 An EM80[3] track evaluation car inspection, carried out on 15 May 2006, identified a Class 1 line geometry exceedance through Utiku North Road level crossing. Because of this, a 40 km/h temporary speed restriction was put in place for all rail movements passing over Utiku North Road level crossing. The speed restriction was still current at the time of the derailment.

[3] The EM80 track evaluation car measured and recorded track geometry, compared the actual values with maintenance tolerances and reported track conditions outside tolerance limits.

1.3 Site information

1.3.1 There were no wheel flange marks on the head of the running rail from which to determine exactly where the wheel had started its rail climb. A wheel flange witness mark was evident on the head of a screw spike on the field side[4] of the low leg rail in the direction of travel at 244.075 km NIMT. For track measure-up purposes, this location was taken as the point of derailment.

1.3.2 Forty-five metres past the point of derailment, the flange wheel witness mark moved out from the top of the screw spike onto the sleeper, 200 millimetres (mm) from the rail. Two sleepers further on there was no witness mark on the top of the screw spike, but there were 2 clearly defined wheel flange witness marks on the sleeper. The 2 witness marks on the sleeper ends continued through the level crossing (see Figure 2).

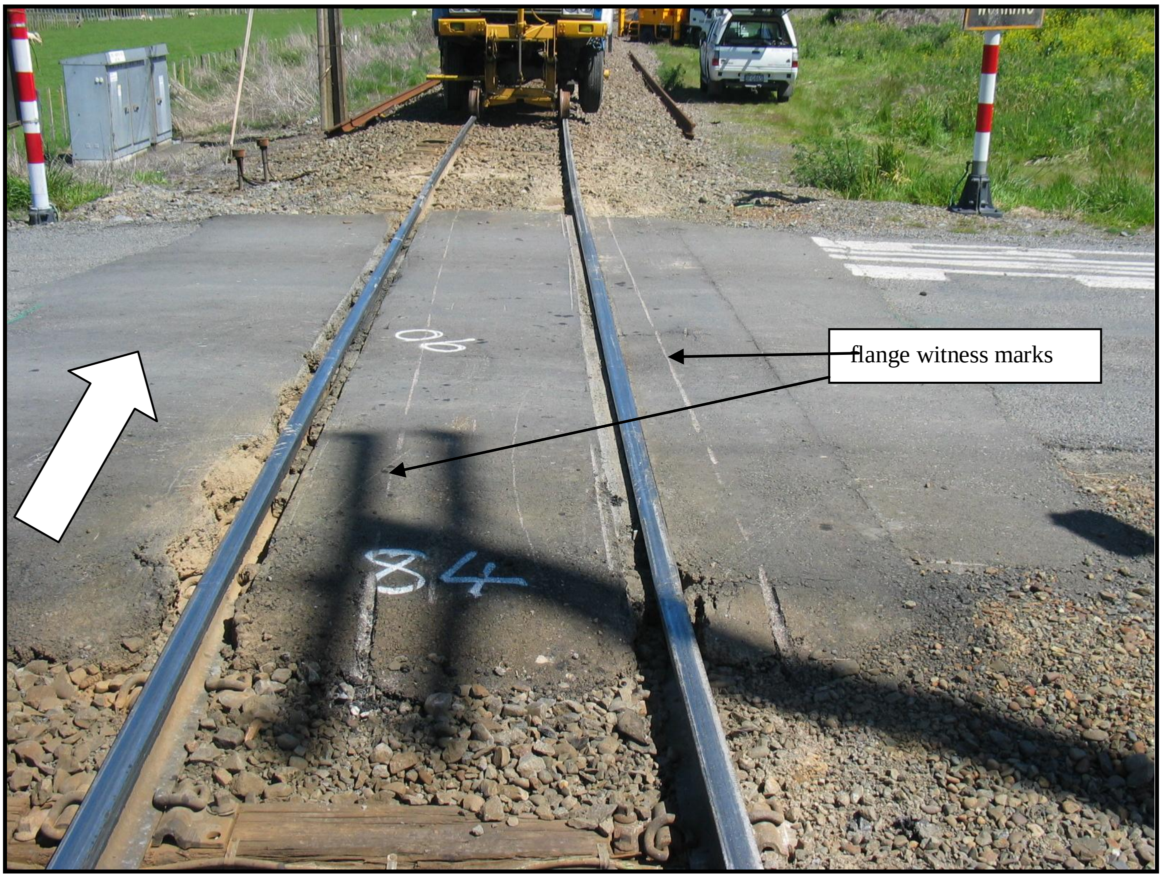

Figure 2
Wheel flange witness marks through Utiku North Road level crossing

1.3.3 About 10 m past the crossing, there were 2 wheel flange marks on the right-hand end of the sleepers (in the direction of travel) about 300 mm from the field side of the rail. Witness marks at the north-end mainline turnout indicated that the trailing bogie of wagon PKH34 and the leading bogie of PKH21 had taken the loop road while all other wagons took the mainline (see Figure 3).

[4] The field side of the rail is the side that is not in contact with the wheel flange.

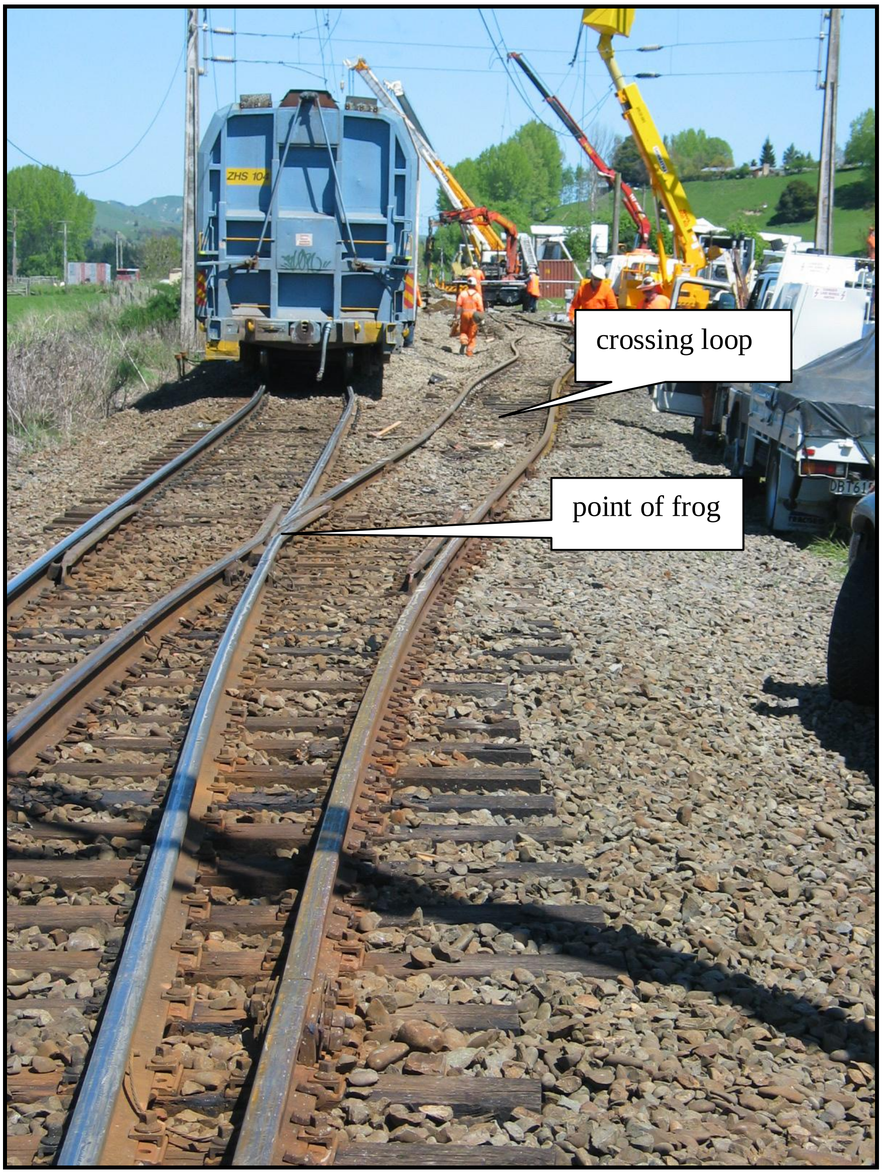

Figure 3
North-end mainline points at Utiku (in direction of travel)

1.3.4 A post-derailment measure-up of the track geometry leading up to the point of derailment did not identify any track conditions that could have contributed to the derailment.

1.4 Wagons PKH34 and PKH21

1.4.1 Wagon PKH21 was built in New Zealand and entered service in the early 1980s as PK1584. The wagon was reclassified as wagon IK20 in November 2004 and changed to PKH21 in mid-2006 after being fitted with heavy-duty draw gear. Similarly, wagon PKH34 was built in New Zealand and entered service in the early 1980s as PK3357. It was reclassified as IK37 in November 2004 and changed again to PKH34 in mid-2006 after being fitted with heavy-duty draw gear.

1.4.2 Wagons PKH34 and PKH21 operated as a fixed pair of wagons connected by a solid drawbar. The design of the solid drawbar was based on a concept previously used on FB-class log-carrying wagons. Over time, as the log product mix changed, the FB wagons were modified and were re-classified as OM wagons used to transport bulk milk. However, the OM wagons were not fitted with solid drawbars.

1.4.3 One of the factors that restricted the size of trains operating on the NIMT was the commonly used hook-and-pin draw gear. To address this issue, Toll Rail introduced a permanently coupled pair of PKH wagons fitted with full-size Alliance automatic couplers at each end and connected by a solid drawbar. Static tests were conducted by Toll Rail on paired wagons PKH21 and PKH34 to confirm the capability of these wagons to cope with the range of track curvatures and track irregularities typically encountered in service.

1.4.4 One test was to place the lead wagon on a traveser[5], with the centre of the solid drawbar directly above the end of the traveser and the other wagon on solid track. The traveser was then moved sideways slowly, to simulate travelling around tight-radius curves, until the drawbar contacted the headstock cut-out (refer to Figure 6). The lateral distance moved by the traveser was measured, then the traveser reversed and the distance to bind up in the opposite direction measured. To pass the test the traveser was required to travel laterally at least 310 mm in each direction. The test was repeated several times in both directions and the traveser was able to offset 355 mm before the drawbar bound.

1.4.5 Another static test was to ensure that one of the coupled wagons could tolerate a vertical height difference of 110 mm without affecting the other. The paired wagons were parked on level track and the under-frame at one end of one wagon jacked to replicate the height difference. The deck height of each wagon was measured before and during the test. The test showed that the drawbar lightly touched the headstock after a 70 mm lift, but the spring pack had enough elasticity and clearance to allow one wagon to be jacked to the full 110 mm without causing any vertical movement to the other wagon. Nevertheless, the headstock cut-out was increased by 20 mm at the top and bottom to reduce the likelihood of the drawbar contacting it in service.

1.4.6 The final static test was to confirm that the wagons were capable of tolerating the maximum mainline twist and yard twist without affecting other wagons. The procedure for the mainline twist was to apply incremental vertical lifts up to 100 mm to the leading end of wagon PKH34 and measure the deck height on wagon PKH21. The test confirmed that there was no discernible wagon height movement on wagon PKH21.

1.4.7 After conducting the static tests and modifying the headstock cut-out, Toll Rail concluded that the solid drawbar provided adequate movement for normal service. Toll Rail considered the twist test case as being much more severe than would likely be experienced in the field because the body of the wagon was jacked instead of the wheels, whereas the wheel suspension system would normally absorb some of the forces imparted to the wagon frame from track twists.

1.4.8 The paired wagons were intended to be marshalled at the head of the train because they could withstand high drawbar forces and allow a heavier trailing load.

1.5 Post-derailment examination of paired wagons

1.5.1 Wagon PKH34 was the sixth wagon on Train 237 and was conveying a loaded 6.1 m container GSM1109 on the leading end of the wagon in the direction of travel. The total weight of the container was reported as 14.6 t but following the derailment it was found to weigh 18 t. The total tonnage ahead of wagon PKH34, excluding the locomotives, was recorded as 140 t. The trailing tonnage was recorded as 1137 t.

1.5.2 Wagon PKH21 was the seventh wagon in the train, immediately behind PKH34, and the pair was connected by the solid bar. PKH21 was conveying 2 loaded 6.1 m containers. Container CRXU2777750, weighing 10 t, was on the leading end and XBC3130, with a declared weight of 18 t but weighing 25 t, was on the trailing end (see Figure 4).

[5] A section of rail that can be displaced laterally for the purpose of testing train/track geometry

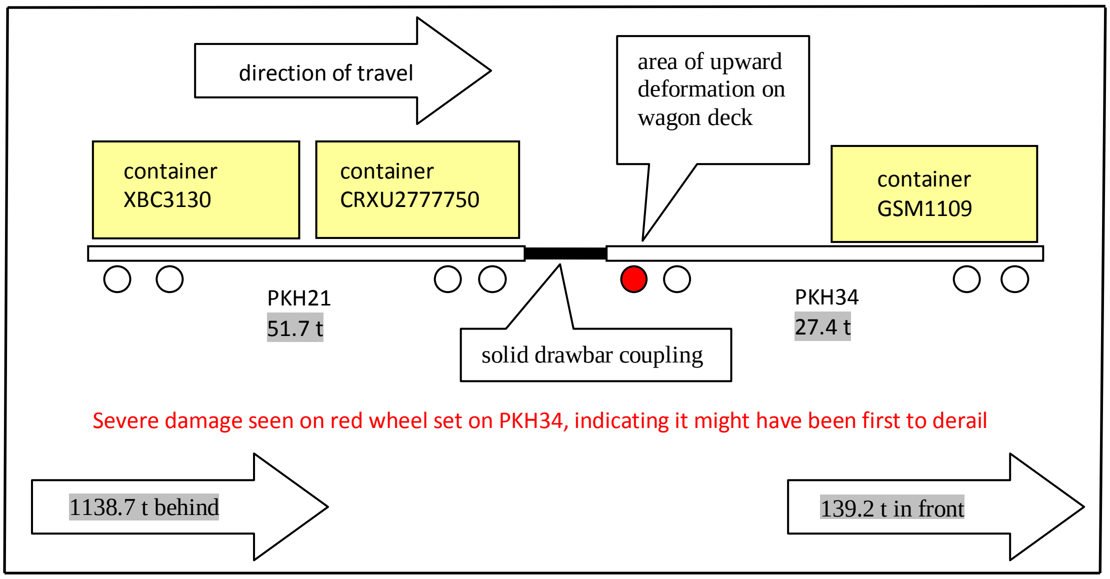

Figure 4
Loading details of PKH34 and PKH21 on Train 237

1.5.3 An examination of the wheel sets of the derailed wagons showed that the trailing wheel set of the trailing bogie of wagon PKH34 (the closest wheel set to the solid coupler) sustained the most severe damage (see Figure 5), which indicated that this could have been the first wheel set to derail.

Figure 5
Derailment damage to the trailing wheel set of the trailing bogie on wagon PKH34

1.5.4 During the derailment sequence the coupler assembly connection to wagon PKH21 became deformed (see Figure 6) but the drawbar pin remained connected. The mating drawbar knuckle on wagon PKH34 fractured during the derailment (see Figure 6). An examination of the fracture surface showed it to have been a fresh overload failure with no discolouration typically present with pre-existing cracks.

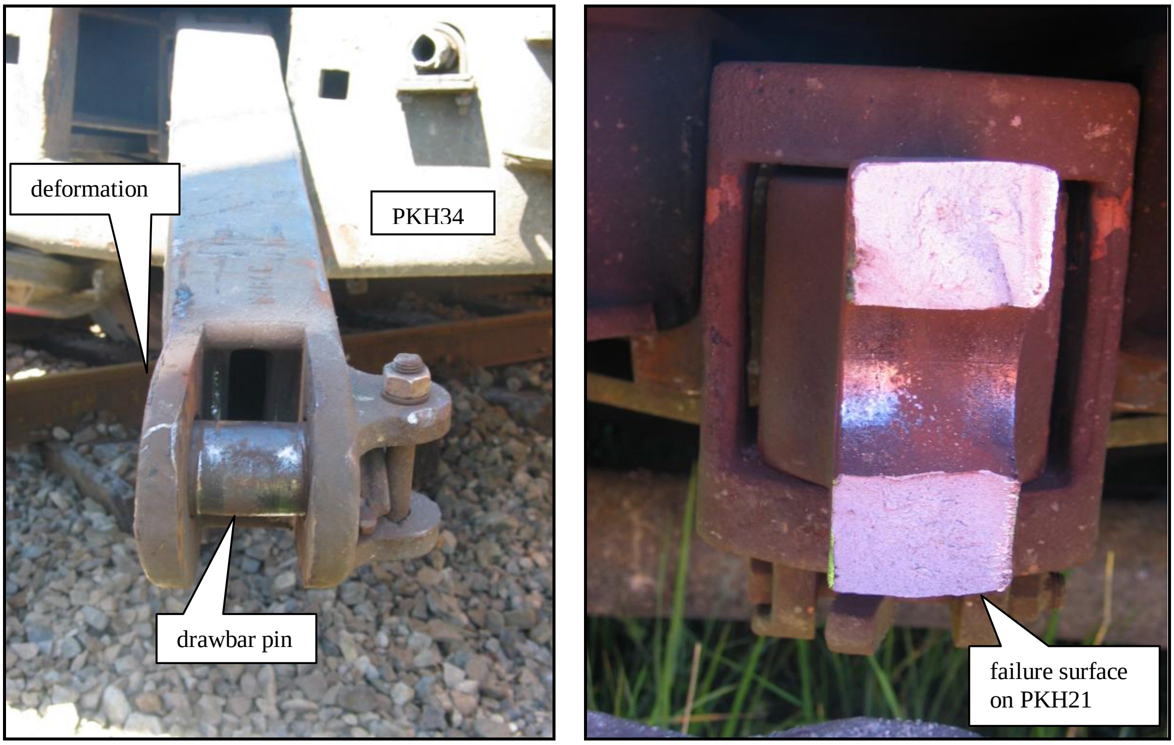

Figure 6
Left, deformed solid drawbar coupler assembly, and right, failed knuckle

1.5.5 The flat cargo deck at the rear of PKH34 was deformed upwards above where the solid drawbar attached to the chassis. Paint had fallen away from the deformed metal and corrosion was present on the metal surface under where the paint had been (see Figure 7).

Figure 7
Deck at the trailing end of wagon PKH34

1.6 Previous derailment and maintenance history of paired wagons PKH34 and PKH21 set

1.6.1 At about 0500 on Tuesday 13 June 2006, southbound express freight Train 237, travelling from Auckland to Wellington, derailed at 271.526 km on the NIMT, between Hihitahi and Ngaurukehu. The train consisted of 2 EF-class electric locomotives in multiple hauling 17 wagons with a gross weight of 616 t and a total train length of 290 m. The position of the wagons on the train complied with Toll Rail's requirements for the marshalling of empty or lightly loaded wagons.

1.6.2 PKH34 and PKH21 were the third and fourth wagons behind the locomotive respectively. The leading PKH34 was empty and the trailing PKH21 had a declared gross weight of 35.6 t. PKH34 derailed all wheels while the train was descending a 1 in 70 grade and about to enter a 110 m long, 280 m radius right-hand curve posted with a restricted line speed of 60 km/h. The wagon ran in its derailed condition for about 9 km until the locomotive engineer noticed sparks while the train was travelling on a right-hand curve.

1.6.3 The electric locomotives were fitted with an older-style Locolog event recorder. From the data downloaded it was estimated that the train was travelling between 35 and 40 km/h when wagon PKH34 derailed.

1.6.4 Toll Rail's investigation concluded that the locomotive engineer had reduced power and engaged the regenerative brake but had not allowed the train to "bunch" gradually before making a heavy brake application in preparation to slow the train to 25 km/h approaching Ngaurukehu. The locomotive engineer was also reported as saying he felt the train "run in". The "run-in" would have been exacerbated by the heavy wagons, near the rear of the train, running freely until the heavy train brake application took effect.

1.6.5 Because there were no clearly identifiable wheel marks on the rail head, consistent with the wagon being lifted, it was not easy to determine an absolute location for the point of derailment. However, an approximation was made after sighting back from the initial drop-off marks on the track fastenings on the right-hand side in the direction of travel. Ontrack's analysis of the post-derailment track measure-up did not identify any track condition outside maintenance tolerance limits or track issues that could have contributed to the derailment.

1.6.6 An examination of the derailed wagon confirmed that wagon PKH34 had been in good condition before it derailed. The bogies were near new, and both the float clearances and wheel profile were within code. There was no wagon condition identified that could have contributed to the derailment.

1.6.7 Both bogies from wagon PKH34 were replaced after having sustained damage to the running gear while being dragged for about 9 km in a derailed condition.

1.6.8 The initial investigation report prepared jointly by Toll Rail and Ontrack stated in part:

> The "run in" resulting from the train handling technique applied by the locomotive engineer was the primary contributor to this incident.
>
> The position and weight of the derailed wagon combined with the solid drawbar coupling may have also contributed.
>
> Further research is being undertaken to evaluate if this [solid bar] coupling arrangement may have made the wagon more susceptible to the "run in" in the vicinity of the point of derailment.
>
> Toll Rail is reviewing the design of solid drawbar couplings to ascertain if these are more vulnerable to excessive in-train forces.

After the derailment at Utiku on 20 October 2006, Toll Rail changed the cause in its initial report to reflect a combination of draw gear design and train handling causing a "pinch-off".

1.6.9 On 20 September 2006, a maintenance B-Check was carried out on the paired wagons. The bogie/suspension component of this check confirmed that:

- the springs were in place, secure and intact
- the bearing keeps were in place and held securely
- the liners were secure
- the wedge heights were within limits
- the bearing adapters were in place and undamaged
- the dampers were secure and there were no signs of oil leaks
- the horns were not bent or loose
- there were no signs of overheating of the bearings, the cap bolts were in place, the backing rings were secure and there was no excessive grease leakage
- the brake blocks were within wear limits
- the VTA valve was functioning correctly and the air supply hoses were in place.

1.6.10 On 15 February 2010, in response to the preliminary report into this accident, KiwiRail advised in part:

> Kiwi Rail has more recently re-visited fitting solid draw bar couplings on freight wagons, initially on CE 3 class coal wagons. Given our experience with the PKH coupler this project has included a review of solid draw bar couplings used on other freight rail systems.
>
> A comparison between the design of the PKH coupler and couplers available in the market place has enabled KiwiRail to better understand why the PKH coupler was more vulnerable to a "run in". In summary, the key differences and their integrity of the coupler were:
>
> - The proposed CE 3 application will use a conventional and well proven American solid drawbar system specifically intended for freight vehicles.
> - Any remaining vertical and lateral movement is resisted by the compression of the draft (spring) pack, which tends to re-centre the system, rather than being completely free.
> - The proposed application has a longer drawbar length. Reducing the angle of the drawbar for a given displacement results in forces that tend to lift a wagon.
> - The system is intended for "heavy" unit train wagons, not comparatively lighter wagons like the PKH that we now recognise was more at risk of derailments induced by "run ins" particularly if empty or lightly loaded.

2 Analysis

2.1 During the 20 October 2006 derailment and the previous derailment involving paired wagons PKH21 and PKH34, there was nothing in either the wagon condition or the track condition that should have caused the derailments.

2.2 In this case it was determined that PKH34 derailed before the class one track exceedence at the Utiku level crossing, and even if it had not, a speed restriction had been put in place to allow for the exceedence, and the train was travelling at less than the maximum allowable speed.

2.3 The fact that both derailments occurred at different locations and with different locomotive engineers suggests that the reason for the derailments was linked to the design of the paired wagons and where they were placed in the consist, together with how they were loaded.

2.4 The wheel set with the most derailment damage in this case was the last one on the light end of wagon PKH34, which leads to a logical assumption that this was the first to derail, with that wheel set sustaining the most damage as it ran along the sleepers and ballast and across the level crossing before striking the mainline turnout at the north end of Utiku crossing station.

2.5 In both cases, the lightly loaded or empty trailing end of the leading wagon of the pair derailed first and the trailing wagon of the pair was loaded. In each case the derailment showed signs of being a "lift-off" (commonly referred to as a "pinch-off") type derailment under braking, where a bogie or wheel loses contact with the rail head, usually due to a run-in of wagons from behind. However, with both derailments it was possible that there was no abnormal "run-in" and the "lift-off" occurred owing to a combination of the loading configuration on the paired wagons and the dynamics with the solid drawbar arrangement alone. The absence of any definitive marks showing the point of derailment supports this theory because when a wheel climbs onto the railhead it leaves a witness mark.

2.6 Why this particular set of wagons was prone to this type of derailment was not clearly established. The tests on this new concept were all static tests under controlled conditions. It appears likely that in a dynamic situation, where the consist is continuously subjected to complex and changing forces as the train brakes and accelerates over changing terrain, the solid drawbar type of coupling was causing the lightly loaded trailing end of the leading wagon to lift off the rail head.

2.7 The upward deformation of the flat container deck on the rear end of PKH34, just above where the solid drawbar was attached to the chassis, was symptomatic of the drawbar having been forced upward with some energy. This could have been as a result of the previous derailment or a cumulative deformation that had developed in normal service. The corrosion products evident on the top of the deformed plate make it unlikely that it occurred as a result of this derailment alone.

2.8 The paired freight wagons connected by a solid drawbar were the only freight wagons of their type in service and their withdrawal from service following the derailment on 20 October 2006 has effectively eliminated the problem.

2.9 The process that was followed for the introduction of a new type of coupler was not particularly robust, and was done without the knowledge of the rail regulator, the NZ Transport Agency (then Land Transport New Zealand) or the owner of the infrastructure, Ontrack. Arguably the concept should have been approved by the rail regulator and/or Ontrack as it represented a new concept. At the very least the paired wagons should have been closely monitored in service until some comfort could be derived that it was compatible with Toll Rail operations.

2.10 After the first derailment, the circumstances warranted the paired wagons being taken out of service until a better assessment could be made. Although the Toll Rail initial internal investigation report on the 13 June derailment alluded to the possibility of the solid drawbar contributing to the derailment, the focus was more on driver technique, so the paired wagons were repaired and returned to service until the derailment occurred at Utiku on 20 October 2006.

3 Findings

3.1 The derailment most likely resulted from a lift-off (pinch-off) event caused by the dynamics between wagons running in from behind and the solid drawbar arrangement between PKH34 and PKH21, while the train was braking on a descending gradient.

3.2 The combination of a lightly loaded trailing end of the leading wagon of the pair and a loaded trailing wagon was likely to have contributed to the dynamics of the derailment.

3.3 Not all reasonable steps were taken for introducing and monitoring the performance of a modified design of a solid drawbar between freight wagons.

4 Safety Actions

4.1 Because wagons PKH34 and PKH21 with the solid drawbar connection were involved in 2 separate derailments in a very short timeframe, Toll Rail withdrew these wagons from service.

5 Safety Recommendation

5.1 Because the wagons involved have been permanently withdrawn from service, and because the Transport Accident Investigation Commission already has open safety recommendation 035/07 to the Chief Executive of the NZ Transport Agency regarding the approval process for new design in the rail industry, no new recommendations have been made in this report. (009/10)

Approved on 25 February 2010 for publication

Hon. WP Jeffries
Chief Commissioner

Recent railway occurrence reports published by
the Transport Accident Investigation Commission
(most recent at top of list)

07-103	Report 07-103, passenger express Train 200, collision with stationary passenger express Train 201, National Park, 21 March 2007
07-115	Report 07-115, express freight Train 533, derailment, 103.848 kilometres, near Tokirima, Stratford – Okahukura Line, 7 November 2007
06-106	Report 06-106, express freight Train 826, signalling irregularity, Cora Lynn, 31 July 2006
07-108	express freight Train 720, track warrant overrun at Seddon, Main North Line, 12 May 2007
07-113	express freight Train 239, wagons left in section at 514.9km, between Te Awamutu and Te Kawa, 22 September 2007
07-110	collision, express freight Train MP2 and Work Train 22, Ohinewai, 19 June 2007
06-110	passenger train 4045, uncontrolled movement, between Britomart and Quay Park Junction, 9 October 2006
06-108	EMU Passenger Train 9268, struck slip and derailed, between Wellington and Wadestown, 26 August 2006
07-101	express freight Train 736, derailment, 309.643 km, near Vernon, 5 January 2007
05-123	empty passenger Train 4356, overran conditional stop board without authority following an automatic air brake irregularity, Meadowbank, 6 October 2005
05-116	collapse of Bridge 256 over Nuhaka River, Palmerston North-Gisborne Line, 6 May 2005
05-124	express freight Trains 834 and 841, collision, Cora Lynn, 20 October 2005
06-112	loss of airbrakes and collision, Tram 244, Christchurch, 21 November 2006
06-102	SA/SD passenger Train 4306, braking irregularity, between Westfield and Otahuhu, 31 March 2006
06-101	diesel multiple unit passenger Train 3163, fire in diesel auxiliary engine, Manurewa, 15 March 2006
05-127	Mainline shunting service M52, track occupation irregularity, Te Rapa, 27 October 2005
05-120	Express freight Train 142, runaway wagons, Mercer, 1 September 2005

Price $21.00 ISSN 0112-6962