



Australian Government
Australian Transport Safety Bureau

Derailment of bogie on freight train 4PM6

Port Augusta, South Australia | 6 May 2011



Investigation

ATSB Transport Safety Report
Rail Occurrence Investigation
RO-2011-008
Final



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ATSB TRANSPORT SAFETY REPORT

Rail Investigation
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**Derailment of a bogie on freight train
4PM6 at Port Augusta, South Australia
on 6 May 2011**

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SAFETY SUMMARY

What happened

On 6 May 2011, the trailing bogie on the 47th wagon of freight train 4PM6 derailed after traversing the Carlton Parade level crossing at Port Augusta, South Australia. The wagon travelled over a second level crossing and re-railed itself when it entered a third level crossing about 1,300 m later.

The train continued towards Adelaide before it was stopped at Winninowie after the network controller had been alerted that the train was emitting sparks and that the half-boom barriers remained down and that warning devices continued to operate at the two level crossings.

What the ATSB found

The ATSB's investigation found a number of factors affecting the passage of train 4PM6 due to the degradation of the track geometry in a short section of line after the Carlton Parade level crossing. Multiple track defects requiring urgent and priority attention in this short section had been detected by a track geometry car inspection 3 months before the derailment and there was a 30 km/h temporary speed restriction (TSR) in force at the time. However, the defects had not been adequately assessed and controlled in accordance with the Australian Rail Track Corporation (ARTC) Track and Civil Code of Practice and the 30 km/h TSR was probably inadequate to minimise the risk of derailment.

The investigation also found that track geometry defect exceedence reports did not contain fields to record the date and time as confirmation that field inspections had been carried out in accordance with the Code of Practice.

What has been done as a result

The ARTC through its Alliance Partner Transfield Services has undertaken additional training in the ARTC Track and Civil Code of Practice. This includes the responses required when multiple localised geometric defects are found.

The ARTC is also developing an improved reporting format for data from the track geometry car measurements for use in all states following the introduction of the new National Code of Practice - Track Standards.

Safety message

Multiple geometric track defects that are located in close proximity to each other significantly increase the derailment risk to rail traffic. The track condition should be thoroughly assessed and managed to ensure that appropriate speed restrictions are imposed until the track can be reinstated to design standards.

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Acknowledgements

Figure 1 Map section of South Australia - NATMAP Railways of Australia

Figure 8 Cross section rail profile drawing – Australian Rail Track Corporation/Transfield Services

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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 appropriate, or to raise general awareness of important safety information in the industry. 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.

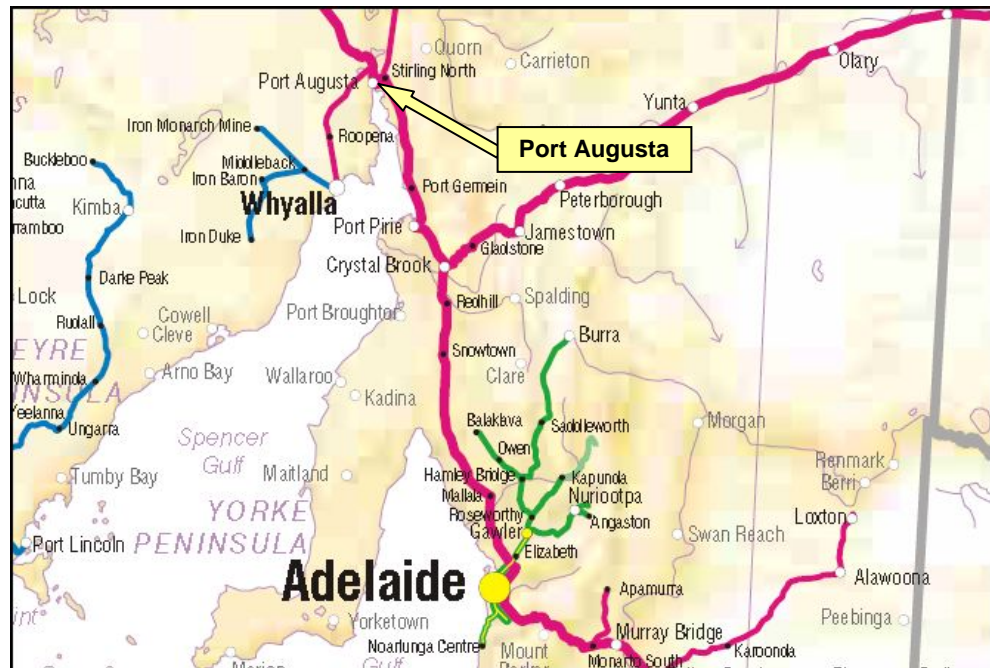
1 FACTUAL INFORMATION

1.1 Location

The derailment of a bogie on train 4PM6 occurred on the Defined Interstate Rail Network (DIRN) in the city of Port Augusta (Figure 1) about 10 m south of the Carlton Parade level crossing and about 312 rail kilometres north of Adelaide.

The point of derailment (POD) was near the 91.559 km point¹ on the Port Augusta to Adelaide track section. At the time of the occurrence, the track was managed by the Australian Rail Track Corporation (ARTC) and maintained through an alliance agreement with Transfield Services.

Figure 1: Map showing location of Port Augusta, South Australia



© NATMAP Railways of Australia

1.2 Track structure

The single line track at the derailment site is within a 375 m radius curve. The track is constructed on a 250 mm bed of ballast that supports concrete sleepers nominally spaced at 667 mm centres. Continuously welded rail of 47 kg/m and 53 kg/m sections were fastened to the sleepers using resilient clips. A temporary speed restriction (TSR) of 30 km/h had been applied to train operations from the northern boundary of Carlton Parade and then east for a distance of about 50 m. The normal maximum speed of trains through the derailment location is set at 60 km/h. In preparation for rail replacement works, multiple loose lengths of welded rail were placed between the running rails, commencing about 15 m south of the Carlton Parade level crossing.

¹ Rail distance measured from the track kilometre zero point located at Coonamia, near Port Pirie South Australia.

1.3 Freight train 4PM6

Train 4PM6 was an intermodal freight service owned and operated by Pacific National. It consisted of two locomotives (NR116 leading and NR58 trailing) and 52 wagons (eight of which were multiple platform vehicles²) transporting containerised freight. The train was about 1737 m long with a total mass of about 4051 t. For the journey between Port Augusta and Adelaide, the train was under the control of a single driver.

1.4 Wagon RQHY 07069C

The RQHY class container wagon is of skeletal construction and 78 were manufactured in China between 2005 and 2006. Overall length is 19.4 m, with a gross mass of 92 t and a total load capacity specified at 72.3 t. At the time of the occurrence, the wagon was carrying three containers in a double stack configuration, two locked on the wagon deck with one container mounted on the top at the leading end in the direction of travel (Figure 2). Wagon RQHY 07069C was not transporting dangerous goods.

Figure 2: Loaded freight wagon RQHY 07069C following the derailment

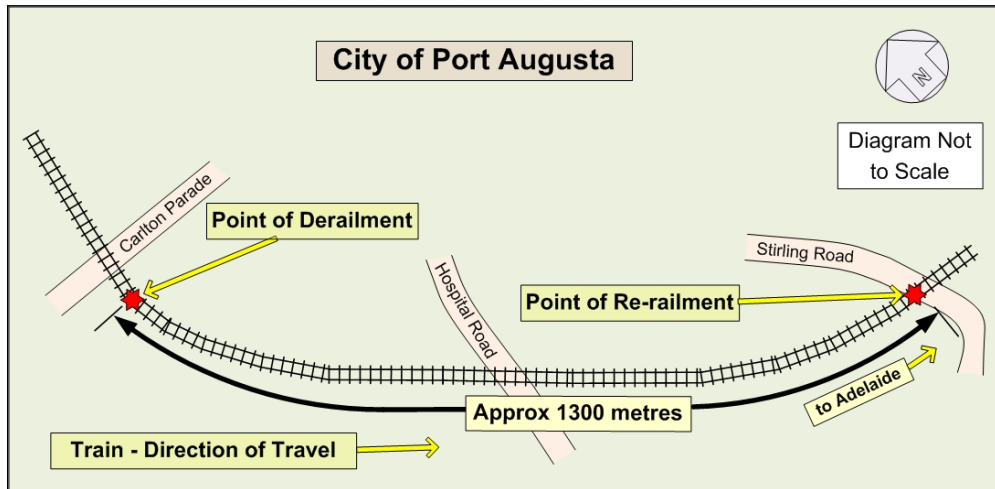


1.5 The occurrence

Train 4PM6 originated from the Forrestfield Freight Terminal in Perth, Western Australia. Its destination was Melbourne, Victoria. The train departed Forrestfield on Wednesday 4 May 2011 arriving at Spencer Junction, near Port Augusta at 1310 on 6 May. At 2006:00, almost 7 hours after arrival, train 4PM6 departed Spencer Junction and proceeded onto the main line bound for the Adelaide Freight Terminal. About 7 minutes and 1.6 km after departing Spencer Junction, lead locomotive NR116 entered the Carlton Parade level crossing near the beginning of the 30 km/h TSR and continued towards Adelaide (Figure 3).

² Multiple platform vehicles on train 4PM6 were 5 pack (an articulated wagon comprising five platforms with common bogies between platforms) and 5 unit wagons, (a wagon consisting of five permanently coupled platforms, each platform independently supported on a pair of bogies).

Figure 3: Diagram showing point of derailment and re-rail of wagon RQHY 07069C on train 4PM6.



At about 2016, the 47th wagon (RQHY 07069C) derailed the trailing bogie shortly after travelling over the level crossing.

At about 2030, a member of the South Australia Police and the Genesee and Wyoming Coordinator separately contacted the ARTC train control to advise that sparks had been reported coming from wagons located near the rear of a train that was travelling through Port Augusta. The network controller contacted the driver of train 4PM6 instructing him to stop the train. As the train was near the Winninowie passing loop (about 18 km from what was later determined as the POD), the network controller told the driver to stop on the main line and to wait for a person to examine the consist.

Soon after the South Australia Police again contacted the ARTC to advise that the level crossing installations at Stirling Road and Hospital Road were ringing continuously and that the track appeared to be out of alignment. At 2109, the Port Augusta Terminal Operator confirmed with the network controller that track components and signalling circuits had been damaged by a derailed wagon between the Carlton Parade and Stirling Road level crossings.

A subsequent track inspection by maintenance workers confirmed that a train had derailed one bogie near the 91.559 km mark, commencing about 10 m south of the Carlton Parade level crossing. The wagon had remained in a derailed state travelling over the Hospital Road level crossing before re-railing itself near the Stirling Road level crossing about 1300 m later.

1.6 Post occurrence

At 2115 the driver of train 4PM6 contacted the network controller and reported that following an examination of the train, damage was visible on wagon RQHY 07069C the 47th in the consist. The driver reported that the wheels and outer bearing surfaces on the left-hand side of the trailing bogie had sustained damage from impact with the ballast, sleepers and other track components.

2

ANALYSIS

2.1 Evidence

Two investigators from the Australian Transport Safety Bureau (ATSB) attended the site of the derailment on Saturday 7 May 2011. Investigators examined and photographed the track through the derailment site and an inspection was made of wagon RQHY 07069C that included wheel-sets, bearings, bogies and running gear. Initial observations indicated that one wheel set derailed soon after traversing the Carlton Parade level crossing where the track exhibited a depression on the right side of the track in the direction of travel. (Figure 4).

Evidence was sourced from various rail organisations including the Australian Rail Track Corporation (ARTC), Pacific National and Transfield Services. A survey was also carried out to determine track twist over 2 m and 14 m and deflections in surveyed track level.

Figure 4: Track within the temporary speed restriction near the Carlton Parade level crossing.



2.2 Sequence of events analysis

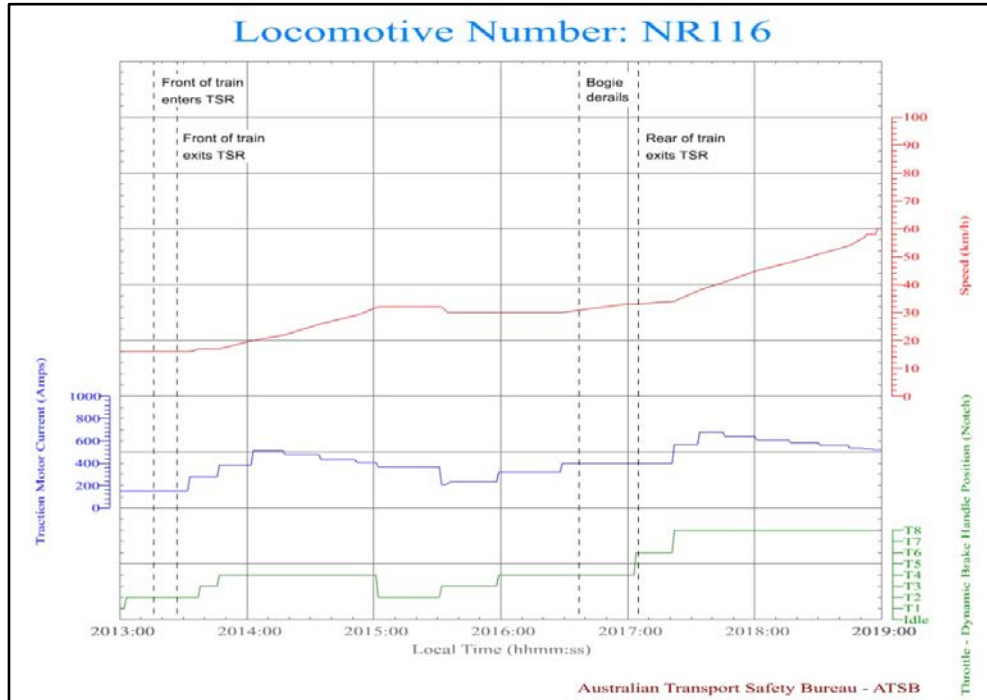
At 2006:00 train 4PM6 departed Spencer Junction and about 7 minutes later the lead locomotive (NR116) entered the TSR (91.550 km) just north of the Carlton Parade level crossing. An examination of event recorder information extracted from locomotive NR116 showed that the front of the train entered the Carlton Parade level crossing (near the point of derailment (POD) at 16 km/h³ with the throttle set at notch position T2. The train accelerated and at 20:16:37, wagon RQHY 07069C

³ The locomotive event recorder indirectly records speed and distance information. Pulses received from the locomotive axle transducer are accumulated and recorded by the event recorder with up to 30 seconds between recordings. Average speed and distance is calculated from the number of pulses and is displayed by the replay software.

derailed. At this time the locomotive throttle was in notch T4 and the train speed had increased to an average speed of 33 km/h.

At 20:17:05, with the throttle set at notch T6, the train continued to accelerate with the rear of the train passing the 30 km/h TSR end board (91.500 km) at an average speed of 34 km/h, 4 km/h above the posted TSR. (Figure 5)

Figure 5: Locomotive NR 116 throttle position and speed through TSR



Analysis of information from the event recorder found two packets⁴ of data were written at intervals of 18 seconds and 29 seconds leading up to and during the time of the derailment. The data packet recorded approximately 8 seconds before the derailment showed the train was travelling at an average speed of 30 km/h (during that 18 second period). The next data packet was recorded 29 seconds later, (approximately 21 seconds after the derailment), and showed the train's average speed during that period was 33km/h.

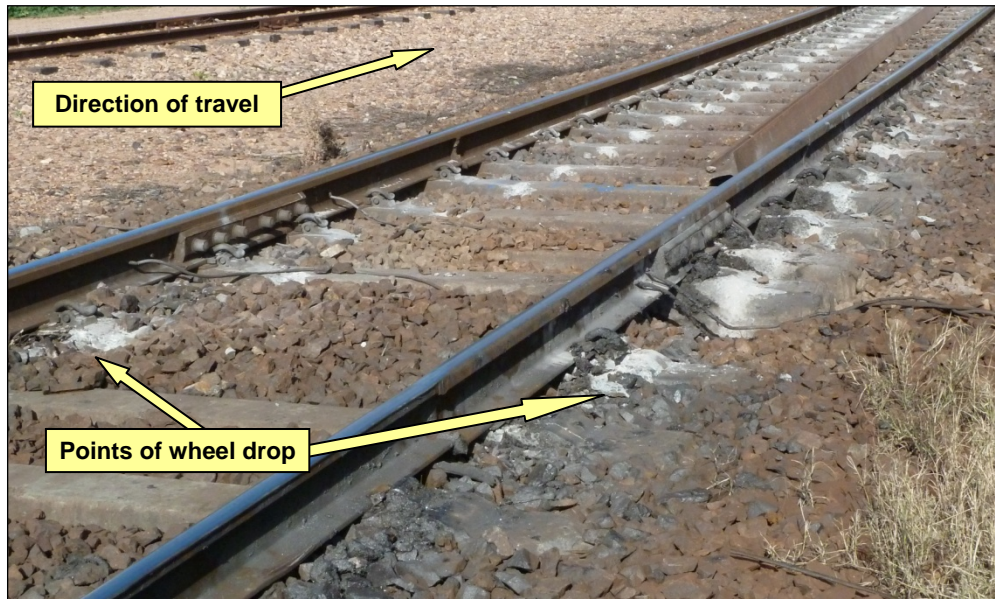
The event recorder does not record speed directly; rather, it records the number of axle rotational pulses between data packets and writes the number of such pulses when each data packet is recorded. The pulse count, when combined with the wheel diameter, provides an average speed across the period between data packet recordings.

As such, an accurate speed of train 4PM6 at the time of derailment could not be determined. While the average train speed is calculated from data pulses, the speed information displayed on the drivers console is a real-time value and may differ from the data stored on the event recorder.

Within the TSR zone near the POD, an examination of the witness marks on parts of the track structure showed that a wagon wheel had lifted up and travelled over the right rail towards the outside of the curve and had dropped onto a sleeper about 250 mm away from that rail (Figure 6).

⁴ Data packet: an encoded block of information, recorded in response to a defined triggering event.

Figure 6: Witness marks on concrete sleepers resulting from contact with RQHY 07069C wagon wheels.

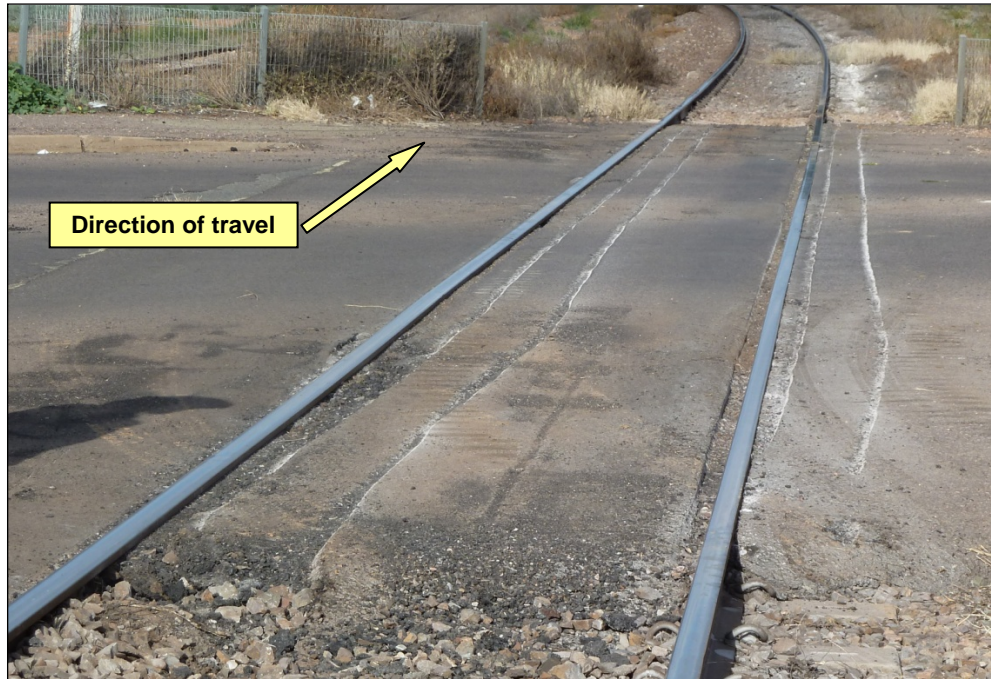


No wheel flange rolling contact marks were visible on the right rail head nor were there any tread marks on the left rail head. It is likely that post derailment witness marks on the rails were erased by other rail traffic following the recommencement of operations before the arrival of investigators the following day.

Near the left rail, witness marks on the sleepers had been made by the corresponding wheel flange of that axle set. Single wheel marks continued between, and to the right, of both rails towards the Hospital Road level crossing. Between the Carlton Parade and the Hospital Road level crossings, the trailing wheels of the trailing bogie had also derailed.

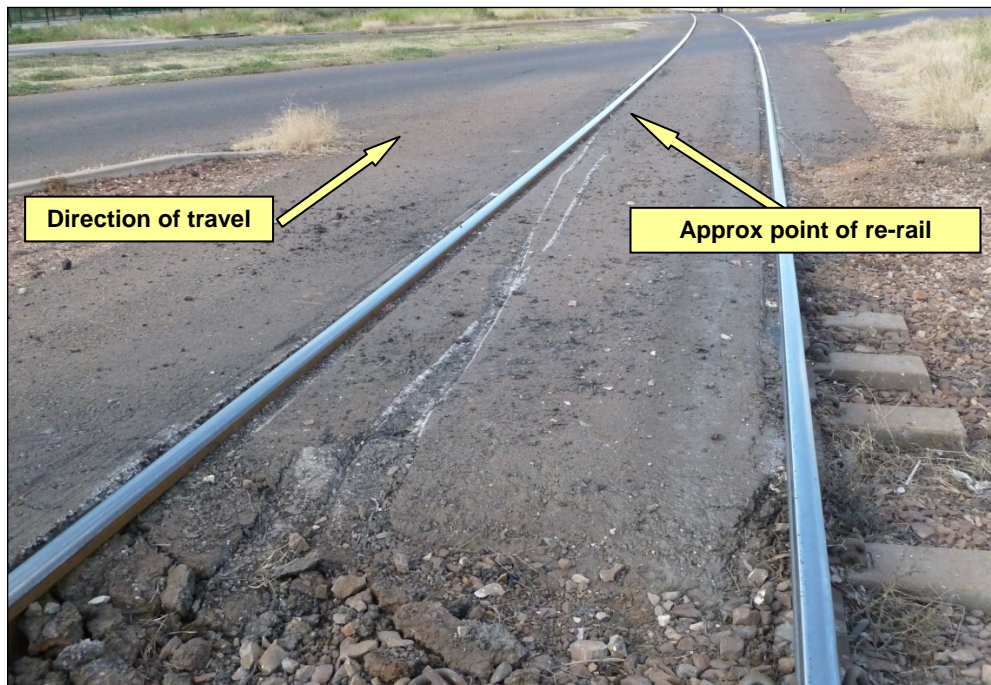
At the Hospital Road level crossing four separate rotating wheel witness marks were observed over the full width of the bitumen road surface that were running near parallel (about 400 mm apart), indicating that the trailing bogie remained skewed to the right. (Figure 7)

Figure 7: Wheel witness marks across the Hospital Road level crossing.



The trailing bogie remained derailed after Hospital Road and continued across the sleepers towards the Stirling Road level crossing. On contact with the raised bitumen road surface leading into Stirling Road, the bogie rotated in an anticlockwise direction and the wheels traversed the road surface progressively re-railing itself (Figure 8).

Figure 8: Wheel witness marks leading into Stirling Road level crossing



Train 4PM6 continued to Winninowie where the network controller directed the driver to stop and inspect the train. An indication to a train driver that the train may have parted or derailed is when there is a rapid loss of brake pipe air and the brakes

are automatically applied. In this instance the train did not separate and the driver was not aware that the train had derailed until the train driver was contacted by the network controller.

Although wagon RQHY 07069C had been derailed for about 1,300 m impacting and fracturing the concrete sleepers, neither the sleepers nor their fasteners were damaged to a stage where the track gauge varied sufficiently to derail the trailing wagons.

Summary

On-site evidence indicated the following as the most likely derailment sequence:

- About 10 m south of the Carlton Parade level crossing, the right-hand wheel on the leading axle of the trailing bogie of wagon RQHY 07069C climbed and travelled over the top of the rail and then dropped to the right side of the track.
- Between Carlton Parade and Hospital Road the trailing wheel-set on the trailing bogie of wagon RQHY 07069C also derailed to the right side of the track.
- At Hospital Road, both wheel sets remained derailed and continued in this state until reaching the Stirling Road level crossing where they re-railed themselves.
- Train 4PM6 continued towards Adelaide in a railed state until the driver was instructed by the network controller to stop at Winninowie for further inspection.
- No other bogies or wagons in the train consist derailed.
- As the train did not separate and the train brakes did not automatically apply, the train driver was not aware that his train had derailed.

2.3 Rolling stock

The trailing bogie on wagon RQHY 07069C was the only one in the train to derail, for that reason it was important to establish whether or not there were any factors specific to the wagon and/or bogie which may contributed to its derailment.

2.3.1 Bogie examination

The bogie which derailed was removed from wagon RQHY 07069 and transported to the Port Augusta maintenance facility where the wheel-sets and their bearings were removed for measurement and a detailed examination.

Wheel profiles, treads and flanges were measured and nominal wear was observed. The wheel tread and flange surfaces showed indentations and notching typical of exposure to ballast strikes and contact with hard or abrasive materials after derailing. On the derailed bogie, flange wear for each wheel was even and there were no indications of binding of the centre bowl that may have affected bogie steering.

Both wheel sets' back to back dimensions were measured and found to be within accepted tolerances. The four package bearing assemblies were systematically dismantled cleaned and examined which revealed normal rolling contact surface dulling on the cups and cones. The right-hand side of the derailed trailing bogie showed light compression witness marks on the inner three coil spring packs. These

marks were clearly visible as the two outer spring packs had been ejected, probably after the wheels had derailed towards the right of the track or after abruptly riding up and over the Hospital Road or Stirling Road level crossings. The five coil spring packs on the left-hand side of the trailing bogie showed no evidence of displacement or bottoming compression contact marks. No abnormalities were found with the bogie, wheels, axles, bearings, suspension or brake components that were considered to have contributed the derailment.

2.3.2 Wagon loading

Wagon RQHY 07069C was the last of three double stacked flat or skeletal wagons to pass over the Carlton Parade level crossing and was coupled to a 5-unit multi platform well wagon.

The distribution of the load on a wagon can have an effect on the way it negotiates/travels over track. The RISSB⁵ Loading of Rail Freight Code of Practice for the longitudinal position of load states that the loading differential between front and rear bogies shall not exceed the value specified for that vehicle. In this case, the three containers loaded on wagon RQHY 07069C were double stacked at the leading end and occupied about two thirds of the wagon platform deck area. The leading end lower container weighed 20.75 t and the upper container weighed 14.64 t. The single container on the trailing end weighed 12.9 t and occupied the remaining one third of the deck area (Figure 2).

The ARTC Wheel Impact and Load Detection (WILD) system is used to identify undesirable rolling stock conditions such as wheel tread flats. Data from the WILD system has been available to operators since 2002 allowing them to actively manage the condition of their rolling stock. The WILD system also provides indicative axle mass as the train passes over the station.

An examination of information extracted from the WILD station located at Parkeston Western Australia showed wagon RQHY 07069C passed through the station at 64 km/h with no wheel impacts recorded. The distribution of the load within each container was unknown however examination of the WILD data showed there were no excessive longitudinal or lateral variances in axle mass.

The data showed that the load over the leading bogie was 2.3 t heavier than that over the trailing bogie. The Pacific National procedure for Loading of Conventional Flat Wagons states *the maximum weight variation over bogies must not exceed 20 t*. In this case the balance of loading on wagon RQHY 07069C complied with Pacific National's procedure and the RISSB Code of Practice.

To ensure high loads maintain lateral stability in transit the loading should be set so that the centre of mass is as close as possible to the centre line of the track. For interstate routes the RISSB Loading of Rail Freight Code of Practice stipulates that, 'the height above rail level of the combined centre of mass of the vehicle and its load shall not exceed 2650 mm'. By comparison, the Pacific National Freight Loading Manual specifies that the centre of mass 'shall not exceed 2489 mm'. The combined centre of mass for wagon RQHY 07069C was calculated to be 2150 mm above rail level.

⁵ Rail Industry Safety and Standards Board

The investigation found that the combined centre of mass was below the specified limits and the distribution of load over the bogies on wagon RQHY 07069C conformed to the RISSB Loading of Rail Freight Code of Practice and Pacific National's Freight Loading Manual.

2.3.3 Rolling stock design performance

Rolling stock standards describe the minimum requirements applicable to the design, construction, operation and maintenance of railway rolling stock. AS 7509.2 Railway Rolling Stock - Dynamic Behaviour - Part 2: Freight Rolling Stock (AS 7509.2) describes the dynamic behaviour requirements for freight rolling stock to minimise the risk of derailment as well as to reduce the likelihood of accelerated degradation of the infrastructure.

Train 4PM6 traversed a section of track that exhibited a combination of conditions, which are relevant to tests documented in the rolling stock standards. The first was a variation in vertical alignment on the left rail and the second was a dip in the right rail that resulted in a track twist. These track deficiencies were located within 20 m of each other.

The dynamic loads of passing rail traffic can affect the geometric alignment of the track. When trains travel over geometrically affected track, rolling stock can be affected by the reactive dynamic behaviour. The reactive effect is usually increased by double stack loading and an increase in the centre of mass.

2.3.4 Static twist tests

Tests are performed to evaluate the capability of rolling stock to accommodate track twist and any unacceptable reductions in wheel loading, particularly at track transition points and on curves.

A wagon's performance in relation to twist is termed as the 'Static Twist Test' and is conducted while the wagon is unloaded and stationary. The test simulates a wagon moving over track where one rail begins to ramp up to a higher level than the other rail, thereby exerting twist through the wagon body. The acceptance criteria is that the maximum wheel unloading shall not exceed 60% at any location and the wagon centre plate shall remain engaged in the bogie bolster centre casting by at least 14 mm.

A static twist test was conducted on the RQHY freight wagon. This test showed that the maximum wheel unloading did not exceed 40%, well within the 60% acceptance criteria. Similarly, bogie engagement measurements remained above the 14 mm acceptance criteria.

2.3.5 Summary of rolling stock

The RQHY class skeletal container wagon was assessed using Australian Standards. When wagon RQHY 07069C was travelling at approximately 33 km/h (its average speed when it derailed it was likely to have behaved in a manner that complied with the requirements documented in AS 7509.2.

The investigation was not able to definitively establish why only the leading wheel set of the trailing bogie derailed. However, when it encountered the series of track geometry defects on the curve just past the Carlton Parade level crossing the twist between the wagon bogies must have been sufficient to unload and disengage the bogie centre plate to an extent sufficient to cause the derailment.

2.4 Track Inspection and assessment

Track inspection and assessment is a critical part of the infrastructure maintenance process aimed at managing the undesirable effects of rail wear and deteriorated track geometry.

Guidelines for the inspection and assessment of the track structure and associated components are documented in the ARTC Track and Civil Code of Practice (CoP). The CoP specifies track geometry defect response category and intervention limits for freight and passenger trains and defines the frequency and methods of assessment.

2.4.1 Rail wear

Cross section profile measurements were taken on both rails to determine the amount of wear at three locations before the point of derailment (91.549 km, 91.554 km and 91.557 km) to determine head loss, vertical wear and gauge face (rail side) wear. Visually the right rail showed a high level of metal loss from the head and gauge face surfaces. (Figure 9)

The CoP (Section 1 - Rail) Table 1.2 - Rail Top Wear Limits note [2] states:

Loss of head area limits are more critical for side wear. Where rails have more than 10 mm of side wear, the loss of head area limit given in Table 1.3 is to be used in the assessment of the rail top wear limit.

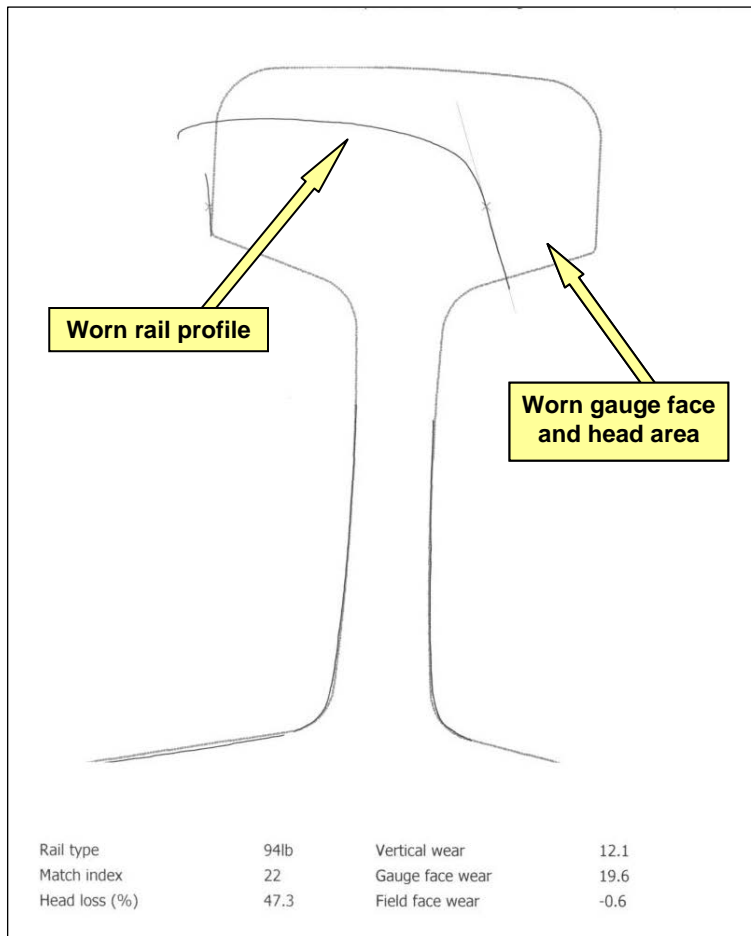
Measurements for side wear are taken 16 mm below the running surface. At the 91.557 km side wear was 19.6 mm when compared with a new rail profile.

Table 1.3 - Side Wear Limits state:

[2] The rail side wear limit is the worst case of either loss of width limit or loss of head area.

[3] The limits apply to the worst location, and not the average rail wear, for the segment of track being considered (such as a curve).

Figure 9: Right rail profile and gauge face wear at 91.557 km



© ARTC/Transfield Services

Table 1.3 of the CoP specifies that for a section of 94 lb/yd rail (47 kg/m) the loss of head area limit should be no more than 34 percent. From the rail profile taken at the 91.557 km it showed the head loss was 47.3 percent. (Figure 9)

The CoP states that:

Where the prescribed wear limits are exceeded a rating of the rail may be carried out taking into account local factors and applied speed restrictions. Alternatively the action should be to re-rail the affected section.

It was acknowledged by track inspection staff that there was extensive wear on the right rail and this was recorded as ‘soft rail’ on track inspection sheets. As the wear was located on a 375 m radius curve these were the primary reasons why TSR’s were applied and regular monitoring of track condition continued at this location. A new section of continuously welded rail had been placed in the centre of track in preparation for future replacement of the worn rail.

The lateral force applied by the passage of rail vehicle wheels to a rail on the outside of a curve has a direct effect on the amount of gauge face wear. As the gauge face angle increases through wear there is a greater likelihood of wheel flange climb and risk of derailment. The CoP prescribes that the gauge face angle is measured from the vertical plane over a distance of 2 m. Through the derailment location between 91.549 km and 91.557 km the gauge face angle on the right rail was measured at 16 degrees, less than the prescribed maximum of 26 degrees.

Although the right rail had a worn profile and an excessive loss of head area, the investigation found that it was unlikely these factors significantly contributed to the derailment of train 4PM6.

2.4.2 Examination of track geometry

The track section immediately north of Carlton Parade and extending to the south of the Stirling Road level crossing consists of a series of curves ranging in radii from 368 m, 375 m (near PoD), 2000 m and 806 m linked by short straight sections. The maximum posted speed through these curves is 60 km/h.

Following the derailment, the ARTC surveyed the track at 1 m intervals for 100 m before and 50 m after the point of derailment. The track geometry was examined and assessed against the ARTC Track and Civil CoP and used as a reference for investigating the effectiveness of the ARTC/Transfield Services monitoring and maintenance program. The survey recorded measurements for gauge, vertical alignment, cant⁶ and twist over chords of 2 m and 14 m. The survey confirmed the general size of the track geometry irregularities between various points through the derailment location were consistent with those recorded by the AK track geometry car⁷ on 4 February 2011.

2.4.3 Assessment and response to defects

Track geometry defects are assessed using a series of defect categories. Actual track measurements are analysed with reference to the defect categories and compared to a table of defect limits and associated response codes. The response codes define the appropriate response required to control any risk to railway operational safety (Table 1).

Table 1: Definition of response categories

Response category	Inspect	Action
E (Emergency)	Prior to next train	Stop trains, carry out repairs, see note [2]
U1 (Urgent Class 1)	within 12 hrs	Reinspect within 48 hrs, See Note [1]
U2 (Urgent Class 2)	within 48 hrs	Reinspect within 7 days, See Note [1]
P1 (Priority Class 1)	within 7 days	Reinspect within 28 days, See Note [1]
P2 (Priority Class 2)	within 14 days	Inspect by exception on regular patrols

Note [1] - Inspect defect within the defined period; and repair the defect or,

- assess the defect and apply an appropriate TSR or,

⁶ The height difference, at a common location, between the running surfaces of both rails.

⁷ A rail vehicle with electronic rail geometry measuring and recording equipment.

- if the defect is found to be spurious, reassign to an appropriate defect category and apply a TSR if required.

If a TSR is applied, reinspect within the defined period, assess rate of deterioration and continue to reinspect defect until repaired.

Note [2]

Combination of faults at U1 or U2 levels - if faults occur within 20 m of each other, apply TSR at appropriate lower speed band and inspect within 24 hrs. Then reinspect every 24 hrs until repaired.

Transfield Services manage the track inspection, assessment and maintenance programs on the section of track where the derailment occurred under an alliance agreement with the ARTC.

The inspection process consists of two complementary inspection types:

- scheduled inspections
- unscheduled inspections.

Scheduled inspections are usually performed by track patrols (at intervals not exceeding 7 calendar days), the AK track geometry car (at intervals not exceeding 4 months) and 'on-train inspections' (at intervals not exceeding 6 months).

Unscheduled inspections usually occur in response to defined events such as extreme weather conditions that are known to increase the risk of geometry defects.

Track inspection and fault records show that on 3 March 2010 a TSR of 50 km/h was imposed for the track between the 91.500 km and the 91.550 km mark due to increased rail wear and wide track gauge. Scheduled track inspections continued to monitor the track condition through the defective region.

During the investigation it was found that datum points used to measure fixed items of infrastructure, track locations and defects varied between the curve and gradient tables, survey plans, AK Car exceedence reports and the position of trackside distance markers. The Transfield Services survey plans probably contained the most accurate track distance measurements. The TSR imposed by Transfield track inspectors that had been marked by 50 km/h TSR signs between the 91.500 km and the 91.550 km did not align with the distances shown on the survey plan.

When acting on an AK Car exceedence reports that specify kilometre distances for track defects, maintenance staff should take into account that the physical location of the defect may be different to that specified on the report. The accuracy in identifying the exact location of defects can be more critical where multiple geometric defects have been identified in close proximity to one another.

The point of derailment (POD)⁸, the defects recorded by track inspectors and the AK Car were contained within the 50 km/h TSR track section. For the purposes of the investigation the track kilometre locations for TSR signs that were replicated on Transfield forms and tables were used as the track kilometre distances in this report.

⁸ The point of derailment was defined as beginning of wheel flange markings and point of impact with track components located about 10 m south of the Carlton Parade level crossing.

Table 2: AK Car defect types and response categories⁹

Track km From	Track km To	Track Defect Type	Defect Max Value	Response Category
91.559	91.569	Gauge ¹⁰	30	U2
91.562	91.566	Surface ¹¹ - Left Rail	42	U1
91.566	91.568	Twist ¹² 2 m chord	19	P1
91.570	91.585	Line - Right Rail	47	U2
91.575	91.577	Twist 14 m chord	-39	P2
91.585	91.586	Twist 2 m chord	15	P2

On 4 February 2011, about three months before the derailment of train 4PM6, an inspection of the track was carried out by the AK Car and six defects were recorded between the 91.559 km – 91.586 km. (Table 2)

The AK Car measures the geometric condition of the track and compares this information against track rated design speed. The two P2 defects reported by the AK track geometry car between the 91.575 km and 91.586 km were within the temporary speed restricted area and were monitored in accordance with the definition of response categories shown in Table 1.

For each defect classified urgent, a defect exceedence report is created by the AK Car. Urgent Class 1 and Urgent Class 2 reports are forwarded to Transfield for inspection within 12 hrs and 48 hrs respectively in accordance with the CoP Response Category (Table 1). A track inspector was assigned to assess the condition of the track for each of these defects. Hand written notes had been made on copies of the AK Car exceedence reports to show maintenance work and materials required to rectify the defects. The AK Car exceedence reports provided to the investigation did not have a field to record time or date information and to show if the assessment had been carried out within 12 or 48 hours of the notification. A track fault summary report showed the geometry defects that were detected by the AK Car on 4 February 2011 (Table 2) were not rectified until 29 February 2012.

In accordance with the ARTC CoP response category, defects categorised U1 or U2 within 20 m of each other are required to apply a ‘TSR at appropriate lower speed band and inspect within 24 hrs. Then reinspect every 24 hrs until repaired’. Table 2 shows that there were combinations of U1, U2 and P1 defects recorded within 20 m

⁹ The geometry defects identified by the AK Car inspection on 4 February 2011 south of the Carlton Parade level crossing and the point of derailment were not closely aligned with distances provided by trackside distance markers or track survey references.

¹⁰ Gauge is measured between points on the gauge (or inside) face of the rails 16 mm below the top.

¹¹ Vertical alignment – left or right rail (also known as top)

¹² The variation in actual track cross level (ie. the difference in level of the two rails) over a length of 2 m or 14 m.

of each other, however none of the responses to these exceedences recommended that the existing TSR of 50 km/h be reviewed or amended.

Transfield Track Inspection and Assessment Reports show that weekly scheduled inspections continued to be carried out between Coonamia and Spencer Junction (3.020 km - 95.300 km). Records provided to the investigation did not show that the combinations of defects were being monitored daily in accordance with the CoP response category notes one and two.

For the period 18-21 March 2011, a total of 35.8 mm of rain was recorded by the Bureau of Meteorology at Port Augusta. With storm water run-off from adjacent roads it is likely that water pooled either side of the bituminised Carlton Parade level crossing with the potential for the track formation to be softened by the regular passage of rail traffic. Rainfall between 22 March 2011 and the day of the derailment was minimal with the maximum of 2.4 mm recorded on 26 March 2011.

On 26 April 2011, (about 2 months after the AK Car inspection) a re-assessment of the rail and track structure between the 91.500 km and the 91.550 km, found that due to continuing deterioration a reduction in the speed for freight and passenger trains was required. At this time a TSR of 30 km/h was imposed, however this speed restriction was probably inadequate to minimise the risk of derailment.

As a result of derailment damage to the track on 6 May 2011, the 30 km/h TSR was reduced to 20 km/h. Maintenance records showed that the geometry defects identified by the AK Car on 4 February 2011 were rectified at and either side of the derailment site on 29 February 2012.

It is probable that routine inspections by track patrols had not taken into account the combination of urgent and priority defects within a 20 m track section between the 91.500 km and the 91.550 km. The application of the 30 km/h TSR that was imposed on the 26 April 2011 was probably inadequate to avoid a train derailment.

When wagon RQHY 07069C derailed at an average speed of 33 km/h, 3 km/h above the 30 km/h TSR, it is unlikely that the exceedence would have contributed to the derailment over the group of track defects near Carlton Parade.

The 20 km/h TSR imposed following the derailment on 6 May 2011 remained in place until the track was reinstated to design standards on 29 February 2012 without further train derailment.

Summary

Programmed visual assessments carried out by track inspectors recorded the deterioration of the right rail immediately south of the Carlton Parade level crossing and applied a 50 km/h TSR on 3 March 2010. When multiple urgent and priority one defects were detected by the AK Car on 4 February 2011 within a 20 m track section at this location, the inspection and assessment regime was not increased in accordance with ARTC Track and Civil Code of Practice. On 26 April 2011, 10 days before the derailment, the TSR was reduced from 50 km/h to 30 km/h to maintain rail operations however this action was insufficient to prevent the derailment.

3.1 Context

On 6 May 2011, the trailing bogie on the 47th wagon of freight train 4PM6 derailed after traversing the Carlton Parade level crossing at Port Augusta, South Australia. The wagon travelled over a second level crossing and re-railed itself when it entered a third level crossing about 1,300 m later. The train continued towards Adelaide before it was stopped at Winninowie after the network controller had been alerted that the train was emitting sparks and the half-boom barriers remained down and warning devices continued to operate at two level crossings.

From the evidence available, the following findings are made with respect to the derailment of a bogie on freight train 4PM6 and should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

- The urgent and priority category defects detected by the AK Car on 4 February 2011 that were located within a 20 m track section were inadequately assessed and controlled in accordance with the ARTC Track and Civil Code of Practice. [*Minor safety issue*]

3.3 Other safety factors

- AK Car defect exceedance reports produced on 4 February 2011 did not include fields to record the date and time of follow-up field inspections and to show that these inspections and assessment of defects were completed in accordance with the ARTC Track and Civil Code of Practice. [*Minor safety issue*]

3.4 Other key findings

- In isolation, the wear on the right rail at the 91.557 km is unlikely to have caused the derailment, however the loss of head area exceeded the limit specified ARTC Track and Civil Code of Practice.
- Track distance measurements in the area of the derailment were not accurately aligned with consistent reference to track kilometre markers, AK Car exceedance reports, curve and gradient tables and track survey alignment plans.
- An examination of freight wagon RQHY 07069C that included twist test data, bogies, wheels and bearings found no defects that would have contributed to the derailment.
- Freight wagon RQHY 07069C derailed while travelling through the 30 km/h temporary speed restriction at an average speed of 33 km/h.

4 SAFETY ACTION

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

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

4.1 The Australian Rail Track Corporation

4.1.1 Multiple geometric alignment defects

Minor safety issue

The urgent and priority category defects detected by the AK Car on 4 February 2011 that were located within a 20 m track section were inadequately assessed and controlled in accordance with the ARTC Track and Civil Code of Practice.

Action taken by the Australian Rail Track Corporation

The Australian Rail Track Corporation through its Alliance Partner Transfield Services has undertaken additional training in the ARTC Track and Civil Code of Practice. This includes the responses required to be applied for multiple geometric defects.

ATSB assessment of action

The ATSB is satisfied that the action taken by the Australian Rail Track Corporation adequately addresses this safety issue.

4.1.2 Exceedence report fields

Minor safety issue

AK Car defect exceedence reports produced on 4 February 2011 did not include fields to record the date and time of follow-up field inspections and to show that these inspections and assessment of defects were completed in accordance with the ARTC Track and Civil Code of Practice.

Action taken by the Australian Rail Track Corporation

The Australian Rail Track Corporation is developing an improved reporting format for data from the AK Car for use in all states following the introduction of the

National Code of Practice Track Standards. The proposed format will be distributed to all Corridor Delivery Managers for comment and acceptance for implementation prior to October 2012.

ATSB assessment of action

The ATSB is satisfied that the action proposed by the Australian Rail Track Corporation should adequately address this safety issue.

APPENDIX B : SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included the:

The Australian Rail Track Corporation

Pacific National Pty Ltd

Transfield Services

References

Pacific National Freight Loading Manual - Centre of Gravity FLM 01-10_06

Pacific National Freight Loading Manual - General FLM 03-10

RISSB Loading of Rail Freight Code of Practice - Loading Distribution - 4.7.2
Longitudinal Position of Load

RISSB Loading of Rail Freight Code of Practice Loading Distribution – 4.7.4 -
Centre of Gravity Height of Wagon & Load

Submissions

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

A draft of this report was provided to Asciano Ltd, the Office of the Rail Safety Regulator, South Australia and the Australian Rail Track Corporation.

Submissions were received from Asciano Ltd and the Australian Rail Track Corporation. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

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Investigation

ATSB Transport Safety Report

Rail Occurrence Investigation

Derailment of bogie on freight train 4PM6 at Port Augusta
South Australia on 6 May 2011

RO-2011-008

Final