



Derailment of Freight Train 6MP9 near Hines Hill, Western Australia 10 March 2008

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INFRA-08438

ABSTRACT

At about 1415¹ on 10 March 2008, train 6MP9 was carrying containerised general freight from Melbourne to Perth when it derailed 11 wagons near Hines Hill in Western Australia. Although there were dangerous goods on the train, they were not involved in the derailment.

The investigation determined that wagon ABFY2797U derailed due to a 'screwed journal' as a result of a wheel bearing failure.

FACTUAL INFORMATION

Location

The derailment occurred near Hines Hill 261.990 track kilometres from the East Perth rail terminal. The railway was maintained and managed by WestNet Rail and consisted of a single track with crossing loops to manage opposing train movements. The rails were 60 kg/m anchored on concrete sleepers by resilient fasteners supported on ballast.

Train information

Freight train 6MP9 was owned by Specialized Container Transport (SCT) Logistics. It consisted of four locomotives (G512 leading, G529, G538, and G593) hauling 72 wagons carrying containerised general freight and dangerous goods. The train

was 1777 m long and the trailing load weighed a total of 5376 t.

The crew of train 6MP9 consisted of two teams of two drivers. The two crews worked rotating shifts where one crew operated the train and one crew rested in a dedicated accommodation van. The driver operating the train at the time of the derailment had more than 25 years driving experience. Both drivers were appropriately qualified, assessed as competent and medically fit for duty.

Wagon ABFY2797U, the first to derail, was an enclosed louvered wagon (painted green) designed for transporting palletised cargo. The wagon weighed 30 t tare, 80 t gross, was 23.8 m in length and was rated for speeds up to 110km/h. The wagon was loaded with general cargo which did not exceed the weight capacity for the wagon, axles or individual wheels. The wagon manifest indicated that the load was evenly distributed.

Wagon ABFY2797U was fitted with three-piece 'Ride Control' bogies rated at 50 t and the bogie wheelsets were fitted with Timken 10 x 5.5 inch D-class tapered roller bearings.

Occurrence

Train 6MP9 departed Adelaide at 1330 Central Daylight Time (CDT) on 8 March 2008 to continue the journey from Melbourne to Perth.

At about 1825 (CDT), the train passed through Australian Rail Track Corporation (ARTC) rolling stock monitoring stations at Port Germein (SA) and nearby Nectar Brook (SA). The train's axle loads were measured and found to be within the

1 The 24-hour clock is used in this report. Western Daylight Time (WDT) was Coordinated Universal Time (UTC) + 9 hours. Unless shown otherwise, all times are WDT.

required limit and no defects were recorded to indicate a potential wheel bearing problem.

At about 0755 on 10 March 2008, train 6MP9 passed through a WestNet Rail rolling stock monitoring station located at Bonnie Vale, WA, about 360 km from Hines Hill. Only closed-circuit television footage was recorded.

At about 1345, train 6MP9 passed through Booran, 34 km from the point of derailment, where a landowner saw the train and noted that a green wagon in the middle of the train was making an unusual noise as it passed. He did not notice any smoke or sparks.

At 1414:39, shortly after the train passed through Hines Hill, the train drivers felt a slight tug followed by a reduction of brake pipe air pressure and an increase in brake pipe air flow. Both drivers looked in the rear-vision mirrors and noticed a substantial amount of dust and smoke in the distance behind the locomotive. The train slowed and came to a stop at 1416:21.

Figure 1: View of derailment site



Note: wagon ABFY2797U without bogies

One of the drivers walked back and noted that the train had separated, and that a number of wagons were derailed in the middle of the train. He found that wagon ABFY2797U was separated from the front portion of the train and was still on the track, but without bogies, (Figure 1). The next 10 trailing wagons were also derailed. Beyond the derailed wagons, he also noticed what appeared to be a bushfire burning in the distance.

The driver contacted train control. Soon after, emergency services began to arrive.

Post occurrence

Train 6MP9 was carrying dangerous goods located in the rear portion of the train. During the emergency response following the derailment and associated bushfire, the emergency services were aware of the dangerous goods and their location, and took appropriate measures to manage the risk.

Eleven wagons in the middle of the train consist were derailed. The undamaged wagons either side were recovered and re-introduced into service after the required inspections and tests. There was minor track damage from the point of derailment which became increasingly worse towards a level crossing where the front and rear portions of the train had separated. A total of 2800 m of track was damaged in the derailment. The line was re-opened at 1800 on 14 March 2008.

ANALYSIS

On 10 March 2008, an investigation team from the Australian Transport Safety Bureau (ATSB) was dispatched to investigate the derailment.

An examination of the derailment site was conducted and revealed an axle journal stub (Figure 2) lying in a clay pan adjacent to the track about 45 m from the point of separation (262.007 km point). The axle journal stub had originated from the first wagon to derail, ABFY2797U. Inspection revealed that aside from the failed axle, the bogies from wagon ABFY2797U appeared to be in serviceable condition with components that indicated normal running. Similarly, there were no signs of irregular wear on the rest of the wagon to indicate uneven loading or abnormal bogie tracking.

Figure 2: Axle journal stub in situ



Further evidence was sourced from the train drivers, SCT Logistics, the WA Department of Planning & Infrastructure, WestNet Rail and the SA Department for Transport Energy and Infrastructure. Evidence included interviews, train running information, voice and data logs, engineering documentation including maintenance history, bearing failure history and other material.

Sequence of events analysis

After departing Adelaide on 8 March 2008, train 6MP9 passed through condition monitoring stations at Port Germein, SA, Nectar Brook, SA, Parkeston, WA and Bonnie Vale, WA. In each case, data indicated that train 6MP9 was running normally. When the train was passing through Booraan, a landowner noted unusual noises coming from a wagon in the middle of the train consist. By the time the train had travelled a further 34 km, the failing bearing had generated and transmitted sufficient heat to the axle journal to make it 'plastic' and allow the end carrying the failed roller bearing assembly to 'screw off'.

After the axle stub separated from the bogie, the wheelset travelled a further 17 m at about 106 km/h (the train speed obtained from the locomotive data logger) before derailing at 261.990 km. The derailed wagon then travelled a further 2790 m, before striking a level crossing formation, losing both bogies and coming to rest 67 m further on.

It was clear from the evidence at the site that the derailment was caused by a 'screwed journal' as a result of a wheel bearing failure on wagon ABFY2797U. The following analysis focuses on the issues associated with the failure of the bearing.

Component testing

A number of components from failed bearing number 189560 found alongside the track were taken for further analysis by the ATSB.

Two tapered rollers were examined, (Figure 3). Those rollers were found in the immediate vicinity of the axle stub.

Figure 3: Tapered rollers from ABFY2797U



The physical condition of the rollers did not indicate any pre-existing condition that may have led to a failure of the bearing. Due to the components having been exposed to extreme heat, the microstructure or mechanical properties of the steel before the derailment could not be accurately ascertained. A sample from one of the rollers was prepared for composition testing. The results from that test indicated that the material used was in accordance with the standard specified by Timken, the Association of American Railroads and Australian Standard 7516.2-2007 *Rolling Stock Axle Bearings: Freight Rolling Stock*.

The axle stub from failed wheelset 9872 was also examined. The locking tabs on the locking plate were correctly installed. The end cap did not show signs of irregular wear on the mating surface. The end-cap bolts were removed and inspected. No evidence of improper fit was found. The axle end was also examined and no unusual signs were found apart from extreme heating.

The adjacent bearing, number 190602, was examined and apart from derailment damage, there were no signs of abnormal wear. The bearing was suitably greased. Similarly, the axle journal for the adjacent bearing was examined and there was no evidence of irregular wear on the mating surfaces.

A sample of Timken 10 X 5.5 bearings in the same batch 12/05 was inspected. Apart from one bearing showing signs of minor water ingress, no other bearing was found with abnormalities that would contribute to a failure. GEMCO Rail are contracted to manage the maintenance for the SCT fleet of wagons and on average bearings are removed every 300,000 km (aligned with wheel life/machining) and replaced with new or requalified bearings.

Bearing failure modes

A variety of factors may contribute to the premature failure of tapered roller bearings, such as the type used on railway rolling stock axles. Premature failure can be defined as a bearing failing to reach its predicted fatigue life.

The most common causes of premature bearing failure include, but are not limited to; rolling surface damage, loose components, lubrication failure, and mechanical damage.

Bearing fatigue life

Basic bearing fatigue life expectancy is calculated using the L10 method². Australian Standard 2729-1994: *Rolling bearings - Dynamic load ratings and rating life* defines basic rating life as:

For an individual rolling bearing, or a group of apparently identical rolling bearings operating under the same conditions, the life associated with 90% reliability, with contemporary, commonly used material and manufacturing quality, and under conventional operating conditions.

Australian Standard 7516.2-2007 *Rolling Stock Axle Bearings: Freight Rolling Stock* specifies a minimum life of 800,000 km based on the axle bearing L10 life expectancy calculation, contained in Australian Standard 2729 -1994. The bearing manufacturer, Timken, specifies an L10 life of 1,460,900 miles (2,351,090 km) at full load 100 per cent of the time and 2,906,900 miles (4,678,202 km) at full load 50 per cent of the time for D class 5.5 X 10 inch bearings. This exceeds the requirements of Australian Standard 7516.2-2007. The standard also specifies a

maximum of eight years or 1,000,000 km between overhauls.

The applied load (vertical, lateral and radial) is the main parameter that may influence bearing fatigue life. Vertical and radial loading is related to wagon load and speed respectively. There was no evidence to suggest that wagon loading or train speed contributed to the premature failure of the bearing on wagon ABFY2797U. Similarly, based on visual examination, it appears that the wagon and bogies were behaving correctly and thus excessive lateral loading due to wagon dynamics was unlikely to have contributed to the failure of the bearing.

The bearing had travelled about 273,000 km before it failed. This was about 10 per cent of the Timken life expectancy and about 25 per cent of the minimum life expectancy specified in the Australian Standard.

Rolling surface damage

Spalling can be caused by metal fatigue (refer to 'Bearing fatigue life') or other factors such as lack of lubrication, contaminants carried in the lubricant, or indentations created in the rolling contact surfaces of the bearing due to impact loading (brinelling).

The rolling surface condition of the failed bearing could not be determined due to the damage caused during its failure. Examination of the adjacent bearing showed no evidence of abnormal rolling surface condition. Similarly, data from the ARTC Wheel Impact and Load Detection (WILD)³ system, showed no evidence of excessive impact loading (due to wheel flats etc.) on the relevant wheel set.

Loose components

Axle deflection under high loading can result in fretting. Over time, fretting can cause a loss of clamping force, eventually leading to loose components and possible journal failure. Evidence of fretting wear has the appearance of corrosion, surface discoloration and pitting.

2 L10 is the basic fatigue rating life in millions of revolutions.

3 WILD does not directly monitor bearing condition.

The physical condition of the failed bearing prevented examination of its journal surface. However, examination of the adjacent journal showed no evidence of fretting nor was there any evidence of improper fitting of components.

Lubrication failure

Tapered roller bearings are lubricated during assembly and do not require any additional in-service lubrication.

The physical condition of the failed bearing prevented any conclusions being made regarding possible lubrication failure. Examination of the adjacent bearing, which was assembled at the same time as the failed bearing, showed no evidence of lubrication failure or abnormal wear. It is reasonable to assume that lubrication of the failed unit would be similar to the adjacent unit and as such was unlikely to have contributed to its failure.

Mechanical damage

Inappropriate assembly and handling of bearings can cause mechanical damage which, in turn, may result in premature bearing failure. In this case, the bearings were brand new, from the same batch (12/05), lubricated, assembled, packaged and shipped by Timken in South Africa. They were fitted to wheelset 9872 on 6 September 2006 and had travelled about 273,000 km before one failed on 10 March 2008.

Since the overhaul, wagon ABFY2797U had undergone maintenance 11 times before the derailment, most recently on 22 November 2007 for wagon body repairs. During the maintenance, there were no unusual observations noted during the inspection, such as leaking grease, recorded for wheelset 9872. Considering the length of service (though considerably less than the predicted fatigue life) and the lack of observed defects at subsequent services, it is unlikely that bearing handling contributed to premature bearing failure.

Bearing failure management

In the rail context, the risk of a wheel bearing failure which leads to a 'screwed journal' and

results in a derailment is well known⁴. To manage the risk, the rail industry relies on regular maintenance and inspection, and predictive and reactive in-service condition monitoring of wheel bearing assemblies.

Bearing maintenance

Maintenance procedures were examined by the investigation team to determine if they may have contributed to the bearing failure.

Wagon ABFY2797U was maintained and/or overhauled in accordance with SCT Logistics' standards, which are based on the Railways of Australia (ROA) and Association of American Railroads (AAR) standards. Those standards are commonly used in Australia. Throughout the maintenance and overhaul process, the bearing and axle handling procedures appear to minimise the risk that bearing components could be dropped, knocked, damaged or incorrectly fitted.

Timken assemble the 10 x 5.5 inch D class tapered roller bearings in accordance with the AAR standard. The bearings are shipped complete (with grease and seals installed) sealed in plastic and boxed. SCT Logistics' maintenance contractor, GEMCO Rail, store the bearings until needed, at which time they are pressed onto the axle journals after a visual examination and hand rotation. In this way, the risk of damage or contamination of lubricants during assembly of new bearings is minimised.

GEMCO Rail also requalifies⁵ tapered roller bearings in accordance with the AAR standard. All requalified bearings are lubricated during assembly using the recommended Timken branded bearing grease. At the time of the investigation, on average, Gemco Rail were requalifying about 100 D class bearings per month and scrapping about 15 per cent due to spalling, fretting, and corrosion (in approximately equal numbers).

Tapered roller bearing units (new or requalified) do not require re-lubricating while in service.

4 ATSB investigation report 2003/005 into the derailment of train 6WP2 at Bates, SA, on 9 November 2003.

5 A bearing that has been stripped, cleaned, inspected, reassembled, and greased.

There was no evidence to indicate that inappropriate maintenance or procedures contributed to the premature failure of the tapered roller bearing unit on wagon ABFY2797U.

Bearing condition monitoring

A number of detection and monitoring methods are used at key locations throughout the rail network with the intention of detecting a failing wheel bearing before it leads to a derailment. Monitoring methods include: acoustic and temperature (specifically to detect failing bearings); speed, weight, wheel impact and loading (for the train and wagons generally). Rail Bearing Acoustic Monitoring (RailBAM®), a predictive method of monitoring, records individual sound signatures emitted from each passing bearing. The data collected is collated with train and wagon information and is used to determine bearing condition and to trend monitor every individual bearing that regularly passes the monitoring stations in the rail network. RailBAM can detect defects in the bearing's rollers, cones, and cups, providing up-to-date condition monitoring after each pass. Both WestNet Rail and the ARTC have found that catastrophic bearing failures have been significantly reduced since the introduction of RailBAM for asset protection.

Temperature monitoring such as Hot Box Detectors (HBD) provide short term (reactive) monitoring of passing bearings for asset protection. Once a problem in a bearing develops, the operating temperature of the bearing invariably increases before it fails completely which leads to a screwed journal and consequent derailment.

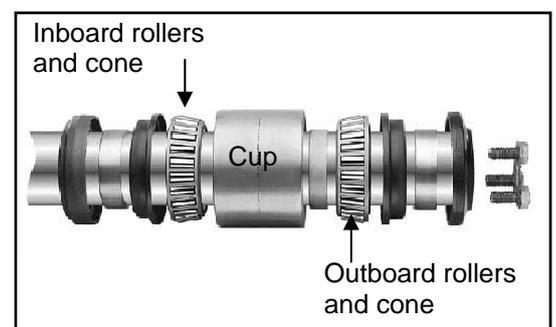
However, there are a number of variables that can affect the performance of HBD's on a mixed freight/passenger rail corridor. Variations in train loading, speed and weather conditions make it possible for bearing components, which may be at imminent risk of failure, to pass undetected. Consequently, hot-box detection is usually used as a 'last line of defence' to protect railway infrastructure assets critical to production processes, such as coal and ore carrying railways.

The WestNet Rail condition monitoring station at Bonnie Vale is designed to visually monitor and weigh passing trains. This site does not

specifically monitor individual bearings. At the time of the derailment, the equipment for this had not been commissioned.

The ARTC condition monitoring stations at Nectar Brook and Port Germein collect RailBAM, Wheel Impact Loading Detection (WILD), and speed information which is used to monitor trends in the health of individual rolling stock. Wagon ABFY2797U had passed these locations 210 times from 6 September 2006 to 8 March 2008, averaging 60 gross tonnes (75 per cent of full load) and 83.6 km/h (76 per cent of maximum rated speed). Only 11 minor RailBAM records for failed wheelset 9872 were detected before the derailment (the last being in February 2008) and one minor record on 8 March 2008. Although the records indicated an acoustic signature on each record, it did not indicate a trend of increasing severity with reproducible faults. The most recent pass on 8 March 2008 indicated a medium level fault on the positive cone and a low level fault on the corresponding positive roller on the failed bearing, (Figure 4). Ordinarily, those faults would not require the wagon to be withdrawn from service, however it would be more closely monitored. Therefore, it was unlikely that the failed bearing had pre-existing mechanical damage that could have contributed to the failure. Once train 6MP9 passed Nectar Brook, there was no bearing monitoring until a WestNet Rail RailBAM station at Millendon WA (about 234 km past the derailment site) which was never reached.

Figure 4: Roller bearing package



History

Since 14 October 2006, there have been five roller bearing failures involving Timken 10 X 5.5 inch D class bearings. Of those five, four were installed on ABFY wagons and one on a VQDW wagon, which failed on 3 March 2008 near Fisher,

SA. The bearing fitted to the VQDW wagon was from the same batch (12/05) as bearing number 189560 and had travelled about the same distance before prematurely failing. Due to the post-failure damage, no clear causes were determined. No other premature failed bearings from the same batch have been reported to the bearing manufacturer, Timken.

Summary

Based on the evidence available, the investigation determined that wagon ABFY2797U derailed due to a 'screwed journal' as a result of bearing number 189560 failing.

The bearing was relatively new and maintenance records indicated that it had been installed correctly.

RailBAM had recorded only 11 minor acoustic signatures (the last being on 8 March 2008) on the failed wheelset prior to the derailment

There was insufficient evidence to positively conclude what factor may have contributed to in the premature failure of the tapered roller bearing unit on wagon ABFY2797U.

SCT Logistics have implemented an upgrade program for ABFY wagons whereby the 50 t bogies are replaced with 70 t bogies, which use bearings other than 10 X 5.5 inch. To date, no other bearings have been found with any defects that may lead to a failure. All but a very few of the 50 t bogies have been phased out of service.

FINDINGS

Context

At about 1415 on 10 March 2008, train 6MP9 derailed near Hines Hill in Western Australia, as a consequence of a 'screwed journal'.

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

Contributing safety factors

- Train 6MP9 derailed as a result of a 'screwed journal' caused by a bearing that failed unexpectedly and undetected by any rolling stock monitoring station.

Other key findings

- There was insufficient evidence to indicate what factor or factors contributed to the premature failure of the tapered roller bearing unit on wagon ABFY2797U.
- Train 6MP9 was travelling about 106 km/h at the time of derailment.
- The wagon was not overloaded or unevenly loaded.
- The wagon had been maintained in accordance with the standards specified by SCT Logistics.
- Testing revealed that the material composition of the failed bearing was within specification.
- The bearing unit end-cap bolt locking tabs were correctly installed and there were no signs of irregular wear on the end cap or bolts.
- The bearing manufacturer's calculated minimum bearing life expectancy significantly exceeded the applicable industry standard.

SUBMISSIONS

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

A draft of this report was provided to SCT Logistics, WestNet Rail, Department of Planning and Infrastructure WA, and a small number of individuals.

Submissions were received from SCT Logistics, WestNet Rail, Department of Planning and Infrastructure WA, and a number of individuals. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.