Derailment of train 1MP9
Mt Christie, South Australia

1 September 2008
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Abstract

At approximately 2130 on 1 September 2008, 13 wagons on freight train 1MP9, owned and operated by SCT Logistics (SCT), derailed near Mt Christie, South Australia. There were no injuries, but about 4.5 km of track was damaged.

The investigation concluded that an axle-box bearing on wagon VQCY 0824U had failed and completely seized, causing the bearing journal to separate from the axle (commonly referred to as a screwed journal). Examination of the bearings suggested that inadequate lubrication had contributed to cage failure with the subsequent misalignment of the rollers and jamming of broken cage material in the rolling surfaces causing the bearing to seize. Maintenance records showed that the bearings on wagon VQCY 0824U were new in July 2004 and the wagon underwent servicing in May 2006 and May 2007. However, it is unlikely that the axle-boxes were re-greased during servicing as required by the maintenance procedures.

SCT has implemented a number of actions aimed at reducing their risk of future derailments due to axle-box bearing failures. Those actions included immediate scheduling for regreasing, a program to remove all axle-box equipped bogies from SCT’s service and a trial to install on-board monitoring for hot bearings on their freight rolling stock.

Though not contributing directly to the derailment sequence, a minor safety issue was identified in relation to documented procedures at crossing loops. ARTC has proposed relevant safety action to address the issue.
The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the Transport Safety Investigation Act 2003 and Regulations and, where applicable, relevant international agreements.

**Purpose of safety investigations**

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

**Developing safety action**

Central to the ATSB’s investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.
**TERMINOLOGY USED IN THIS REPORT**

**Occurrence:** accident or incident.

**Safety factor:** an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

**Contributing safety factor:** a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

**Other safety factor:** a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

**Other key finding:** any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which ‘saved the day’ or played an important role in reducing the risk associated with an occurrence.

**Safety issue:** a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

**Risk level:** The ATSB’s assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.

- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.

- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

**Safety action:** the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.
EXECUTIVE SUMMARY

At about 2100\(^1\) on 1 September 2008, westbound freight train 1MP9, owned and operated by SCT Logistics (SCT), was travelling towards the Mt Christie crossing loop in South Australia. This train had been instructed to take the loop at Mount Christie to allow an opposing eastbound freight train, designated as 1PM5, to proceed through Mount Christie via the main line without stopping. However, the points at the eastern end of Mount Christie failed to automatically re-set for the main line and, as such, the eastbound train was required to stop before traversing the east-end points. Because the rear of the eastbound train was clear of the points at the western end of Mount Christie at this time, westbound train 1MP9 was able to depart the loop. However, after moving about 400 m past the west-end points, the drivers felt the locomotive surge forward before the train stopped due to a loss of brake pipe pressure. Upon further examination they found that the train had derailed.

In total, 13 wagons derailed and about 4.5 km of track on the eastern approach to, and within, the yard limits of Mount Christie was damaged, including a section of broken rail at the eastern end points that had prevented eastbound train 1PM5 from continuing its journey. There were no injuries as a result of this occurrence.

The investigation found that an axle bearing on wagon VQCY 0824U had failed and completely seized, causing the bearing journal to separate from the axle (commonly referred to as a screwed journal).

The bearings on the VQCY class wagon were of an axle-box design with each axle-box housing two spherical bearings. Examination of the bearings suggested that inadequate lubrication had contributed to cage failure with the subsequent misalignment of the rollers and jamming of broken cage material in the rolling surfaces causing the bearing to seize. Maintenance records showed that the bearings on wagon VQCY 0824U were new in July 2004 and the wagon underwent servicing in May 2006 and May 2007. However, it is likely that the axle-boxes on wagon VQCY 0824U had not been regreased during servicing as required by SCT’s maintenance procedures.

Following this derailment, SCT implemented a number of actions aimed at reducing their risk of future axle-box bearing failures. Those actions included immediate scheduling for their entire fleet of axle-box configured rolling stock to be regreased. A program has since been completed that removed all axle-box equipped bogies from service and replaced them with bogies equipped with packaged bearings (packaged bearings do not require in-service regreasing). SCT has also invested in a trial to install on-board monitoring for hot bearings on their freight rolling stock.

Considering the corrective actions taken by SCT, the ATSB has not made a recommendation in relation to the failure of the axle-box bearing on VQCY 0824U. However, the ATSB has noted a minor safety issue in relation to documented procedures at crossing loops, to which the ARTC have proposed actions to address the safety issue.

\(^1\) The 24-hour clock is used in this report to describe the local time of day, Central Standard Time (CST), as particular events occurred.
1 FACTUAL INFORMATION

1.1 Overview

At approximately 2130\(^2\) on 1 September 2008, 13 wagons on freight train 1MP9 derailed near Mt Christie, South Australia. There were no injuries. About 4.5 km of track was damaged.

Location

Mt Christie crossing loop is located at the 638 km mark\(^3\), about 134 track km west of Tarcoola on the Defined Interstate Rail Network (DIRN) between Adelaide and Perth (Figure 1). The track is owned and operated by the Australian Rail Track Corporation (ARTC), with maintenance contracted to Transfield Services.

Figure 1: Location of Mt Christie, South Australia.

The track consisted of a bi-directional single line with crossing loops (short sections of double track) provided at regular intervals to allow trains to cross (travelling in opposing directions) or pass (travelling in the same direction) each other. The track structure consisted of continuously welded rail secured to concrete sleepers supported on ballast. When approaching Mt Christie crossing loop from the east, the track is mildly undulating with a number of curves as it passes through

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\(^2\) The 24-hour clock is used in this report to describe the local time of day, Central Standard Time (CST), as particular events occurred.

\(^3\) Distance in kilometres from a track reference point located at Coonamia in South Australia.
numerous sand dunes. The posted track speed for the few kilometres leading up to
the crossing loop was 80 km/h. In general, the track appeared to be in good
condition and there were no temporary speed restrictions in force at the time.

**Train information**

Freight train 1MP9 was owned and operated by SCT Logistics (SCT). It consisted
of two locomotives (SCT 008 and SCT 010) hauling 51 wagons. The train was
about 1230 m long with a total weight of about 4195 t. The maximum allowable
speed for train 1MP9 was 110 km/h.

The operating driver at the time of the derailment had about 20 years train driving
experience. Both train drivers were appropriately qualified, assessed as competent
and medically fit for duty.

At the time of the derailment, westbound train 1MP9 (travelling to Perth) was
crossing eastbound train 1PM5 (travelling to Melbourne). Freight train 1PM5 was
owned and operated by Pacific National (PN) and consisted of three locomotives
hauling 50 wagons for a length of 1750 m and a weight of about 3600 t.

**Train control**

The type of safe-working system used to manage trains travelling between Tarcoola
and Kalgoorlie, is called ‘train order working’. Train order working is a system of
safeworking in which written authorities for movements between block locations
are issued by train controllers to train crews. The train controllers are located at the
ARTC control centre at Mile End in Adelaide and communication with train crews
and track workers is achieved using UHF radio or telephones. Train crews and track
workers are required to comply with the train controller’s instructions and any
additional trackside indications.

The crossing loops on the DIRN between Port Augusta and Kalgoorlie are locally
controlled, that is, there is no control or indication facility at the ARTC control
centre. The points are controlled by train crews (or track workers) using local
controls (push-buttons in a control cabinet). To help with efficient train operations,
local control is enhanced by the availability of an ‘In Cab Activated Points System’ (ICAPS)
and self restoring points. The control equipment at each end of the
crossing loop also includes a data recording system.

1.2 The occurrence

At about 2100 on 1 September 2008, freight train 1MP9 was travelling in a westerly
direction towards the Mt Christie with authority to take the loop at Mt Christie in
order to cross eastbound freight train 1PM5.

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4 ICAPS is a system which provides train crews with the ability to operate the facing main line
points from within the train cab as the train is approaching the crossing loop. Note that track
maintenance machines do not have the facility to use ICAPS.

5 Self restoring points automatically reset back to the main line after a train has passed over the
points into (or out of) the crossing loop. Note that track maintenance machines must enter and
depart the crossing loop using manual operation of the points.
The ICAPS on the locomotive (train 1MP9) was inoperative, thereby requiring control of the points using the local control push-buttons. Consequently, train 1MP9 stopped short of Mt Christie. IMP9 then ‘crept’ up to the points track circuit (indicated by two sleepers painted white) to allow the second driver to alight from the locomotive. The second driver operated the points using the local controls in the control cabinet before returning to the locomotive. Once the points to the loop had set, the driver moved train 1MP9 into the crossing loop. When clear of the points, the driver of 1MP9 contacted the crew of 1PM5 to advise them that they could proceed through Mt Christie on the main line.

Having already obtained authority to proceed, and eastbound train 1PM5 having passed over and cleared the west-end points, the second driver of 1MP9 set the points to allow their train to move back onto the main line to continue its journey towards Perth. However, after moving about 500 m (about 400 m past the west-end points), the drivers felt the locomotive surge forward and noted a reduction of brake pipe pressure, indicating that brake pipe air was exhausting to the atmosphere and the train brakes would be in the process of applying.

Concurrent with these events, eastbound train 1PM5 had pulled up at the east-end points and, because the points had not automatically returned to the normal position, the crew had manually operated the points so they could continue their journey east. Just as they were preparing to depart Mt Christie, the driver of 1PM5 contacted the ARTC train controller to advise that the east-end points had failed to operate automatically. During that conversation, the drivers also noticed a section of broken rail immediately in front of their train and noted the track would be impassable. While talking to the train controller, the drivers also became aware (through train to train radio communication) that train 1MP9 had stopped due to a loss of brake pipe pressure and passed this information to the train controller.

Meanwhile, the drivers of westbound train 1MP9 had walked back to investigate the cause of the brake pipe pressure loss and discovered that 13 wagons had derailed and a significant portion of track under their train had been damaged. The drivers of both trains advised the ARTC train controller that train 1MP9 had derailed near the west-end points and that neither train would be able to continue its journey.

**Figure 2: Derailment site**

![Derailment site](image)

**Post occurrence**

Australian Transport Safety Bureau investigators and representatives from both the ARTC and SCT arrived on site the following morning. Investigators interviewed the train drivers and examined the site throughout the day. Due to the remote
location, heavy lift cranes and recovery equipment could not access the site and begin restoration work until Wednesday 3 September 2008. Despite the remote location, repair and recovery teams were able to reopen the track for rail traffic at about 2100 on Friday 5 September 2008. A total of 13 wagons were damaged along with about 4.5 km of track, including the points at the western end of the Mt Christie crossing loop.
2 ANALYSIS

An investigation team from the Australian Transport Safety Bureau (ATSB), along with representatives from the ARTC and SCT, travelled to the derailment site at Mt Christie on 2 September 2008.

Investigators examined and photographed the derailment site before releasing the site to permit recovery operations to begin. Evidence was sourced from the derailment site, various witnesses and the rail companies involved, including the ARTC, Transfield, SCT and Pacific National.

2.1 Sequence of events analysis

The primary sources of information for identifying the sequence of events were the statements of the train drivers. To assist with verifying the sequence of events as described by the train drivers, two sources of recorded data were available and examined; recorded data from the locomotive and recorded data from the Mt Christie crossing loop control system.

Recorded data from the locomotive

According to the locomotive log, westbound train 1MP9 had been travelling at about 80 km/h before slowing to a stop about 500 m short of Mt Christie (Figure 3). About 30 seconds later, the train crept forward 500 m (maximum speed was about 14 km/h) and stopped slightly short of the east end points at Mt Christie.

Figure 3: Locomotive log – train speed vs. distance

After about 4 minutes, train 1MP9 moved into the Mt Christie crossing loop (maximum speed was about 32 km/h) and stopped about 500 m short of the west end points. The train remained at this point for about 5 minutes before creeping forward and stopping about 400 m closer to the west-end points. About 13 minutes later, train 1MP9 departed the Mt Christie crossing loop, accelerated to about 33
km/h before losing brake pipe air pressure and coming to its final stop with the locomotive about 400 m past Mt Christie crossing loop.

The sequence of events as described by the train drivers is consistent with the locomotive data log.

**Recorded data from the points control system**

The data recorded by the signalling equipment at the Mt Christie crossing loop (Table 1) showed the door of the east-end control cabinet opening at 21:07:44. The data recorded the east-end points being controlled into the reverse position before the door was closed and a flashing yellow aspect was displayed on the ‘points light indicator’\(^6\), advising that the points had been set correctly for a train to move onto the crossing loop track.

<table>
<thead>
<tr>
<th>Time</th>
<th>Signal data</th>
<th>Mt Christie - East</th>
<th>Mt Christie - West</th>
</tr>
</thead>
<tbody>
<tr>
<td>21:07:44</td>
<td>Door open&lt;br&gt;Indicator red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21:07:46</td>
<td></td>
<td></td>
<td>Indicator steady yellow</td>
</tr>
<tr>
<td>21:09:18</td>
<td>Points called reverse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21:09:32</td>
<td>Points detected reverse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21:09:34</td>
<td>Door shut,&lt;br&gt;Indicator flashing yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21:11:00</td>
<td>East track occupied (1MP9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21:25:36</td>
<td></td>
<td></td>
<td>West track occupied (1PM5)</td>
</tr>
<tr>
<td>21:30:39</td>
<td></td>
<td></td>
<td>West track clear (1PM5)</td>
</tr>
<tr>
<td>21:33:13</td>
<td></td>
<td></td>
<td>Door open</td>
</tr>
<tr>
<td>21:34:46</td>
<td></td>
<td></td>
<td>Points called reverse</td>
</tr>
<tr>
<td>21:34:58</td>
<td></td>
<td></td>
<td>Points detected reverse</td>
</tr>
<tr>
<td>21:35:00</td>
<td>Door shut,&lt;br&gt;Indicator flashing yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21:38:19</td>
<td></td>
<td></td>
<td>West track occupied (1MP9)</td>
</tr>
</tbody>
</table>

At 21:11:00, the signal data indicated that the east-end track circuit was occupied (implying that train 1MP9 was passing over the east end points). However, the data indicates that the track circuit did not clear and the points did not automatically return to their normal position, even though the train had moved completely into the crossing loop.

At the west-end of Mt Christie crossing loop, the points were in their normal position (set for a train movement on the main line). However, the points light indicator had been displaying a steady yellow indication since the east-end control

\(^6\) The points light indicator is a track side light (looking similar to a trackside signal) that provides an indication of the direction the points have been set.
cabinet door had been opened at 21:07:44. This indicated that the east-end points were not set correctly for a train movement to depart Mt Christie on the main line.

At 21:25:36, the data showed the west-end track circuit being occupied, then clear at 21:30:39, implying that eastbound train 1PM5 had passed over the west-end points, was clear of the points track circuit, and was on the main line within the Mt Christie yard limits. Just under 3 minutes later (21:33:13), the data showed the west-end control cabinet door opening followed by the points being controlled into the reverse position, the door closing and a flashing yellow aspect displayed on the points light indicator. At 21:38:19 the west-end track circuit showed occupied, implying that train 1MP9 had begun to depart the Mt Christie crossing loop and was passing over the west-end points. The track circuit did not clear and continued to show occupied because train 1MP9 had stopped as a result of the derailment and wagons remained standing over the points.

The sequence of events as described by the train drivers is consistent with the data recorded by the signalling equipment at the Mt Christie crossing loop.

### 2.2 Initial observations

Investigators examined the derailment site and observed damage to both rolling stock and track infrastructure.

**Rolling stock**

Initial observations found that an axle bearing on a VQCY class wagon had failed. The bearing appeared to have completely seized which resulted in the bearing journal separating from the axle (commonly referred to as a screwed journal - Figure 4).

**Figure 4: Lead bogie of wagon VQCY 0824U**

![Lead bogie of wagon VQCY 0824U](image)

The VQCY class wagons are flat platform wagons designed for transporting shipping containers. They are about 20 m long, have a tare mass of about 20 t and the capacity to carry a payload of about 60 t. The two bogies under wagon VQCY 0824U were three-piece ‘Super Service Ride Control’ bogies rated at 50 t each. The
axles were broad gauge axles that had been modified for standard gauge use by positioning the wheels slightly further inwards. The bearings were of an axle-box design with each axle-box housing two spherical bearings (Figure 6).

The bogie appeared to be in reasonable condition except that the wheels showed significant levels of hollowing. All four wheels on the lead bogie showed hollowing in the order of 3–4 mm. The bearings were of an axle-box design with each axle-box housing two spherical bearings (Figure 6).

Track infrastructure

It was evident that the bearing journal had separated from its axle and that the wheel-set had derailed well before train 1MP9 reached Mt Christie crossing loop. While the most extensive track damage was where the majority of freight wagons eventually derailed, the derailed wheel-set had already caused sleeper damage for about 4.5 km.

Of key interest was track damage in the vicinity of the east-end points at Mt Christie. It was evident that, as wagon VQCY 0824U passed over the east-end points, the derailed wheel-set placed a high lateral load on the rail, causing a section of rail (about 9 m long) to break and roll onto its side (Figure 5). It is likely that the broken section of rail caused the track circuit to continue indicating that the track was occupied (consistent with recognised signalling design principles), thereby preventing the points from automatically returning to their normal position ready for a main line movement. It was for those reasons that train 1PM5 did not receive the expected green indication when approaching Mt Christie from the west and was subsequently required to stop slightly short of the east-end points. Similarly, the track occupied indication also prevented the points from being controlled using the local push-button controls. Consequently, the points could only be operated manually using the throw levers mounted on the points machine.

Figure 5: Section of broken rail – east end of crossing loop
2.3 Bearing examination

A search was conducted (for a few kilometres behind train 1MP9) for the failed bearing components. The recovered components from the failed bearings (‘A’ end of axle) and the associated wheel-set (including the partner bearings located at the ‘B’ end of axle), were sent to PearlStreet Engineering Testing & Research Services (PearlStreet ETRS) for further examination.

Figure 6: Axle-box components

‘A’ end bearings

Examination found that both bearings had lost interference fit on the axle journal before the journal sheared off at the inboard bearing position. The inboard bearing had completely failed with only the inner and outer rings of the bearing having been recovered from the derailment site. The other bearing (outboard) was intact but had been mechanically damaged by abrasion. The bottom of the axle-box had also been ground away by contact against the ballast and all parts of the rear seal (water-guard and collar) were not recovered.

There was no evidence of grease loss on the axle wheel seat radius (inboard side of the axle-box), nor was there any evidence of grease loss on the outboard side of the recovered axle-box in the vicinity of the axle-box plug. Similarly, there was no evidence of grease on the axle-box components nor was there any carbon residue from the lubricant on the bearing components.

Considering the loss of cages and rollers from the inboard bearing, it is likely that the cages had failed in service. Both the inner and outer rings of this bearing showed evidence of overheating. The outer ring raceways showed evidence of heavy wear and flaking in the loaded zone (top of the axle-box). The outboard

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7 PearlStreet Engineering Testing & Research Services were engaged by SCT.
bearing also showed evidence of overheating. The cage of this bearing showed signs of smearing as a result of contact between rollers and the cage window. Overheating and smearing are both indicators of inadequate lubrication.

**Figure 7: Recovered components from ‘A’ end axle-box.**

Minor fretting corrosion was evident within the axle-box and on the outer races of the bearings. Three of the four water-guard studs and nuts at the back of the axle-box indicated that the water-guard had broken. It was considered likely that failure of the water-guard occurred as a result of the axle-box being dragged through the ballast.

**‘B’ end bearings**

The axle-box on the ‘B’ end of the axle was intact and showed no external signs of damage.

There was no evidence of grease loss on the axle wheel seat radius (inboard side of the axle-box). While the PearlStreet ETRS report noted that the axle-box plug on the outboard side was loose and showed signs of grease around its exterior surface, this was due to removal of the axle-box housing prior to the examination. Photographs taken at the derailment site showed no evidence of grease loss on the outboard side of axle-box in the vicinity of the axle-box plug.

The axle-box contained an adequate quantity of residual grease which was assessed to be well above the minimum amount required for the bearings to operate without lubrication failure. A sample of the grease was taken and tested for its mechanical properties and moisture content. The mechanical properties were found to be below the required grade 3[^8] grease specified for use in freight axle-boxes. However, the results indicated that the grease was likely to have been grade 3 grease, which had degenerated slightly during the service life of the axle-box. The moisture content of the grease was within the range normally expected for railway axle-boxes.

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[^8]: Grading of lubrication grease, based on its consistency, is commonly achieved using a nine-level scale established by the National Lubricating Grease Institute. The lower grades are softer and flow better, while the higher grades are firmer and are better suited where leakage is a concern.
The bearings at the ‘B’ end of the axle were intact and rotated freely. However, there were signs of discolouration due to overheating of the outboard and inboard bearing rollers. Inspection of the inner and outer races of both inboard and outboard bearings indicated that they were similarly overheated but smearing of the roller windows was not detected on the bearing cages. The rolling surfaces showed no evidence of indentation on rollers or races.

The axle-box and bearings on the ‘B’ end of the axle appeared to be in a serviceable condition. While the signs of discolouration due to overheating are generally regarded as indicators of inadequate lubrication in bearings, the quantity of residual grease (even in its slightly degraded condition) should have been suitable for continued operation of the bearings without failure.

2.3.1 Summary of bearing examination
The PearlStreet ETRS report concluded that, in relation to the bearings on the ‘A’ end of the axle:

The pattern of damage to the bearings in the axle-box suggested that the inboard bearing had failed first. Cage failure was a likely contributing factor to this bearing failure. The subsequent damage within the bearing would be expected to contribute to loss of interference fit of the bearing inner ring. The loss of interference fit of the bearing inner ring would be expected to generate frictional heat in the axle journal and contribute to the loss of interference fit of the outboard bearing and wasting of the axle journal at the inboard position.

The report also concluded that inadequate lubrication or over speed/overload operating conditions were potential contributing factors to the overheating of the bearings at the ‘B’ end of the axle and failure of the bearings at the ‘A’ end.
2.4 Bearing failure

Loss of interference fit between the bearing and axle journal often occurs later in the failure sequence. That is, other faults combine to cause the loss of interference fit. Slippage due to loss of interference fit can be progressive whereby the initial slippage is small, but as the journal material wears, the amount of slippage increases. Alternatively, slippage of the inner ring on the journal can occur suddenly due to bearing seizure.

The damage caused to the failed bearing limited the ability to clearly identify the cause of the failure. Consequently, the investigation looked at the common failure modes for railway bearings to provide stronger support to any possible conclusions.

All bearings have a finite life. In a laboratory test environment, bearings will most likely reach their predicted fatigue life. However, in a field environment, a variety of factors may contribute to the premature failure of a bearing. Premature failure can be defined as a bearing failing to reach its predicted fatigue life. This could be due to in-service failure or removal during normal maintenance due to failure to meet the required servicing standards.

Fatigue life

Bearing fatigue life is commonly referred to as the L_{10} life. This is a calculated prediction of bearing life in terms of stress cycles (related to revolutions) based on 10% of bearings showing the first evidence of fatigue. The first evidence of fatigue is defined as when one of the rolling contact surfaces develops a spall measuring approximately 6 square mm (refer to Rolling surface damage).

The applied load is the main parameter that influences bearing fatigue life. For roller bearings, fatigue life is inversely proportional to the \(10/3\) power of the load applied. For example, if the load is halved, the fatigue life will increase by a factor of about 10. Conversely, doubling the load will result in a decrease in fatigue life by a factor of about 10. Consequently, excessive loading is likely to have a significant effect on bearing fatigue life.

The bearings were new when the bogies under wagon VQCY 0824U were replaced in July 2004. The ARTC Wheel Impact and Load Detection (WILD) system at Port Germein (South Australia) was used to examine the loading of wagon VQCY 0824U. There was no evidence of excessive loading over the period between July 2004 and September 2008. (Refer to section 2.5.2 Trackside condition monitoring).

Considering the age of the bearings and no evidence to suggest excessive loading, it is unlikely that the bearings failed due to simple bearing fatigue.

Cage failure

The bearing cage is designed to retain the rollers within the bearing in a consistently spaced and correctly aligned position. The cage has no role in the transmission of forces. The cages in spherical bearings, used in railway axle-boxes, are usually pressed out of metal plate.

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9 Port Germein is located about 613 km before Mt Christie.
The main philosophy with roller bearings is to avoid sliding friction. However, sliding at the cage surfaces cannot be avoided. Consequently, the softer material of the cage (when compared to other components) is likely to be the first area to wear when lubrication becomes inadequate or foreign material causes abrasion. As the cage windows increase in size due to wear, the cage loses its ability to correctly align and guide the rollers. The resultant forces can lead to rapid deterioration and fracture of the cage. Under these conditions, broken cage material may become jammed in the rolling surfaces with bearing seizure the likely result. The main causes of cage failure are vibration, excessive speed, wear and foreign material.

If cage failure was caused by vibration or excessive speed, it would be expected that similar indicators would exist on bearings at both ends of the axle. In this case, the bearings on the ‘B’ end of the axle showed no signs of cage damage. Consequently, vibration and excessive speed are unlikely to have been contributing factors.

Excessive wear can contribute to cage failure as the metallic wear debris circulates in the bearing. If appropriately lubricated, excessive wear would only be expected in bearings that had been in service for long periods, for example, three wheel lives or longer service. In this case, the bearings were fitted new about 4 years earlier and the wheels were almost due for their first re-profile. Wear due to normal service was considered an unlikely contributing factor.

Both bearings (‘A’ end of axle) showed evidence of discoloration due to overheating. In addition, the outboard bearing showed evidence of smearing as a result of contact between the rollers and the cage window. Considering the evidence available, the most likely contributing factor to cage failure would be wear due to inadequate lubrication. The issue relating to foreign material is discussed in the following section.

**Rolling surface damage**

Spalling is the flaking of material from the rolling contact surfaces due to repeated stress cycles. Spalls generally begin as small cracks below the material surface, which gradually join and grow until they break through the surface. Metal fragments that separate from the spalled area are carried in the lubricant and gradually increase the size of the spalled area.

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

The outboard bearing on the ‘A’ end of the axle was extensively damaged such that much of the direct evidence was destroyed and examination of the rolling surfaces provided no useful information. The inboard bearing showed evidence of heavy wear and flaking in the loaded zone (top of the axle-box) of the outer ring raceways. The bearings on the ‘B’ end of the axle showed no signs of indentations on the rollers or races.

Bearing failure caused by foreign material ingested into an axle-box during assembly will usually occur, or there will be indications of imminent failure, relatively early in the bearing’s service life. In this case, the bearings had been in service for about 4 years. Flaking within one axle-box, later in its service life, is more likely to be caused by ingress of foreign material or impact loading while in service.
If sufficient lubrication existed, rolling surface damage and bearing deterioration is likely to be progressive and detectable by trackside condition monitoring equipment. In this case, the ARTC WILD system showed no wheel impact alarms relating to wagon VQCY 0824U since the bearings were replaced in July 2004. Similarly, the ARTC Bearing Acoustic Monitoring system (RailBAM®) at Nectar Brook, South Australia recorded no information that would indicate a developing rolling surface defect. Refer to section 2.5.2 Trackside condition monitoring.

It is unlikely that rolling surface defects initiated the failure of the inboard bearing on the ‘A’ end of the axle. However, it is possible that rapid development of rolling surface damage could occur if the bearing contained inadequate lubrication.

**Loose components**

Fretting is caused by motion between tightly fitting parts such as between the bearing inner rings and the axle journal. A major contributor to fretting in this area is axle deflection under high loading. As an axle bends under load, the journal surface becomes slightly longer at the top and slightly shorter at the bottom. Under some conditions, this can cause very small amounts of sliding at the interface between the journal and the bearing inner ring. Over time, fretting can cause a loss of clamping force, eventually leading to loose components and possible journal failure. Fretting can also occur between the bearing outer rings and the inner surface of the axle-box. Contributing factors to fretting in this area are vibrational loading or clearance between the bearing outer rings and axle-box.

The bearing inner rings and the ‘A’ end axle journal could not be examined for evidence of fretting due to the damage caused during the failure sequence. Only a minor amount of fretting was evident on the outer rings with no evidence of fretting on the inner surfaces of the axle-box. Considering there was no evidence of excessive loading on this wagon since the bearings were installed in July 2004 and only a minor amount of fretting was evident on the outer ring surfaces, it is unlikely that fretting contributed to the failure of the bearings.

**Lubrication failure**

The function of a lubricant is to separate the rolling contact surfaces at the points of high pressure contact. The lubricant film between the surfaces acts to reduce wear, friction and corrosion such that the bearing should be able to achieve its predicted fatigue life; assuming no other factors exist that may cause premature failure. Lubrication failure can occur due to an inappropriate grade of lubricant, contamination of the lubricant or insufficient lubricant.

It is likely that the lubricant in the axle-box on the ‘B’ end of the axle was the correct grade but it had degenerated slightly during the service life of the axle-box. No lubricant could be recovered from the failed bearing on the ‘A’ end of the axle. However, since the axle-boxes at each end of the axle would have been assembled at the same time, it is reasonable to assume that the correct lubricant was used in both axle-boxes.

Contamination of the lubricant can occur during assembly, servicing, or by ingress of foreign material through the rear axle-box seal. Contamination during assembly or servicing will usually affect both axle-boxes and will usually shown signs of

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10 Nectar Brook is located about 580 km before Mt Christie.
failure in the earlier stages of service life. In this case, no evidence of contamination
was found in the axle-box on the ‘B’ end of the axle. Considering the axle had been
in service for approximately 4 years, it is unlikely that the lubricant had been
contaminated during assembly or servicing.

Axle-boxes have a labyrinth (meshed fingers) type grease seal at the rear of the box.
The labyrinth seal has gaps between its meshed fingers allowing the minor leakage
of grease during service. This is normal and required to provide a seal against
ingress of foreign material or moisture into the bearing enclosure.

Examination of the ‘B’ end axle-box indicated that the rear seal contained an
adequate quantity of grease to prevent ingress of moisture and foreign material. The
presence and condition of grease in the ‘A’ end labyrinth seal could not be
established since all parts (water-guard and collar) of the rear seal were missing.
However, examination of the water-guard studs and nuts indicated that the water-
guard had been broken during the bearing/axle failure sequence. Assuming the
labyrinth seal was intact, ingress of foreign material or moisture would only occur if
there was insufficient grease available to seal the gap between the meshed fingers.

2.4.1 Summary of bearing failure

The recovered bearing components were examined in relation to the common
failure modes for railway bearings. Where the physical evidence suggested the
possibility of a specific failure mode, closer examination suggested the failure
sequence would have been progressive in most cases. The ARTC Bearing Acoustic
Monitoring system showed no evidence suggesting a progressive deterioration in
bearing condition. However, in each case, damage to the bearing components could
be explained by inadequate lubrication.

Considering the evidence available, it is likely that loss of interference fit between
the inboard bearing (‘A’ end of axle) and the axle journal occurred suddenly due to
bearing seizure. It is likely that the bearing seized due to cage failure, the
subsequent misalignment of the rollers and jamming of broken cage material in the
rolling surfaces. The most likely contributing factor to the failure of the cage was
excessive wear due to inadequate lubrication.

2.5 Bearing failure management

As the rail industry continues to strive for greater operational efficiency, the
demand to carry higher loads has increased. To counter the effect of reduced fatigue
life due to increased load, bearings have had to undergo evolutionary change. This
evolution has included a major change when plain bearings (sliding metal surfaces
using low friction coefficient alloys such as bronze) were replaced by roller
bearings. However, the design of roller bearings has also undergone improvement
over the years.

In this case, the bearings were of an axle-box design with each axle-box housing
two spherical bearings. Axle-box bearings have a labyrinth (meshed fingers) type
grease seal at the rear of the box. The labyrinth seal is an air gap seal where grease
leakage is normal, requiring regreasing on a regular basis to maintain correct
bearing lubrication. However, a more recent approach has been the adoption of
cartridge tapered roller bearings, often referred to as packaged bearings (Figure 9).
Unlike axle-box bearings, a packaged bearing has the advantage of being a sealed
unit which does not require in-service regreasing. This reduces the risk of inadequate, excessive or contaminated lubricant during operation.

Figure 9: Packaged bearing

2.5.1 Inspection and maintenance

Rolling stock standards describe the minimum requirements applicable for inspection and maintenance of railway rolling stock. At the time when train 1MP9 derailed, the relevant rolling stock standard was AS7516.2 – Railway Rolling Stock – Axle Bearings – Freight. However, with respect to lubrication, AS7516.2 does not state a minimum schedule for lubrication. The requirement is that a rail operator must have systems in place for relubrication and provides guidance that a lubrication schedule should be based on experience, manufacturers’ recommendations or condition of lubricant samples taken during service use. SCT comply with AS7516.2 by issuing documented work instructions. The instruction for Inspection of Bearings and Adapters is numbered SF2.2 (dated October 2002) and covers both packaged bearings and axle-boxes. In this case, the bearings on wagon VQCY 0824U were housed in axle-boxes.

Apart from the inspection for physical damage and leaking lubricant, SCT’s instruction notes that axle-boxes require regreasing on a regular basis to maintain correct bearing lubrication. The instruction states that re-greasing should be carried out every time a wagon receives scheduled servicing or at a specified time-based interval (whichever is sooner). The time-based interval is determined by a system of colour coding, which means that regreasing should occur every 2 years and not exceeding 3 years.

SCT contract the maintenance of their rolling stock to Gemco Rail. Examination of maintenance records confirm that the bearings on wagon VQCY 0824U were new in July 2004 and the axle-boxes were marked with pink paint. The pink paint
indicated that regreasing would be required before the end of 2006, at which time the axle-box should have been re-painted white. Maintenance records show that wagon VQCY 0824U underwent servicing in May 2006 and May 2007. At each service, the axle-box colour code was noted as pink. Considering that at the time of the derailment (September 2008) the axle-box colour code was still pink, it is likely that the axle-boxes on wagon VQCY 0824U had not been regreased since installation in 2004 (a period exceeding 4 years).

There was a slight anomaly between Gemco Rail’s inspection checklist (Form 54) and SCT’s instruction for bearing inspection (SF2.2) with respect to regreasing of axle-boxes. Gemco’s checklist states:

Check wheel bearing regrease colour code and regrease if code has expired or will within three months of service date. Refer R.O.A. Section 24.2.

Gemco’s document implies that regreasing is only required if the colour code has expired or is about to expire. The colour pink did not expire until the end of 2006. Therefore, it could be interpreted that regreasing may not have been required at the service conducted in May 2006. However, SCT’s instruction clearly states that axle-boxes should be regreased at every service. Similarly, the reference in Gemco’s checklist (Railways of Australia – Manual of Engineering Standards and Practices, Section 24.2), while not quite as clear as SCT’s instruction, also states that axle-boxes shall be regreased ‘... in the year indicated by the colour code’.

It is evident that the axle-boxes on wagon VQCY 0824U should have been regreased at the service in May 2006, although there may have been an interpretation anomaly with Gemco’s checklist for that service as the colour code was not due to expire for a further 7 months. However, regardless of interpretation, it is clear that the axle-boxes on wagon VQCY 0824U should have been regreased at the service in May 2007.

2.5.2 Trackside condition monitoring

Reactive and predictive condition monitoring are akin to reactive and preventative maintenance. A reactive approach applies action after a serious condition develops or equipment failure occurs, whereas a predictive/preventative approach applies action before a serious condition develops. In the case of rolling stock condition, the predictive/preventative approach is likely to be a more cost-effective approach, considering the consequences of rolling stock failure and its potential impact on infrastructure condition and operations.

Hot-box detectors

Hot-box detectors are a reactive method of condition monitoring. They usually detect the infrared signature of bearing components and alarm if the temperature exceeds a predetermined setting. However, there are a number of variables that can affect their performance on a mixed freight/passenger rail corridor. It is possible for bearing components, which may be in imminent risk of failure, to pass undetected under some conditions. These variables include but are not limited to:

- train loading
- train speed
- weather conditions.
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 reactive method of condition monitoring using hot-box detection has not been adopted on the DIRN for freight/passenger rail operations. However, considering the potentially unreliable performance of hot-box detectors under these conditions, it is evident that more effort has been directed towards predictive condition monitoring of railway rolling stock travelling on the DIRN.

**Bearing acoustic monitoring (RailBAM®)**

RailBAM® is a predictive condition monitoring system that senses the acoustic signature of various bearing faults as they develop. It is the primary method for detecting potential bearing faults on rolling stock travelling on the DIRN. Recorded data from each train is stored in a database allowing evaluation, trending and maintenance of rolling stock based on predicted bearing condition.

RailBAM® uses sensitive acoustic arrays to record the sounds emanating from wheels and bearings passing through the monitoring site. The recordings are processed for the sound characteristics that are unique to specific types of bearing faults. RailBAM® is best at detecting faults on rolling surfaces such as the inner and outer raceways, and rollers in spherical bearings (axle-box bearings). RailBAM® will also detect looseness or fretting faults and ‘noisy’ wheels (flanging and wheel flats).

The processed data is stored in a database and available to rail operators through a web interface. The RailBAM® database categorises bearing faults in the form of alarm levels (1, 2, and 3 with level 1 being the most critical). The database allows operators to analyse bearing fault history and trends in order to plan their preventative maintenance strategies.

As for any monitoring system, there are some limitations. For example, RailBAM® is a system that ‘listens’ for bearing noises, and under some conditions, other noises (rubbing equipment, tread defects or flanging wheels) may affect the results. However, being a predictive condition monitoring system, multiple passes of potentially defective bearings allows true alarm trends to be clearly identified and actioned before a defect reaches a critical level.

It would appear that predictive condition monitoring and a pro-active approach by train operators has been successful in reducing the number of faulty bearings operating on the DIRN between Adelaide and Perth. RailBAM® showed the percentage of bearing passes indicating level 1 rolling surface faults reducing from 0.42% in 2002 to 0.02% in 2008.

In the 12 months before the derailment, wagon VQCY 0824U travelled through the ARTC RailBAM® site at Nectar Brook 26 times with only four passes recording fault alarms (Figure 10). The alarms were not recorded on successive passes, nor were the alarms consistent in type, severity or location (axle number/bearing). With no apparent alarm trend, those records were more likely the result of noises other than bearing faults.

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11 This refers to maintenance action, in addition to scheduled maintenance, which removes a potential bearing fault from service before the complete failure of the bearing.
Similarly, no recorded bearing fault was detected when train 1MP9 passed through Nectar Brook about 9 hours (580 km) before the derailment. The lack of any detectable bearing fault at this point in time provides further support to the theory that failure of the bearing on wagon VQCY 0824U occurred suddenly (see 2.4.12.4.1 Summary of bearing failure) and was unlikely to have failed due to the progressive development of a running surface, looseness or fretting fault. Consequently, it is unlikely that the imminent failure of the bearing would have been detected by the bearing acoustic monitoring system.

Figure 10: Previous 12 months RailBAM® data for wagon VQCY 0824U

Wheel impact and load detection (WILD)

The wheel impact and load detection (WILD) system is a predictive condition monitoring system that measures impacts and mass of passing wheel-sets. It is the primary method for detecting wheel flats on rolling stock travelling on the DIRN. While wheel flats are undesirable due to the potential damage they can cause to the track, they also place undesirable forces on rolling stock components, including axle bearings. The data is stored in a database and available to rail operators through a web interface. There were no records of excessive wheel impact for wagon VQCY 0824U between July 2004 and September 2008.

Data from the ARTC WILD system at Port Germein, South Australia was also used to examine the loading of wagon VQCY 0824U between July 2004 (new bearings) and September 2008 (derailment due to bearing failure). As discussed previously, applied load is a key factor influencing bearing fatigue life (Refer to section 2.4 Bearing failure). The WILD system showed 88 passes in each direction with an average load of 60.4 t towards Perth and 42.5 t towards Adelaide. Only two passes showed a load that was within 5% of the wagon’s maximum load capacity (80 t gross).

It is unlikely that the WILD system data could have been used to predict the imminent failure of a bearing on wagon VQCY 0824U.

2.5.3 In-service inspections

In-service inspections consist of train examinations and roll-by inspections. In both cases, inspections are conducted by qualified workers and involve examination for
defects or issues that may affect the train’s ability to safely operate over the rail corridor.

**Train examination**

A train examination involves an inspection of the train, while stationary, by qualified workers before commencement of its journey. In general, the inspection looks for issues related to the train brake system, couplers, bogies, wheels, bearings, load security and any other associated equipment essential for the safe operation of the train.

With respect to bearings and axle-boxes, SCT requires train examinations to be completed in accordance with their instruction number SF2.2, *Inspection of Bearings and Adapters*. As previously explained (Section 2.5.1 Inspection and maintenance), the time based interval for regreasing is indicated by a system of colour coding. In this case, the bearings were new in 2004 and the axle-boxes were marked with pink paint. If regreasing had occurred before the end of 2006 as required, the axle-boxes should have been re-painted white.

It is evident that the train inspections on wagon VQCY 0824U, from 2006 onwards, did not identify that the axle-boxes required regreasing.

**‘Departure point’ roll-by inspection**

A departure point roll-by inspection involves observation of a train by a qualified worker as the train departs its originating location. The intent is to help verify that a train and its load are acceptable for travel over the intended route.

In this case, evidence suggests that the failure sequence (cage failure, misalignment and jamming of the rolling surfaces, seizure and subsequent separation of the bearing journal from the axle) occurred relatively quickly. Consequently, it is unlikely that the imminent failure of the bearing would have been detectable during the departure point roll-by inspection. The last departure point roll-by occurred in Adelaide and indications of imminent bearing failure were not detected at that time.

**‘In-operation’ roll-by inspection**

An in-operation roll-by inspection involves observation of a train by the crew of other trains during cross or passing movements. Again, the intent is to help verify that a train and its load are acceptable for continued travel over the intended route. While train crews look for any irregularity, the main consideration is to ensure the train is complete by observing the end-of-train marker (red light mounted on the rear coupler of the last vehicle in the train consist). That is, no wagon has decoupled from the train and been left behind and unattended.

In this case, without the appropriate conditions during cross or passing movements (audible or visible), it is unlikely that the imminent failure of the bearing would have been detectable during the occasional in-operation roll-by inspections. The last in-operation roll-by occurred at Tarcoola (about 2 hours and 134 km before the derailment) and indications of imminent bearing failure were not detected at that time. At Mt Christie, the drivers of train 1PM5 noted that train 1MP9 was complete, but did not notice any other irregularity such as a screwed journal.
2.5.4 On-board condition monitoring

In the past, condition monitoring of freight rolling stock has been the realm of trackside equipment (Hot box, RailBAM, WILD etc.). However, trackside monitoring equipment is usually fixed at a specific geographical location. While predictive systems may provide a broader level of protection, reactive systems are limited to protection of equipment and infrastructure in the immediate vicinity.

The ideal system would be one that continuously monitored each wagon and immediately communicated any alarm conditions to the train drivers. This type of system is referred to as an on-board condition monitoring system. While various limitations (functional and economic) have prevented these systems being widely used on railway freight operations in the past, recent technological developments have now made the concept more attractive.

2.5.5 Summary of bearing failure management

The SCT instruction for Inspection of Bearings and Adapters (numbered SF2.2 and dated October 2002) states that regreasing should be carried out every time a wagon receives scheduled servicing or at a specified time-based interval (whichever is sooner). Maintenance records show that the bearings on wagon VQCY 0824U were new in July 2004 and the wagon underwent servicing in May 2006 and May 2007. However, it is likely that the axle-boxes on wagon VQCY 0824U had not been regreased during servicing as required by SCT’s maintenance procedures.

The primary form of trackside condition monitoring for identifying potential bearing faults on rolling stock travelling on the DIRN is RailBAM®, a predictive system that senses the acoustic signature of various bearing faults as they develop. In this case, the failure mode was not a result of progressive development of running surface, looseness or fretting faults (faults that RailBAM® would probably predict). Consequently, it is unlikely that the imminent failure of the bearing would have been detected by the bearing acoustic monitoring system. Similarly, roll-by inspections (a reactive form of fault detection) were unlikely to detect imminent failure of the bearing due to the relatively quick nature of the failure sequence in this case and the relatively narrow window of opportunity to detect such failures.

2.6 Broken rail

The intended crossing movement at Mt Christie was to be relatively straight forward with westbound train 1MP9 directed by train control to take the crossing loop and eastbound train 1PM5 to take the main line. Train 1MP9 was the first to reach Mt Christie and, after operating the points, moved onto the crossing track. However, it was evident that the bearing had already failed and separated from the axle journal by this time, thereby causing bogie components to drag along the track. The dragging components caused a section of rail (about 9 m long - Figure 5) to break as the train passed over the east-end points. The broken rail resulted in a condition (consistent with the track circuit being occupied) that prevented the points from automatically resetting after train 1MP9 had fully cleared the east-end points.

As per the specified procedure, train 1PM5 had moved onto the main line and stopped before the east-end points. The second driver had alighted from the locomotive, walked past the broken rail to the control cabinet, manually controlled the points when the push-buttons did not work, walked back past the broken rail and...
re-boarded the locomotive in readiness for departure. At no point during these actions did either driver notice the section of broken rail.

At the time, it was about 3 hours after sunset and only 1 day after the new moon, so the level of ambient light was negligible. When walking to and from the control cabinet, the driver would have walked on ground adjacent the track rather than on the track itself. Consequently, it is not surprising that the driver did not see the broken rail. The driver of train 1PM5 only noticed the broken rail, stopped the train and reported the issue to the ARTC train controller when he switched on the high beam headlight and had just started to throttle up for departure.

The points control system at Mt Christie operated as designed and provided an indication to the driver of train 1PM5 that something was not working as expected at the east-end points. That is, instead of a green indication, a steady yellow light was displayed indicating that the points were not normal and locked. Had the driver not noticed the broken rail and train 1PM5 attempted to depart Mt Christie as normal it would also have derailed, albeit at a relatively low speed.

Even though there was a system in place to manage the fault at the east-end points, the only action that avoided a derailment was the driver’s vigilance. However, there were a number of conditions or actions whereby the broken rail may have been discovered before the driver of train 1PM5 was about to throttle up for departure.

The first indication of a problem with the east-end points was the points light indicator (western end of the crossing loop) displaying a steady yellow light. This was followed by the illumination of the track occupied LED and the inability to operate the points using the push buttons in the east-end control cabinet. The drivers’ interpretation of these two conditions was that the points control circuit had failed, subsequently requiring the points to be manually operated. At no time did they consider that failure of the points to operate electrically may have been due to a condition that may have affected the safe operation of the train. Consequently, the driver who had alighted from the locomotive to operate the points was not looking for any track related problem and twice walked past the section of broken rail without seeing it. It should also be noted that based on most drivers experience, the probability of the cause being a broken rail due to a prior derailment would have been negligible.

Both PN and SCT advised that training of train crews in the operation of points at crossing loops is conducted with reference to an ARTC document titled Operating Protocols for In Cab Activated Points System (ICAPS) at crossing locations between Tent Hill and Parkeston (dated 8 October 2006). However, this document is an amendment to section 6.9 of the ARTC Addendum to the Code of Practice for the Defined Interstate Rail Network. It is possible that training in the operating protocols for crossing locations between Tent Hill and Parkeston may have been conducted without reference to the parent document, the ARTC Addendum to the Code of Practice. More specifically, reference to section 15 Light Indicator or Associated Points Failure which provides instructions in the event that the points fail to operate.

The instructions state that when a points failure occurs, the train controller will authorise each subsequent train through the location and a speed restriction will

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12 Note also that the driver referred to the track occupied LED as the ‘Service Light’. This is a reference to a system which had been removed from service almost 10 years earlier.
apply, 70 km/h if the points have been clamped and 20 km/h if the points have not been clamped. However, the instructions are slightly ambiguous as to whether the instructions are relevant to trailing points as well as facing points. Similarly, an application of a speed limit implies proceeding with caution but is not specifically stated.

The broken rail and subsequent points failure were not integral to the derailment sequence of train 1MP9. Therefore, the possibility of inadequate training with respect to points failure was not a contributing factor in this case (noting also that the sequence of events itself, in the context of the broken rail, was very unusual). However, it should be noted that consolidation of documentation (amendments and addendums) and the removal of any ambiguity may assist organisations with the provision of appropriate training and reduce the risk that inadequate training may contribute to other incidents in the future.
3 FINDINGS

3.1 Context
At approximately 2130 on 1 September 2008, 13 wagons on freight train 1MP9 derailed near Mt Christie, South Australia. There were no injuries.

From the evidence available, the following findings are made with respect to the derailment of train 1MP9 and should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors
• An axle bearing on wagon VQCY 0824U failed and completely seized, causing the bearing journal to separate from the axle (commonly referred to as a screwed journal).
• It is likely that the bearing seized due to cage failure, the subsequent misalignment of the rollers and jamming of broken cage material in the rolling surfaces.
• It is likely that the cage failed due to excessive wear caused by inadequate lubrication.
• It is likely that the axle-boxes on wagon VQCY 0824U had not been regreased at the maintenance service in May 2006 or May 2007, as required by SCT’s maintenance procedures.
• Inspections on wagon VQCY 0824U, both in-service and at scheduled maintenance, did not identify that the colour coded axle-box housings required regreasing. This indicates that the operator’s system for inspection and maintenance of wheel bearings was not sufficiently robust to adequately manage the risks. [Significant Safety issue]

3.3 Other safety factors
• The drivers of train 1PM5 did not notice a section of broken rail (about 9 m long) until they were about to throttle up for departure from the Mt Christie crossing loop.
• The rules and instruction with respect to crossing loop operation, including equipment failure, were distributed over a number of documents and slightly ambiguous. Without any consolidation or cross-referencing, it is possible that training of operational staff could be inefficient or at worst, incomplete. [Minor Safety issue]

3.4 Other key findings
• No other axle-boxes from SCT’s fleet were found to have expired colour codes that would indicate any further lapses in maintenance procedures. It appeared as though the failure to regrease the axle-box on wagon VQCY 0824U was an isolated case.
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.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

4.1 SCT Logistics (SCT)

4.1.1 Inspections did not identify that regreasing was required

Safety issue

Inspections on wagon VQCY 0824U, both in-service and at scheduled maintenance, did not identify that the colour coded axle-box housings required regreasing. This indicates that the operator’s system for inspection and maintenance of wheel bearings was not sufficiently robust to adequately manage the risks.

Action taken by SCT

Following the derailment of train 1MP9, SCT immediately scheduled their entire fleet of axle-box configured rolling stock to be regreased. During this process, no other axle-boxes were found to have expired colour codes that would indicate any further lapses in maintenance procedures. It appeared as though the failure to regrease the axle-box on wagon VQCY 0824U was an isolated case.

In addition, SCT has accelerated its schedule to replace the 50 tonne bogies with 70 tonne bogies. Under this process, all SCT freight wagons fitted with 50 tonne bogies and axle-box bearings were removed from service. The wagons were fitted with 70 tonne bogies and packaged bearings before being returned to service. The packaged bearings, being a sealed unit, do not require in-service regreasing thereby removing the risk of inadequate lubrication due to inadequate maintenance practices.

SCT has also invested in a trial to install on-board monitoring for hot bearings on their freight rolling stock. The initial trial (scheduled for 2010) involves installation of communication equipment on their locomotives and monitoring equipment on 10 wagons. If successful, the intent is to expand the system to cover more of SCT’s rolling stock and is likely to significantly reduce SCT’s risk of derailment due to bearing failure.
**ATSB assessment of response/action**

The ATSB is satisfied that the action taken by SCT, in particular the preventative actions to replace axle-box bearings with packaged bearings not requiring in-service regreasing and the trial of an on-board monitoring system, will adequately address the safety issue.

### 4.2 Australian Rail Track Corporation (ARTC)

It is recognised that the following safety issue is relevant to train operation rather than to infrastructure management. However, since train operators are required to refer to ARTC documentation with respect to the operation of points at crossing loops, the following safety issue was brought to the attention of ARTC for consideration.

#### 4.2.1 Track condition affecting both safety and point operation

**Safety Issue**

The rules and instruction with respect to crossing loop equipment failure were distributed over a number of documents and slightly ambiguous. Without any consolidation or cross-referencing, it is possible that training of operational staff could be inefficient or at worst, incomplete.

**Response from the ARTC**

The ARTC agreed that there is a need to consolidate all instructions relating to the Self Restoring Points System and ICAPS control system into one document and add clarification regarding the requirements for both facing and trailing movements over points when in failure mode.

**ATSB assessment of response/action**

The ATSB is satisfied that the intended action by the ARTC will adequately address the safety issue, assuming ARTC also communicates with all relevant operators to advise that changes have been made to the documentation.
APPENDIX A : SOURCES AND SUBMISSIONS

Sources of Information

Australian Rail Track Corporation
Pacific National
SCT Logistics

References

ARTC Track and Civil Code of Practice, April 2007
AS7516.2 – Railway Rolling Stock – Axle Bearings – Freight.
SCT instruction SF2.2 - Inspection of Bearings and Adapters (October 2002)

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:

• Australian Rail Track Corporation
• SCT Logistics
• South Australian Railway Safety Regulator

Submissions were received from the Australian Rail Track Corporation and SCT Logistics. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.
Derailment of train 1MP9
Mt Christie, South Australia

1 September 2008