Report 01-102

express freight Train 237
and
express freight Train 144

derailment and collision on double-line track

Paerata - Pukekohe

23 February 2001

Abstract

At about 2218 on Friday, 23 February 2001, northbound Train 144 struck a derailed wagon while passing southbound Train 237 between Pukekohe and Paerata on the North Island Main Trunk line. The incident occurred when a PK wagon conveying containers on Train 237 became derailed at Paerata as a result of a wheel bearing failure. The LE of Train 237 had seen sparks coming from the middle of his train and suspected a possible dragging brake rod. He was unaware of the derailment and proceeded slowly from Paerata towards Pukekohe where he intended to stop and inspect his train. The collision occurred as Train 237 reached Pukekohe, causing minor damage to locomotives and wagons on Train 144 and derailing a loaded C coal wagon. Major damage to the PK wagon and track resulted from the initial derailment. There were no injuries.

The safety issues identified were the potential consequences of derailed wagons on double line track.

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The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

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List of Abbreviations

CRM	crew resource management
km	kilometre(s)
km/h	kilometres per hour
LE	locomotive engineer
LE1	locomotive engineer of Train 237
LE2	locomotive engineer of Train 144
m	metre(s)
mm	millimetre(s)
NIMT	North Island Main Trunk
POD	point of derailment
t	tonne(s)
TC	train controller
Tranz Rail	Tranz Rail Limited

Data Summary

Train type and number:	express freight Train 237 express freight Train 144
Date and time:	23 February 2001, about 2218
Location:	Pukekohe, 629.2 km North Island Main Trunk (NIMT)
Type of occurrence:	collision
Persons on board:	crew: Train 237 1 Train 144 1
Injuries:	nil
Damage:	major damage to wagon PK 3138 and the track; minor damage to Train 144
Operator:	Tranz Rail Limited (Tranz Rail)
Investigator-in-charge:	R E Howe

1. Factual Information

1.1 Narrative

1.1.1 At about 2200 on Friday, 23 February 2001, southbound express freight Train 237 was approaching Paerata North Junction, at about 632.5 km NIMT, on the Down Main. The train consist was DFT 7307 and 32 wagons, with a gross weight of 1030 t, and length 510 m. It was crewed by a locomotive engineer (LE1).

1.1.2 LE1 had slowed his train for an unposted 25 km/h temporary speed restriction in force between 633 km and 631.4 km. As the train was rounding a right-hand curve at 632.5 km LE1 looked back and saw sparks on the right side from a wagon near the centre of his train. He assumed it to be a dragging chain or hand brake rodding. He contacted the train controller (TC) by radio at 2210, and told him he was going through Paerata, and advised him "some sparks back there, back on the wagon". LE1 then requested information on traffic approaching him on the adjacent Up Main.

1.1.3 The TC told LE1 that Train 144 was "five or ten minutes at the most away from you". LE1 said he would take his time up to Pukekohe and walk and inspect his train there. His reason for this was the lighting available at Pukekohe to assist his inspection.

1.1.4 Train 144 was a loaded northbound coal train. The train consist was DFT 7213, DC 4507 and 23 loaded wagons, with a gross weight of 1449 t and length 496 m. It was crewed by a locomotive engineer (LE2).

1.1.5 At about 2213 the TC called LE2. The taped transcript included the following exchange:

22:13:17	TC	Yea 144 receiving over
22:13:19	LE 144	Yea, just coming over top of Bucklands there
22:13:28	TC	Roger yeah 237 is on the Down Main; he's just checking his train just keep an eye out for him, you got lights through Paerata. He's still … around about Paerata there
22:13:45	LE 144	… on the north end or the south end of it.
22:13:55	TC	Yeah, no you've got lights through Paerata. He's just on the Down Main … He's going to check his train out, just keep an eye out for him that's all.
22:13:59	LE 144	Yea OK yeah she's a bit slippery out here these two locos doing a bit of hard work at the moment so oh yea I'll let him know I'm coming.

1.1.6 Train 144 was passing through Tuakau when LE2 was advised by the TC of the need for LE1 to check Train 237. LE2 believed from his conversation with the TC that Train 237 was to "be checked somewhere around Paerata" and as he approached Pukekohe at 80 km/h on the Up Main he was surprised to see Train 237 there on the Down Main.

1.1.7 On seeing Train 237, LE2 sounded the train whistle, dipped the lights and applied train brakes as he approached. Immediately after passing the locomotive of Train 237 he put his lights back to full, and then saw sparks from a derailed wagon, and a container encroaching on the Up Main. He recalled noting the container "rocking in and out" as he approached and hoping it was rocking out as he passed, before taking cover behind the brake pedestal on the left side. About 10 seconds later his train struck the container and continued on about 550 m before coming to a stop.

1.1.8 LE1, still unaware of the derailment, was preparing to stop Train 237 at Pukekohe as Train 144 approached. His train was still moving as the locomotive of Train 144 passed him. He did not feel any following impact, and his first knowledge of the collision was when he overheard LE2 advising the TC by radio that Train 144 had been struck. LE1 was aware that his train had come to a sudden stop following the passing of Train 144. This was the result of a burst hose on Train 237 following the impact.

1.1.9 At about 2218 an emergency alarm was received in Train Control from Train 144 advising of the collision.

1.1.10 Neither of the LEs sustained any injuries as a result of the collision.

1.2 Site information

Train 237

1.2.1 Train 237 came to a stop at 628.93 km with wagon PK 3138, the fifteenth wagon in the consist, at 629.19 km under Bridge 315, East Street overbridge. Figure 1 is a site plan of the derailment/collision area. PK3138 was derailed all wheels approximately 300 mm to the right of the Down Main (towards the Up Main) with the trailing end closer to the Up Main. The wagon, with its containers still attached, was leaning at an angle of 10^0 towards the Up Main. The leading container showed no collision damage. The trailing container showed increasing collision damage on the right side from the leading end back towards the trailing end (refer Figure 2).

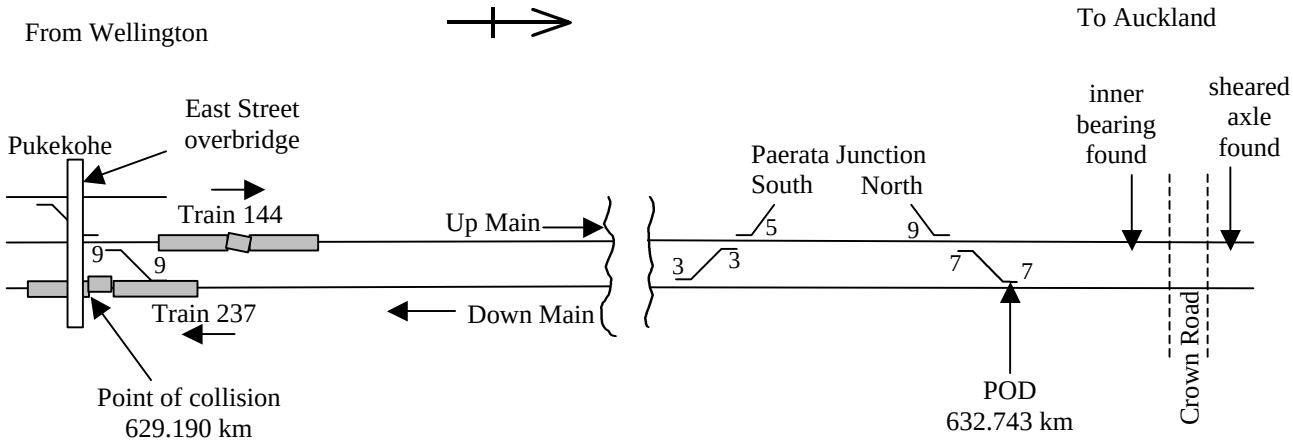

Figure 1
Site plan
(not to scale)

1.2.2 The leading axle of the trailing bogie on PK 3138 had sheared on the right side (refer Figure 3).

1.2.3 Various parts from PK 3183 were found trackside as follows:

- the sheared axle end (refer Figure 3) was found on the right side of the Down Main at about 633.6 km (just north of Crown Road level crossing)
- a bearing inner race was found on the right side of the Down Main at about 633.56 km
- a section of brake block was found at 632.7 km
- brake rigging was found on the left side at 631.95 km.

Despite detailed lineside inspection, the tapered bearing unit adaptor and other missing components of the failed bearing were not recovered.

Figure 2
Wagon PK 3138 following the collision
(looking south)

Figure 3
The end of the sheared axle found near
Crown Road level crossing at 633.6 km NIMT

Train 144

1.2.4 Train 144 came to a stop at 629.74 km. Wagon C164, the fourteenth wagon in the consist, had one axle of the rear bogie derailed.

1.2.5 The 2 locomotives and all wagons on Train 144 showed minor damage on the right side consistent with collision at container top height.

Track

1.2.6 Marks on the inside of the right running rail and a wheel flange mark across the rail head to the right side identified the point of derailment (POD) at 632.743 km, approximately 800 m past Crown Road level crossing and 12 m past No. 7 Down Main facing points.

1.2.7 The turnout in which the derailment occurred was in heavyweight rail with all materials in good condition. No significant track tolerance exceedances or maintenance deficiencies were noted at the site.

1.2.8 Minor track damage occurred from the POD to the point of collision. Major track damage occurred at No. 3 crossover at Paerata South and No. 9 crossover at the north end of Pukekohe.

1.2.9 The point of collision occurred on straight track. The centre to centre distance from the Up Main to the Down Main at the point of collision was 3.8 m, which was more than the 3.67 m minimum requirement.

1.3 Operating details

1.3.1 The rail corridor between Paerata and Pukekohe consisted of a Down Main line for trains running to Pukekohe and an Up Main line for trains running from Pukekohe. This was defined as double line running.

1.3.2 A rule of left-hand running applied, which meant that LEs, positioned as they were on the right-hand side of the locomotive, travelled next to the opposing line and passing trains.

1.4 Locomotive event recorders

1.4.1 The Kaitiaki event recorder from each leading locomotive was extracted and the logs obtained for analysis.

1.5 Wagon PK 3138

1.5.1 Wagon PK 3138 was loaded with 2 containers of steel. The wagon tare weight was 13.1 t and the maximum permissible load weight 44 t, giving a maximum gross weight of 57.1 t. The actual gross weight of the wagon as measured by weighbridge was 55.22 t.

1.5.2 The two Tranz Rail inspection procedures that included bogie suspension checks were the B-check and C-check. B-checks covered safety critical items and were performed whenever two or more brake blocks were changed, or after an incident. The more detailed C-check was performed generally every 24 months, with an upper limit of 27 months. Earlier C-checks were possibly required if wagons had been involved in derailments or collisions, or had a braking fault.

1.5.3 The inspection and maintenance history of PK 3138 showed:

B & C CHECKS – (Scheduled Maintenance)	
20 February 2001	B Check at New Plymouth – no materials
13 February 2001	B Check by Southdown Field Unit – no materials
21 December 2000	B Check by Southdown Field Unit – two blocks replaced
13 December 2000	C Check at New Plymouth – no materials
14 November 2000	B Check – no materials
31 October 2000	B Check by Southdown Field Unit
REPAIRS	
15 February 2001	Change Twist Lock at Te Rapa
08 February 2001	Hand Brake Bolt and Brake Blocks replaced
BAD ORDERS	
13 February 2001	Brake piping, cleared at Westfield
01 August 2000	Ends, sides, drawgear, pushrod retention FM10049B, cleared at Southdown

None of these orders made any comment about marking up bearings or had any materials booked to them, except where noted.

1.5.4 The wheelset on the leading axle of the trailing bogie of PK 3138 was manufactured at Hutt Workshops on 23 September 1997. New wheels and overhauled bearings were fitted. The computerised asset management system showed a bogie change at Hutt occurred on 30 September 1997.

The wheel rim thickness (Z) readings at the time of derailment were:

A1 = 55	B1 = 55
A2 = 61	B2 = 54
A3 = 60	B3 = 60
A4 = 60	B4 = 59

B3 was the bearing that failed. A1 was the corner nearest the handbrake, B the other side, and the numbers increase along the length of the wagon. The minimum permissible thickness of these wheels is 16.

Tranz Rail records showed this wagon was last at a wheel lathe in November 1999, repairing skidded wheels. There was no other record of wheelset change.

Bearing overhaul background

1.5.5 In response to a question regarding the recent background to bearing overhaul processes, with particular regard to an understood problem about 1997, Tranz Rail advised:

> The vast majority of Tranz Rail's fleet of wagons run with "package type" tapered bearing units on their axles. These bearings are overhauled at Tranz Rail's Hutt Workshops during their lives, at intervals of four to ten years.
>
> In late 1997 two separate audits were carried out concerning overhaul processes at Hutt, which revealed that not all work was being performed to the required standard. The second audit was aimed at the overhaul of axleboxes rather than package bearings, although there are relevant aspects to both types. Specific problems found at the time included:
>
> - Lack of formalised training of staff involved in the overhaul of bearings.
> - Failure to carry out checks to bolt hole threads, bearing components, and fitted bearings.

- Inadequate procedures covering the overhaul of axle boxes and bearings.
- Lack of measuring of axle journals
- Measurement of lubricant
- General lack of in-depth knowledge amongst staff at that time.

Training and technical input was immediately sought from Rolling Bearing Consultants for staff involved in the inspection and overhaul of wheel bearings. Soon after, Tranz Rail's bearing supplier, FAG Australia Pty Ltd, conducted a two day in-house training course for the same staff. Supplier provided training has occurred every February at Hutt workshops and the standard has improved noticeably. Tranz Rail's present supplier, SKF New Zealand Ltd, have recently stated that work performed is to a good level of quality.

In 1998 other work was then carried out to ensure field and depot staff were aware of correct inspection procedures and criteria for the removal from service of bearings. This was done with on-site training courses, with staff from every mechanical work centre attending. Follow up was made by issuing FAG training videos outlining proper field inspection.

Hillside workshops fit bearings and qualify axle journals and staff have also had purpose designed, supplier provided training.

A new procedure was implemented in M2000 whereby bearings which are suspected of leaking lubricant are cleaned and the cap marked with blue paint. This indicates to other mechanical staff the bearing has been examined and if leakage is found, the bearing should be removed from service.

Documentation such as the Wheelset Manual and site procedures have been updated in accordance with updated AAR manuals.

1.6 Post-incident testing

1.6.1 Tranz Rail commissioned SKF New Zealand Limited to evaluate the recovered damaged components and, based on their condition, report on the possible causes of the in-service failure. The SKF Failure Report comments were:

> The failed bearing has suffered severe overheating due to spinning on its journal. The heat generated by the relative movement between the bearing cones (inner ring) and the journal has resulted in the lubricant failure followed by bearing seizure. This in turn has led to accelerated overheating of the journal, softening of the axle material, and eventual fracture of the axle.
>
> The wear and damage to the cone face indicates that the cone was loose on the journal. In this case inadequate fits and tolerances were the primary cause of failure.

1.6.2 SKF New Zealand Limited were also commissioned to inspect and report on the bearing on the opposite end of the failed axle to see whether this bearing had any condition which may have influenced the failure. The SKF Failure Report comments on this bearing were:

> The damaged suffered by this bearing is as a result of the failure of the bearing at the opposite end of the wheelset. There is nothing that can be determined from the inspection of this bearing that indicates that it contributed to the failure of the opposite end bearing.
>
> The cage distortion, damaged outer ring ends and damaged seals are due to the bearing having been run in a misaligned condition. This misalignment would have occurred during and following failure of the opposite end bearing.

1.6.3 Following the derailment Tranz Rail commissioned SKF New Zealand Ltd to carry out a specific audit of bearing overhaul practices at Hutt Workshops. The audit objectives were:

- to determine if the practices and procedures currently used by Tranz Rail when refurbishing axle boxes and package bearings result in a reliable product being returned to service
- to recommend any changes to procedures which may improve reliability of products being returned to service.

The audit was carried out on 24 April 2001. The audit found all key processes were carried out competently, and included in its comments:

> The fitters involved with bearing refurbishment showed a high level of motivation and desire to achieve excellent results. They were familiar with the dimensional requirements of each assembly and showed the necessary skills to be able to accept or reject components based on the references provided.

1.7 Tranz Rail requirements for defects detected on trains

1.7.1 Rule 6, Special Precaution for Safe Operations, included:

> (a) Staff must watch for defects on trains.
> If in a position to do so, staff must watch for defects on trains. If they detect any of the following conditions they must advise the crew of the train or Train Control:
>
> - Overheated axle boxes (hot boxes).
> - Sticking brakes.
> - Sliding/skidding wheels.
> - Wheels not properly positioned on the rails (derailed).
> - Dragging equipment (brake rodding, bond chains etc).
> - Insecure loads.
> - Signs of smoke or fire.
> - Headlight or end of train signal improperly or not displayed.
> - Any other dangerous condition.
>
> Where possible, staff inspecting the passing train must advise the Locomotive Engineer the condition of the train.

1.7.2 Rail Operating Code, Section 6, Operating Instructions for Train Control included:

> 19.0 Dragging Equipment (on wagons)
>
> Immediate action is required if dragging gear or bond chains are suspected as the cause of any trackside problems or loss of points detection. At selected sites, Dragging equipment detectors (DEDs) are provided. These send an automated message to Train Control and at some locations all radio users in the immediate vicinity of the detector when activated. These sites are listed in Working Timetable Section G1.
> When a Dragging Equipment alarm is activated or Dragging equipment is suspected:
>
> - The train must be stopped immediately.
> - The train consist must be examined for possible dragging equipment.

- If possible the train is to be held outside the station in advance until it is checked (to protect points).
- If the problem required Mechanical staff to rectify then the Mechanical Field Manager for the area is to be advised.

In electrified areas, trip-outs may occur when diesel hauled services are the only service in the area. In these cases also, the train must be stopped and checked for loose tarpaulins, etc.

OCCLOGS must be sent for all confirmed instances of dragging equipment.

2. Analysis

2.1 The bearing failure

2.1.1 Post-incident testing attributed the bearing failure to a loose cone on a journal due to inadequate fit and tolerances. Although fitted to the axle in September 1997 it is likely that the failed bearing had been overhauled about a month earlier and taken from stock, based on the normal stock turnover for such bearings.

2.1.2 Tranz Rail had recognised a quality control problem regarding overhaul processes at Hutt workshop in late 1997, and this was immediately addressed and has had ongoing attention since. However, it is likely that at the time of overhaul and fitting of this bearing the problems identified by bullet points in paragraph 1.5.5 were present.

2.1.3 The wagon had been inspected to Code requirements, the last B-check being 3 days before the incident. Such inspections would not necessarily detect the defects which led to failure. It is for this reason that quality control of overhaul and installation is of such importance, as recognised by Tranz Rail's actions since 1997 when a problem was identified.

2.1.4 Axle failures of this nature are not common. Although attributable to inadequate fit and tolerances on this occasion, there was no indication that such quality control problems had been widespread since 1997.

2.2 The derailment

2.2.1 The nature of the failure made derailment inevitable. Once the axle had failed, the wheel, while restrained laterally, could move vertically and tilt. Any inward tilt of the wheel would have applied pressure to the wheel-rail interface and freedom of movement vertically would have permitted the wheel to climb the rail. The fact that the derailment occurred in a turnout shortly after the axle parted was most likely caused by the additional dynamic rolling stock response usually associated with the standard turnout arrangement.

2.3 The collision

2.3.1 The most significant consequence of this incident was that it resulted in a relatively high-speed collision. Analysis of the event recorder output from DFT 7307 showed Train 237 was travelling at about 20 km/h at impact. The event recorder from DFT 7213 showed Train 144 was travelling at about 70 km/h at impact. In this incident the offset and orientation of PK 3138 resulted in a glancing impact on the trailing container and resulted in little damage and no injuries. Potentially Train 144 could have struck the leading end of the leading container with more severe consequences.

2.3.2 LE1 had identified a possible defect on his train before the collision but elected to continue to a convenient location to make his train inspection. This prompted a close look at the suitability of the procedures in place to respond to such indications, with particular regard to the potential for collision in double track territory.

2.4 Requirements when defects were detected on trains

2.4.1 Tranz Rail required staff to report all such potential defects observed on a train promptly to the train crew or Train Control in accordance with Rule 6 (a). Although procedures in place required Train Control to stop a train immediately when advised of suspected dragging equipment there were no documented Tranz Rail procedures relating directly to the action LEs must take in such circumstances.

2.4.2 Although LE1 reported the sparks to the TC, he did not relay his thoughts on the possible cause. A number of defects, such as sticking brakes or overheated axle boxes, are more likely to be the source of sparks than dragging gear, and the TC's action in agreeing to the inspection at Pukekohe was not inappropriate given the information available to him.

2.4.3 The LE made his report to the TC some 3 minutes after the derailment and some 8 minutes before the collision. Had the TC known of the suspected dragging hand brake gear and taken action to stop the train and advise the LE of Train 144 of the circumstances, the collision may have been avoided, or at least would have occurred at a lower speed. This would also have been the case had there been a procedure in place that told LE1 to stop his train immediately when he suspected dragging gear.

2.4.4 The LE of Train 237 did not suspect a derailment. He was traversing a 25 km/h temporary speed restriction when he observed the sparks, and he continued at that speed to Pukekohe. Although it would have been desirable for him to have conveyed his thoughts on the suspected dragging brake gear to the TC, his decision to continue at low speed to Pukekohe where there was better lighting was not inappropriate considering the lack of instructions to the contrary.

2.4.5 In the event Train 237 did not have dragging brake gear as suspected by LE1. Although there were no Rule or procedural omissions by staff involved, better communication between LE1 and the TC might have resulted in Train 237 being stopped earlier. Such communication forms part of crew resource management (CRM), the value of which had been recognised by the Commission in previous Railway Occurrence Reports (98-107 Ngaruawahia and 00-106 Mataura). As a result two safety recommendations were made to the managing director of Tranz Rail.

Safety recommendation 001/99 of 18 March 1999 recommended that he:

> Introduce formalised crew resource management training for train control operators, signalmen and LEs based on the training available in the aviation and marine industries.

Safety recommendation 006/01 of 30 April 2000 recommended that he:

> Introduce the formalised crew resource management procedures recommended in safety recommendation 001/99, and ensure that such procedures include remote control operators operating main line shunts.

On 15 May 2001 the managing director of Tranz Rail replied to Safety Recommendation 006/01:

> Tranz Rail accept this recommendation. This is presently been evaluated to determine the best way to facilitate these principles to staff. Tranz Rail expect to complete this evaluation by end of June 2001.

Tranz Rail advised that the evaluation is well in hand with completion expected by the end of September 2001.

2.4.6 The relatively high speed of Train 144 at the point of collision was attributable to the difference between the intent of LE1 to proceed to Pukekohe and inspect his train, as conveyed to the TC, and LE2's understanding from his discussion with the TC that Train 237 would be stationary "around about Paerata". LE2's intended action at Paerata was to slow his train, sound the train whistle and keep an eye out for LE1, who he expected to be on the ground doing his inspection. He had not taken these precautions as he approached Pukekohe. This is another example where better communication using the principle of CRM would have at least minimised the consequences of Train 144 passing derailed Train 237.

2.4.7 In view of Tranz Rail acceptance of recommendations regarding CRM, and actions to date, no further recommendations have been made in this area.

3. Findings

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

3.1 The bearing failure on PK 3138 was initiated by a loose bearing inner cone, probably caused by inadequate fits and tolerances during bearing overhaul in 1997.

3.2 Overheating generated by the loose cone ultimately resulted in axle failure, with related unrestrained wheel movement leading to the derailment of PK 3138.

3.3 The nature of the bearing failure meant it was not necessarily detectable during the required inspection procedures, which were correctly carried out on wagon PK 3138.

3.4 Early evidence of sparks as a result of the derailment gave LE1 concern regarding possible dragging brake gear. This concern was not communicated to the TC to alert him to the actions required for such a suspected fault, which included stopping the train immediately.

3.5 Continued movement of Train 237, albeit at slow speed, in a double-line area where facing points were encountered prior to the proposed inspection stop was undesirable in circumstances where dragging brake gear was suspected.

3.6 Had Train 237 been stopped near Paerata the collision with Train 144 could have been avoided, or at least been at a lower speed.

3.7 Although the actions taken by LE1 and the TC were not inappropriate based on the information available to each and the Tranz Rail procedures applicable, improved communication may have resulted in the train being stopped near Paerata.

3.8 Improved communication between Train Control and LEs had been previously recommended by the Commission as part of recommendations to introduce crew resource management training for such operating staff. Tranz Rail are actioning the second recommendation, made and accepted April/May 2001.

3.9 The axle bearing overhaul quality control problem which existed in 1997 was appropriately addressed. Subsequent monitoring, including a post-incident audit, revealed no shortcomings in recent overhaul procedures and there is no reason to suspect an underlying problem with recent axle bearing overhauls exists.

3.10 The elapsed time since the 1997/98 quality improvement, the low incidence of similar failures, and the service life of overhauled bearings do not indicate a particular ongoing problem with bearings overhauled up to 1997 and still in service.

4. Safety Actions

4.1 Tranz Rail have checked and confirmed the suitability of current bearing overhaul practices and procedures (refer 1.6.3).

4.2 The following additional actions were taken following the incident:

- on 2 March 2001 the Rule of the Week distributed reminded all staff of the action to be taken when dragging equipment was suspected
- a Safety Briefing was given to Train Controllers on 20 April 2001, highlighting actions required when advised of defects on trains.

4.3 Tranz Rail advised it is reviewing the process currently documented in Rule 6 to clarify actions required of locomotive staff.

4.4 Tranz Rail have compiled a CRM training module and completed a pilot presentation. Case studies are being added and training is programmed to commence in October 2001.

4.5 In view of the above actions, no safety recommendations have been made as a result of this incident.

Approved for publication 31 October 2001

Hon. W P Jeffries
Chief Commissioner