Australian Government
Australian Transport Safety Bureau

Australian Transport Safety Bureau
PO Box 967, Civic Square ACT 2608
Australia

1800 020 616

+61 2 6257 4150 from overseas

www.atsb.gov.au

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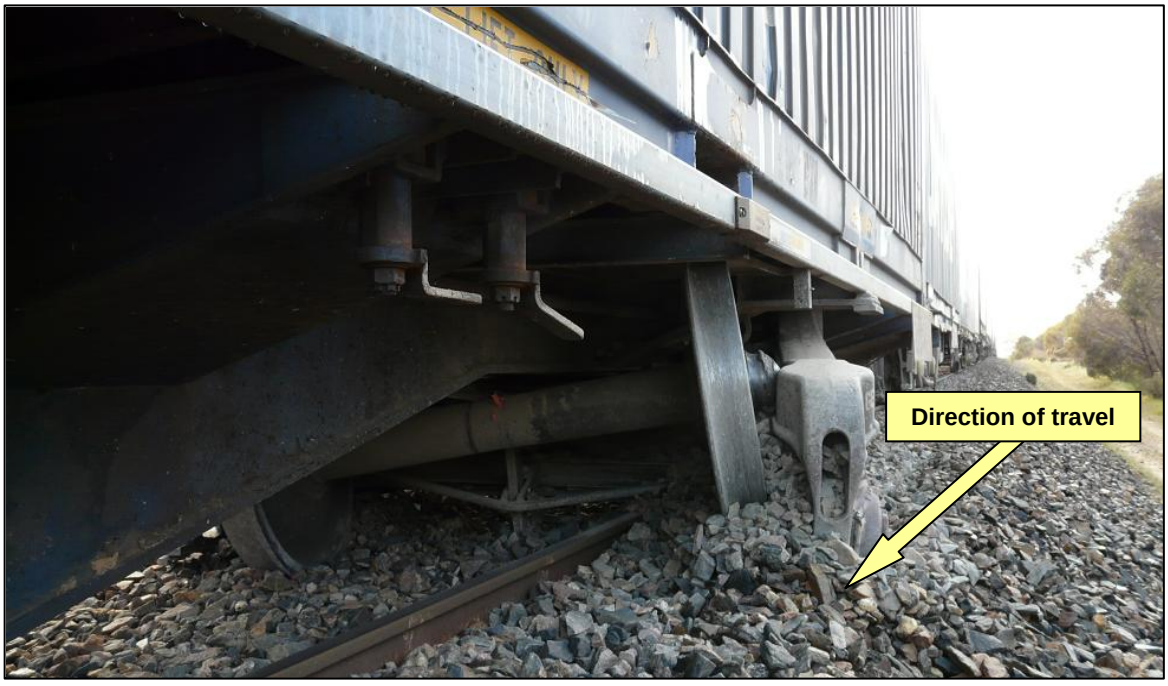
ATSB TRANSPORT SAFETY OCCURENCE REPORT
Rail Occurrence Investigation RO-2010-010
Final

Derailment of freight train 5MP5 near Keith, South Australia 8 October 2010

Figure 1: Derailed bogie (NWNB 0645) under wagon RQJW 22034D, looking towards Melbourne



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Abstract

At about 0415[1] on 8 October 2010, freight train 5MP5 travelling from Melbourne to Perth reported having derailed on the Defined Interstate Rail Network (DIRN) between Wirrega and Keith in South Australia.

No one was injured and there was only minor damage to rolling-stock during the derailment, however approximately 400 m of track required repairs before services could resume and 2900 concrete sleepers were subsequently replaced to restore track integrity.

It was established that the derailment was the result of a screwed journal[2] on the 12th wagon (RQJW 22034D) in the consist behind the locomotives.

1 The 24-hour clock is used in this report. Australian Central Daylight-saving Time (CDT), UTC +10.5 hours.

2 The term 'screwed journal' is widely used throughout the rail industry to describe the failure of a wheel bearing and the subsequent separation of the wheel set from the axle portion upon which the bearing was assembled.

The investigation found that the derailment was initiated by a bearing failure probably caused by the ingress of moisture and contaminants into the left-hand-side axle-box of the leading wheel-set of the wagon's trailing bogie as a result of the loss of the grease nipple on the underside of the axle-box. It was also found that there was a significant surface defect on the tread of the wheel, same axle-box, and this may have accelerated the loosening and subsequent loss of the grease nipple.

It was concluded that enhanced examination of data collected by trackside monitoring systems, in particular looking for underlying trends, may provide opportunity to identify growing defects and facilitate early intervention.

FACTUAL INFORMATION

Location and weather

The derailment occurred on the Melbourne to Adelaide section of the DIRN between Wirrega and Keith, approximately 264 km by rail from Adelaide, South Australia (Figure 2).

The DIRN at this location is owned and managed by the Australian Rail Track Corporation (ARTC). The passage of trains through this section is managed by an ARTC network controller operating off the Phoenix Control System (South Board) Network Control Centre West, located in Adelaide.

The weather recorded by the Bureau of Meteorology on the day of the derailment at Keith at 0600 was fine and calm with a temperature of 9.3°C. Negligible rain had fallen in the preceding 24 hour period.

Train information

The train involved in the derailment was the Pacific National (PN) freight service, 5MP5. The train comprised two locomotives, NR82 (leading) and NR76 (trailing) hauling 27 wagons. The train had an overall length of 1285.8 m and trailing mass of 3005.8 t.

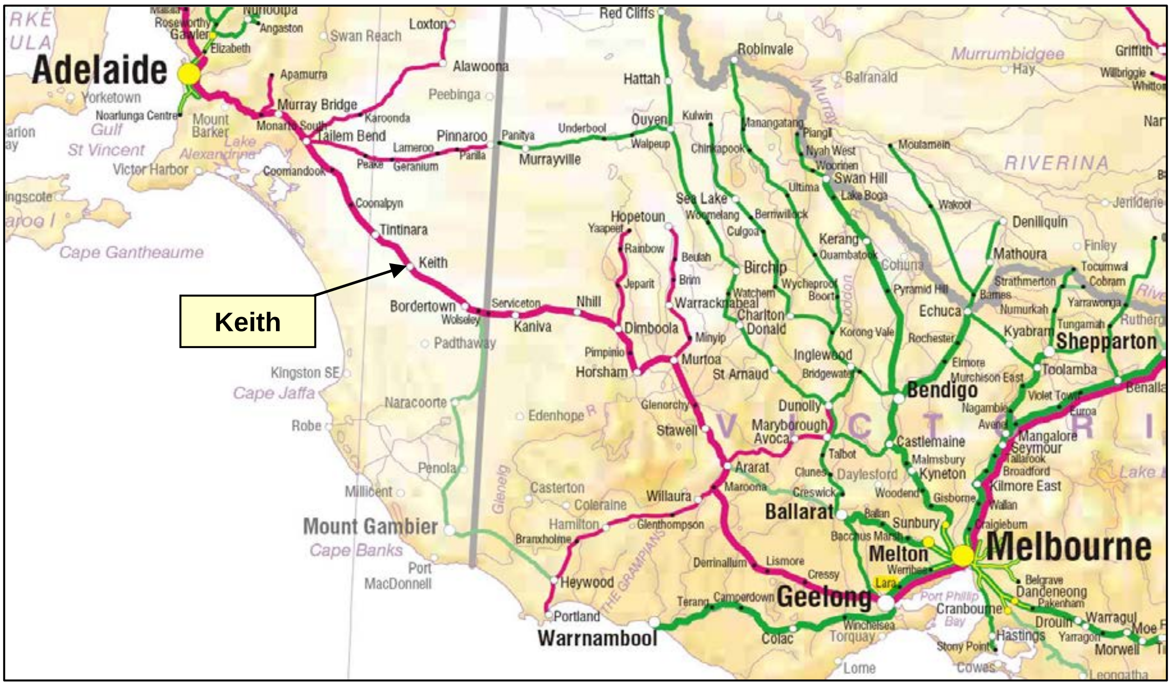
The crew of train 5MP5 consisted of two drivers. Both were appropriately qualified, assessed as competent and medically fit for duty.

Occurrence

On Friday 8 October 2010, the two drivers involved in the derailment booked on for duty at Dimboola to work train 5MP5 through to Adelaide.

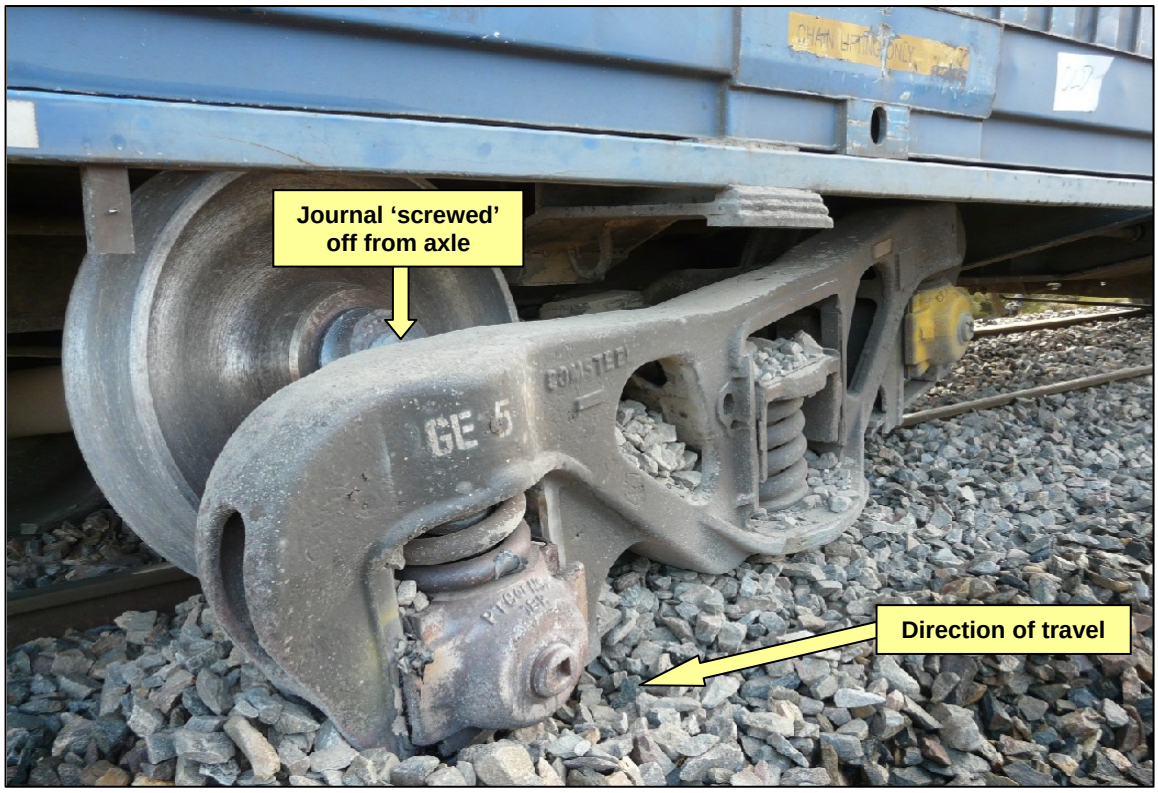
On arrival at Dimboola, the Melbourne train crew reported that the earlier part of the journey was uneventful and no defects had been identified on the train.

Figure 2: Location of Keith (248.503 km), South Australia



Map – Geoscience Australia. Crown Copyright©

Figure 3: Derailed wheel-set of wagon RQJW 22034D



Train 5MP5 departed Dimboola (Victoria) at 0305[3]. The drivers stated that they swapped driver/observer roles at Bordertown with the first driver now performing the role of observer and the incoming driver (hereinafter referred to as the incident driver) working the train from Bordertown to the derailment site.

In his statement the incident driver indicated that the early part of the journey from Bordertown through to just before the derailment site was uneventful. It was not until a warning light on the 'Integrated Function Control' (IFC) screen flashed yellow, showing that the brake pipe pressure at the rear of the train had a slow leak, that he realised that there may have been a potential problem.

The incident driver said that he then checked the train brake pipe pressure gauge and observed that it was not falling and the flow meter was steady, reaffirming his belief of a possible slow leak. Following this he conversed with the observer suggesting that he thought they were about to lose air pressure. He then began to slow the train from about 100 km/h[4] bringing it to a stand about 2½ minutes later.

When the train had stopped the observer disembarked to check the rear of the train for any problems. After walking back about 900 m he reported to the incident driver that he had found that the trailing bogie on wagon RQJW 22034D, the 12th in the consist behind locomotive NR76, was derailed as a result of a screwed journal (Figure 3).

Post occurrence

The incident driver of 5MP5 contacted the network controller to advise that their train was stationary near the 259 km post and that the trailing bogie of the 12th wagon, lead wheel, left-hand-side in the direction of travel was derailed as a result of a screwed journal.

Following advice about the incident, PN arranged for both train drivers to be breath tested; they returned zero readings. PN also arranged for cranes and a replacement bogie to be dispatched from Adelaide to the derailment site to re-rail

3 Australian Eastern Daylight-saving Time (EDT), UTC +11 hours.

4 Posted track speed through this location is 110 km/h.

wagon RQJW 22034D and recover failed components.

The ARTC arranged for the track to be inspected. It was established that about 4 km was damaged with 400 m requiring extensive reinstatement. Repairs were undertaken throughout the day and the site was available for normal traffic operations by 1900.

ANALYSIS

On 8 October 2010 the Australian Transport Safety Bureau (ATSB) received notification of the derailment of freight train 5MP5 near Keith, South Australia. Following an initial review and establishing the derailment was as a result of a screwed journal, the ATSB decided to investigate following several similar recent occurrences involving various operators.

As part of the investigation process the ATSB sourced all perishable evidence including Phoenix train control data files, voice logs and locomotive data log files. This information was supplemented with data comprising; train graphs, train running information, maintenance documentation and PN work procedures.

Sequence of events analysis

Based on the analysis of the evidence, including locomotive data, the train driver's statements and on-site observations it was concluded that:

- After passing through Wirrega (273.023 km) the condition of the 2L[5] wheel bearing on wagon RQJW 22034D rapidly deteriorated, finally seizing and causing the journal to separate from the axle. When this occurred the bogie side frame was no longer supported by the axle allowing it to collapse onto the ballast and sleepers. As the train continued, the side-frame and leading wheel-set were dragged through the ballast and over the concrete sleepers until the train was brought to a stand.
- Events captured on the locomotive data log were consistent with the occurence as described by the train crew. Based on available information it was found that the actions of the train driver in the handling of the train were unlikely to have contributed to the derailment and minimised track and rolling stock damage.

The balance of the report focuses on:

- An examination of the failed wheel-set and the associated axle-box/bearings of the derailed wagon.
- A review of wagon inspection/maintenance practices and trackside bearing and wheel condition monitoring.

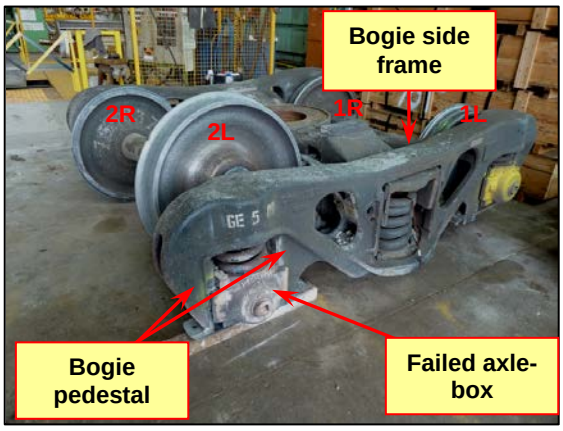
Axle-box examination

Investigators from the ATSB travelled to Port Augusta on 12 October 2010 and met with representatives from Pacific National at the Downer EDI Rail (EDI) workshops to examine the failed wheel bearing and bogie.

'2L' end observations

Observations undertaken at the EDI workshops confirmed that wheel-set 755837 of bogie NWNB 0645 (Figure 4) had failed as a result of the axle journal separating from the axle.

Figure 4: Bogie NWNB 0645



The wheel-set was removed from the bogie allowing it and the failed axle-box to be examined. As evidenced at Figure 5 the journal had separated from the axle within the 2L axle-box. Also visible within the axle-box was the inboard bearing's 'outer ring'.

5 Convention used for naming of wagon wheels '2L' designates left-hand-side axle-box on the leading wheel-set of the trailing bogie in direction of travel.

A End	4R 3R / 4L 3L	WAGON	2R 1R / 2L 1L	B End (handbrake end)

Figure 5: View inside failed '2L' axle-box with the screwed part axle journal remaining

Figure 7: Surface defect in 2L wheel

On inspecting the axle wheel seat radius (inboard side, see Figure 8) of the failed axle-box there was no evidence of grease loss or carbon residue. The outboard side of the axle-box also showed no evidence of grease loss or carbon residue. The axle-box plug was firmly in place.

Further examination of the axle-box (Figure 6) established that the grease nipple, located on the under-side of the axle-box, was missing. On checking the grease nipple thread (Figure 6 inset) it was evident that it was largely undamaged (other than exhibiting signs of oxidation associated with the overheating of the axle-box during the failure sequence) indicating that the grease nipple had worked loose and was probably not in place at the time of the derailment.

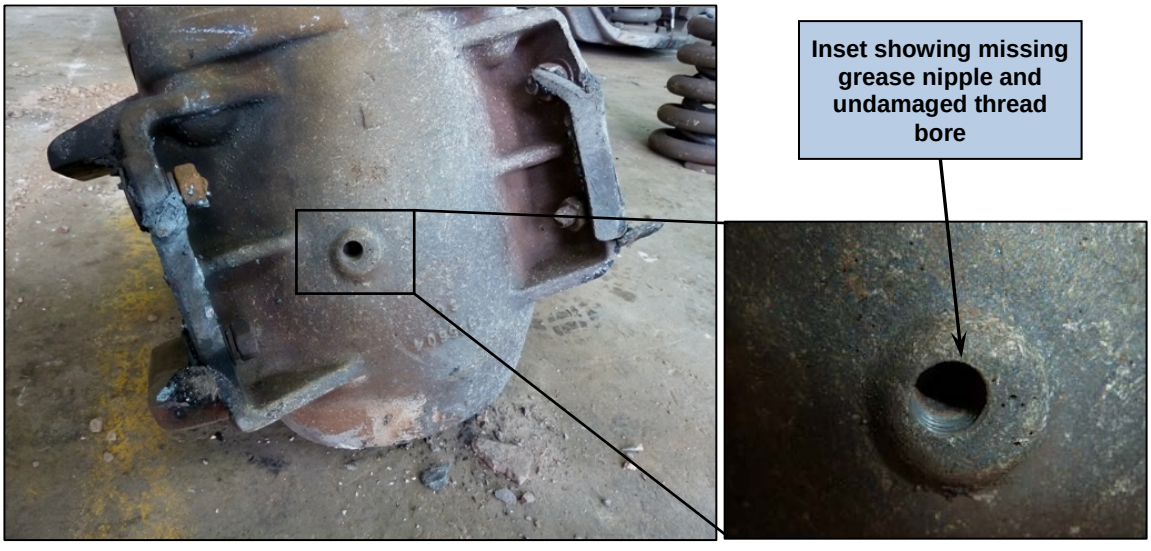
However, also of note on the 2L wheel (the wheel associated with the failed axle-box) was a significant surface defect[6] (Figure 7) on the wheel tread in one location.

'2R' end observations

The axle-box on the 2R end of wheel-set 755837 was intact with no visible signs of damage. There was no evidence of grease loss on the axle wheel seat radius. The grease nipple was securely in place and the axle-box contained an adequate quantity of grease for the bearings to operate.

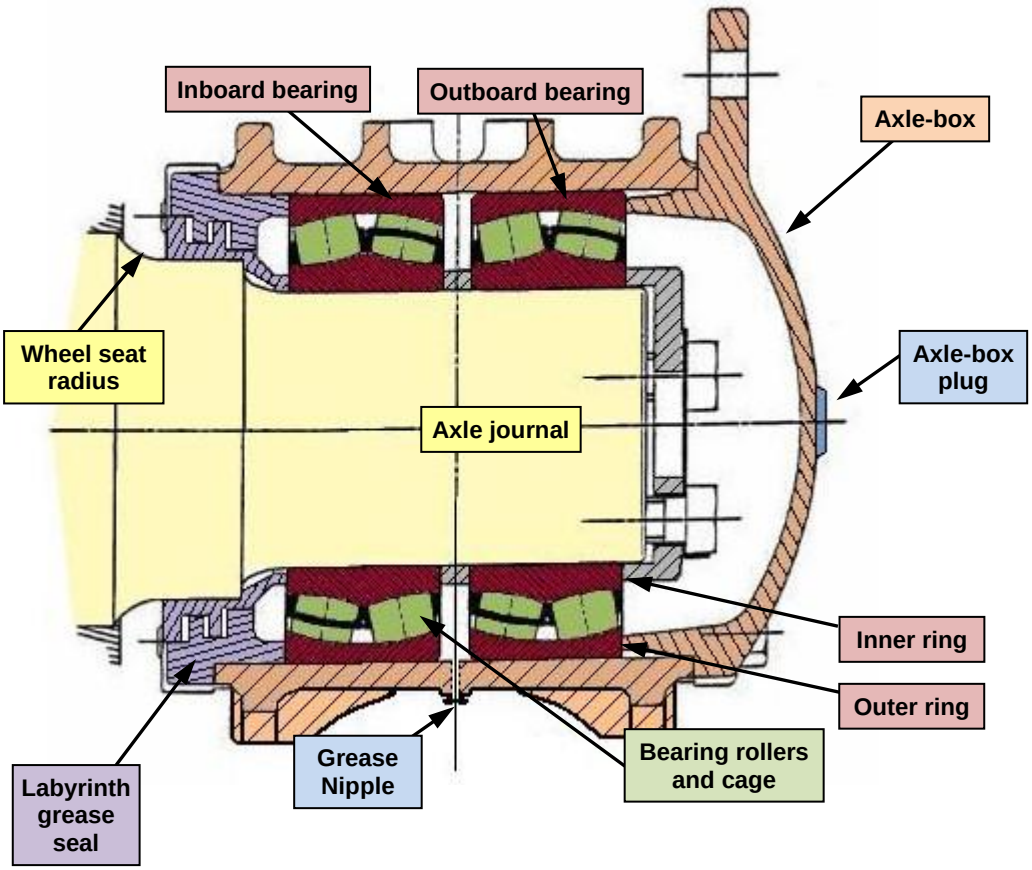
A sample of the grease was taken and tested for a range of mechanical properties. In part the results revealed high levels of contamination comprising Iron, Chromium, Copper and Aluminium. Testing of the intact trailing wheel-set of the same bogie showed comparable levels of contamination.

Figure 6: Failed axle-box showing missing grease nipple (inset view of grease nipple thread)



6 Note: Some material may have broken away in the course of the derailment.

Figure 8: Axle-box schematic



Following a discussion with PN it was established that although these levels are high compared to packaged bearings which have travelled a similar distance – 364,622 km – PN generally experience a greater occurrence of wear particles within axle-box bearings as a result of in-service re-greasing (if not done in a perfectly clean manner) and through the labyrinth grease seal (Figure 8) which are not as effective as the seals used on package bearings.

The investigation concluded that the grease in the failed axle-box was probably a similar age and quality to that of the intact axle-box on the other end of the axle.

Summary of axle-box examination

It was concluded that, at some time before the derailment (and probably after the previous re-greasing), the grease nipple became dislodged from the failed axle-box. The undamaged condition of the threaded bore for the grease nipple suggests that in-service vibration probably contributed to the grease nipple working loose and falling out. Once the grease nipple was lost, the axle-box was open to the ingress of moisture and contaminants which eventually led to bearing rolling contact surface damage. As the condition of the bearings deteriorated, the axle-box would have run progressively hotter until the viscosity of the grease was reduced to the point where it was lost through the grease nipple bore.

The progressive loss of lubrication[7], would have accelerated the breakdown of the bearing rolling contact surfaces and ultimately this led to the catastrophic failure of the axle-box bearings which in turn led to the journal failure and then the derailment.

Bearing inspection and maintenance

Pacific National's wagon inspection and maintenance procedures are prescribed in their 'Wagon Maintenance Manual'. Maintenance generally involves in-service inspections and scheduled maintenance.

7 ATSB report RO-2008-010 Derailment of train 1MP9 Mt Christie, South Australia, 1 September 2008 – Section 2.4 Bearing failure/Lubrication failure refers.

In-service inspections

In-service inspections consist of train pre-departure examinations and roll-by examinations[8].

Pre-departure examinations were carried out at the Melbourne Freight Terminal in Victoria prior to train 5MP5's departure with a subsequent roll-by examination being undertaken at Dimboola by the retiring train crew; no issues were identified[9]. The train subsequently departed and proceeded towards Keith in South Australia. Prior to reaching Keith (248.503 km) the train derailed at the 263.8138 km point.

Scheduled maintenance

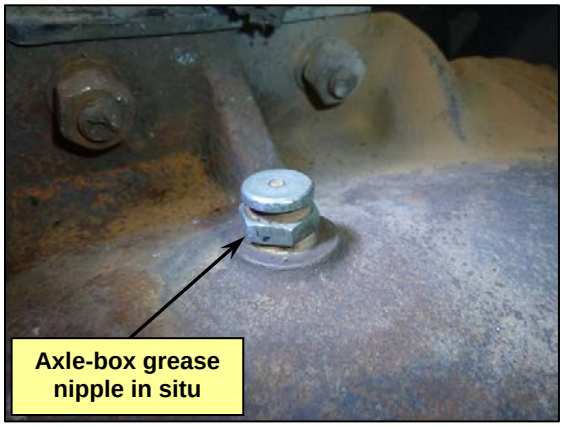
The axle-box at each end of a wheel axle houses two spherical roller bearings separated by a spacer with a labyrinth grease seal located outside the inboard spherical bearing (Figure 8). The labyrinth grease seal is of an air gap design and therefore a small amount of grease leakage is normal, requiring regular re-greasing. PN maintenance instructions require that axle-box bearings are regularly re-greased to maintain correct bearing lubrication.

The Wagon Maintenance Manual stipulates that regreasing should be carried out every time a wagon receives scheduled servicing or at specified time-based intervals. PN outsource the reconditioning of their bearings to one of three contractors; re-greasing is done both internally by PN or outsourced as necessary. The last re-greasing of the axle-box was done by National Rolling-stock Services (NRS).

Examination of maintenance records showed that the wheel-set was overhauled with all bearings being replaced with requalified bearings on 24 October 2008. Pacific National records and the colour coding (yellow) of the axle-boxes on bogie NWNB 0645 established that they had been re-greased within PN's designated 2 year service interval, on or about 8 July 2010. Examination of the intact bearings (2R) showed evidence of fresh grease within the axle-boxes; it was therefore considered likely that the failed bearing was also re-greased at the same time.

Re-greasing of the axle-box requires that the axle-box plug shall be removed and grease injected through the grease nipple located on the bottom of the axle-box[10]. The maintenance instructions require that the axle-box grease nipple is checked for leakage and tightness following re-greasing.

Figure 9: View of grease nipple in situ



It can therefore be concluded that the grease nipple was either fit for purpose (similar to that shown at photograph (Figure 9) or was replaced if leakage was observed. In either case the grease nipple should have been checked for tightness.

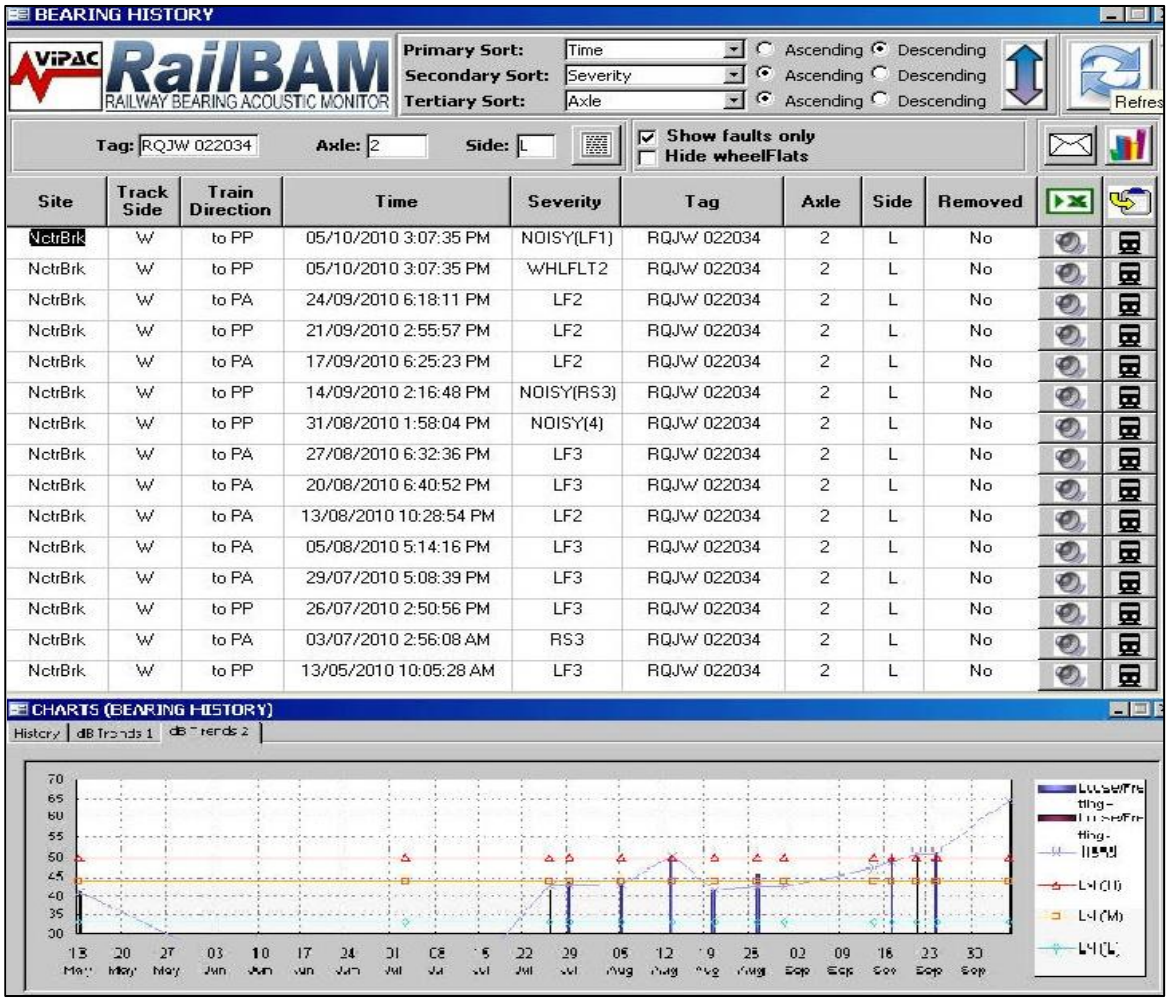
Figure 10: View of grease nipple removed showing tapered thread

8 Roll-by examination. A visual inspection of a moving train to identify equipment, loading security or other defects or failure. The extent of the defects detected will be dependent on the speed of the train during the roll-by examination. (Source: Glossary for the National Codes of Practice and Dictionary of Railway Terminology).

9 Roll-by examinations are only likely to identify obvious bearing faults, such as very noisy bearings, a very hot axle-box (paint cooked off, etc) or clear signs that grease was being ejected from the axle-box.

10 Figure 9, is of a grease nipple in situ on an identical axle-box.

Figure 11: RailBAM readout for 2L wheel of wagon RQJW 22034D



The grease nipple used in the axle-box was of mild steel and a tapered thread design (Figure 10). Tapered thread fittings provide good sealing qualities and excellent resistance against working loose when properly installed. However, if loosely inserted and/or not tightened properly they can easily work free, particularly if exposed to high levels of vibration.

The derailment occurred about three months after the axle-box was re-greased with wagon RQJW 22034D having travelled about 20,000 km since that date.

The loss of the grease nipple in the relatively short time between the previous service and the derailment suggests that the grease nipple was not properly tightened during the service which then allowed it to work loose during the subsequent 20,000 km in operation.

Trackside monitoring

Bearing acoustic monitoring (RailBAM®)

RailBAM® is a predictive monitoring system that detects and ranks wheel bearing faults and out-of-shape wheels (wheel flats) by monitoring the noise they make. It is the primary method for detecting potential bearing faults on rolling-stock travelling on the DIRN however, it is also helpful in identifying wheel flats, especially if used in conjunction with the WILD[11] data.

RailBAM® data is continuously stored by the ARTC[12] in an electronic database that allows rail operators to monitor rolling-stock bearing performance through a web interface.

RailBAM® categorises bearing faults into two groups, rolling surfaces (RS) and

11 WILD is an acronym for 'Wheel impact and load detection'

12 RailCorp, WestNet and PN also have available RailBAM® systems for assessing bearing condition.

looseness/fretting[13] (LF). There are three alert levels 1, 2, and 3 with level 1 being the most critical.

Action taken by operators following the identification of potential bearing faults can range from immediate removal through to a watching/trending analysis. However, PN generally does not respond to LF alerts as they have, in the past, produced unreliable results in predicting looseness/fretting bearing faults. This is reflected in PN maintenance documentation which places no requirement on maintainers to remove wagons from service based on reported LF alerts.

Taking into account the likely event initiator, loss of the 2L axle-box grease nipple, data was sourced from the RailBAM® site at Nectar Brook, South Australia and interrogated (Figure 11) for a five month period preceding the derailment.

This established that before 8 July 2010 (date of re-greasing the 2L axle box) there was minimal evidence of bearing noise associated with the 2L axle-box. After 8 July 2010 the 2L axle-box had triggered one low level (3) RS alert and nine medium level (2/3) LF alerts before triggering one high level (1) LF alert on 5 October 2010, three days before the derailment. This alert was probably indicative of a growing wheel surface defect problem which is corroborated by the WILD data.

Based on PN maintenance documentation and RailBAM® data there was no requirement for PN to remove wagon RQJW 22034D from service to check for bearing faults. However it is evident in examining the RailBAM® data, particularly the graph at Figure 11, that there was a steady increase in the level of acoustic noise associated with the 2L axle-box and that inspection was probably warranted.

Wheel impact and load detection (WILD)

The ARTC uses the wheel impact and load detection (WILD) system on the DIRN for calculating the weight of rolling-stock and detecting wheel flats by measuring wheel impacts. The system does not directly detect bearing faults. However, the onset of wheel impact loading may in some cases be a pre-cursor to bearing failures. PN has seven WILD response conditions ranging from, 1 through to 7. Each condition requires a specific action (Figure 12) ranging from 'Monitor' through to immediate removal of wagons from traffic 'Out'.

Figure 12: Wheel-set removal decision matrix

Impact Category	WILD Reading (kN)	Decision (M = Monitor; I = Imminent, O = Out)							
1	450 & over	O	O	O	O	O	O	O	O
2	400 to 449	O	O	O	O	O	O	O	O
3	350 to 399	I	O	O	O	O	O	O	O
4	300 to 349	M	I	O	O	O	O	O	O
5	250 to 299	M	M	M	I	O	O	O	O
6	200 to 249	M	M	M	M	M	I	O	O
7	150 to 199	M	M	M	M	M	M	I	O
No. of Months*		0	1	2	3	4	5	6	7

An examination of WILD data extracted for wagon RQJW 22034D for the period 23 April 2010 to 6 October 2010 (Figure 13) shows that until 30 May impact loadings generally did not exceed 88 kN which represents normal wheel loads.

After the 30 May, there were increases in wheel impact loadings, which reached a maximum of 320 kN on 30 September, and were a direct result of the growing wheel surface defect in wheel 2L, (Figure 7).

Examination of PN's 'wheel-set removal decision matrix' (Figure 12) shows that a response/action was not required for a further month and only if the wheel impacts continued.

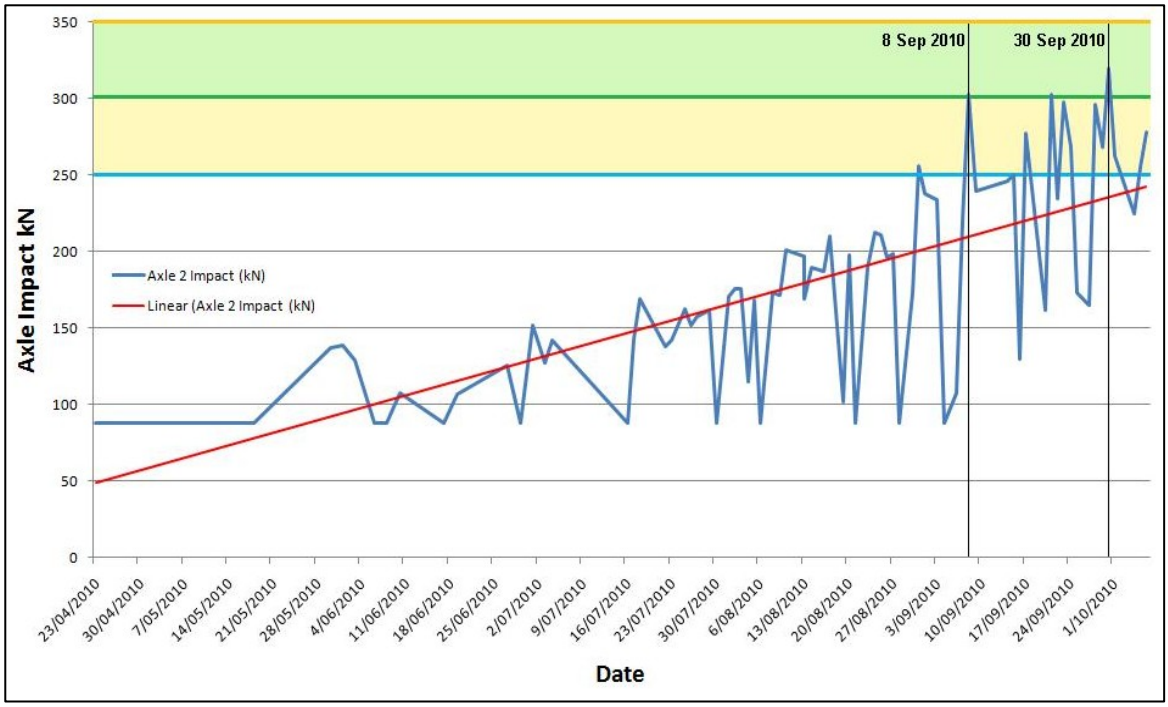
Summary

An examination of PN's 'wheel-set removal decision matrix' (Figure 12) and the maximum wheel impact recorded by WILD, of 320 kN on 30 September, shows that there was no immediate requirement to take wagon RQJW 22034D out of service. However, a review the WILD data covering the period, 23 April 2010 to 6 October 2010, showed a clear trend indicating a growing wheel impact problem. The trend analysis (Figure 13) shows that it was probably inevitable that the wagon needed to be withdrawn from service for examination rather than relying on withdrawal based on simple exceedence criteria.

The working loose of the grease nipple was probably accelerated by vibrations associated with the surface defect on the 2L wheel. Had PN withdrawn wagon RQJW 22034D from service

13 Looseness & Fretting wear is typically associated with:
* the cyclic abrasion of bearing surfaces and/or
* loss of interference fit between journal and wheel bearing cone/ring surfaces.

Figure 13: WILD data for period 23 April 10 through to 6 October 10



earlier they may have also identified that the grease nipple was missing on the 2L axle-box of wheel-set 755837 and thereby averted the derailment.

FINDINGS

Context

At about 0415 on 8 October 2010, freight train 5MP5 travelling from Melbourne to Perth derailed on the Defined Interstate Rail Network (DIRN) between Wirrega and Keith in South Australia. It was determined that the derailment was as a result of a screwed journal on the trailing bogie of wagon RQJW 22034D.

From the evidence available, the following findings are made with respect to the derailment and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- It was determined that the derailment was initiated as a result of a screwed journal on the 2L axle-box (left-hand-side leading) on the trailing bogie of wagon RQJW 22034D.
- Examination of the 2L axle-box established the grease nipple was not in place in the underside of the axle-box and was probably not in place at the time of derailment.
- The loss of the grease nipple probably allowed the ingress of moisture and contaminants into the axle-box leading to a catastrophic failure of the axle bearings.
- It was considered likely that the grease nipple was incorrectly tightened when wagon RQJW 22034D was serviced on the 8 July 2010.
- The action of the grease nipple working loose was probably accelerated by vibrations associated with a surface defect on the 2L wheel.
- Examination of RailBAM® data established that under PN's existing maintenance guidelines there was no requirement to take wagon RQJW 22034D out of service. However, inspection of the data showed that there was a growing problem with the 2L axle-box. *[Minor safety issue]*

Other safety factors

- An examination of wheel impact (WILD) data established that under PN's existing maintenance guidelines there was no requirement to take wagon RQJW 22034D out of service. However, running a trend analysis of WILD data clearly showed that there was a growing wheel impact problem. *[Minor safety issue]*

Other key findings

- Examination of PN records showed that the wagon, wheel-set and associated bearings were maintained in accordance with PN maintenance instructions.
- PN maintenance instructions prescribe that grease nipples should be checked for leakage and tightness when re-greasing.
- The train pre-departure examination at the Melbourne Freight Terminal and a roll-by inspection at Dimboola did not identify any wheel bearing or wheel defect issues.
- The actions of the train drivers were not considered factors that contributed to the derailment.
- Track and associated infrastructure were not considered factors that that contributed to the derailment.

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the rail industry, the ATSB may issue safety recommendations or safety advisory notices as part of the final report.

Pacific National

Trackside monitoring

Minor Safety Issue

Examination of RailBAM® data established that under PN's existing maintenance guidelines there was no requirement to take wagon RQJW 22034D out of service. However, inspection of the data showed that there was a growing problem with the 2L axle-box.

ATSB safety advisory notice RO-2010-010-SAN-010

The Australian Transport Safety Bureau advises that Pacific National should consider the implications of this safety issue and take action where considered appropriate.

Minor Safety Issue

An examination of wheel impact (WILD) data established that under PN's existing maintenance guidelines there was no requirement to take wagon RQJW 22034D out of service. However, running a trend analysis of WILD data clearly showed that there was a growing wheel impact problem.

ATSB safety advisory notice RO-2010-010-SAN-011

The Australian Transport Safety Bureau advises that Pacific National should consider the implications of this safety issue and take action where considered appropriate.

SOURCES AND SUBMISSIONS

Under Part 4, Division 2 (Investigation Reports), Section 26 of the Transport Safety Investigation Act 2003, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to:

- Asciano Ltd (Pacific National)
- The Australian Rail Track Corporation
- Train Drivers.

Submissions were received from:

- Asciano Ltd (Pacific National)
- The Australian Rail Track Corporation.

The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Sources of Information

Information for this report was obtained from:

- Asciano Ltd (Pacific National)
- The Australian Rail Track Corporation

References

- Glossary for the National Codes of Practice and Dictionary of Railway Terminology
- Pacific National, WMM 01-01_04 – *Maintenance of Freight Wagons* (dated 17/12/09)
- Pacific National, WMM 10-01_08 – *Bearings – Maintenance Policy & General Description* (dated 29/07/08)
- Pacific National, WMM 01-12_02 – *Management of Wayside Condition Monitoring Systems* (dated 04/11/09)
- Pacific National, WMM 01-15_01 – *Condition Monitoring Bearing Removal & Inspection* (dated 04/01/10)
- Pacific National, WMM 10-11_05 – *Greasing of Bearings and Overhaul time of EPU Coal Bearings* (dated 25/07/06)