



Australian Government
Australian Transport Safety Bureau

Grain train 5422N parting and derailment

Parkville, New South Wales | 6 April 2016



Investigation

ATSB Transport Safety Report
Rail Occurrence Investigation
RO-2016-004
Final – 4 June 2018

Cover Photo: ATSB

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Addendum

Page	Change	Date

Safety summary

What happened

On 6 April 2016, Pacific National (PN) grain train 5422N parted at Parkville on the Main North Line. A fractured yoke on the trailing end of the fifth wagon allowed the yoke pin to fall out and the coupler shank to disengage from the wagon. The coupler shank fell into the four foot of the track and damaged the underbelly discharge doors on 10 wagons as the train progressed over the coupler. Approximately 10 tonnes of barley was released from the wagons as a result. The trailing wheelset on the thirteenth wagon was derailed, then ran in a derailed state for approximately 45 metres causing damage to several track sleepers before the train came to a stop. Regular services were able to continue under caution past the incident site via the adjacent crossing loop. Wagon recovery and track repairs was completed without any further incident.

What the ATSB found

A draftgear component (the yoke), that was not compliant with a PN maintenance standard, was not identified during a maintenance inspection and re-entered service undetected. The yoke was an earlier design and susceptible to fatigue failure. PN had identified the issue and completed a programme to replace this yoke design across their grain wagon fleet however, the yoke on this wagon had been overlooked.

What's been done as a result

PN issued an additional Rolling Stock Notice to their maintenance teams to advise of the incident and to mandate that all yokes in the grain wagon fleet were checked to ensure no yoke of this design remained in service.

Safety message

Maintenance systems must ensure that when a non-compliant component is identified as needing replacement, all such units are located and replaced.

Figure 1: 5422N at Parkville



Source: ATSB

Contents

The occurrence	1
Context	2
Incident location	2
Rail infrastructure information	2
Safeworking system	3
Train information	3
The yoke and draw gear assembly	3
Maintenance systems	4
Site observations	5
Safety analysis	9
Yoke failure	9
Fatigue cracking in yokes	11
Wagon maintenance	11
Train handling	13
Previous incidents	16
Pacific National investigation	16
Findings	17
Contributing factors	17
Other factors that increased risk	17
Safety issues and actions	18
Preventative maintenance systems	18
General details	19
Occurrence details	19
Rail Infrastructure details	19
Train details	19
Sources and submissions	20
Sources of information	20
Submissions	20
Appendices	21
Appendix A – Pacific National Rolling Stock Notice	21
Australian Transport Safety Bureau	23
Purpose of safety investigations	23
Developing safety action	23

The occurrence

At 0230 on 6 April 2016 PN grain train 5422N parted at Parkville (approximately 322.350 km¹) on the Main North Line, Hunter Valley, NSW. The train parted due to a fractured yoke (in the draw gear assembly) on the trailing end of the fifth wagon (NGKF 35898X). The crew of 5422N comprised of a driver and second person.

The fractured yoke allowed the yoke pin to fall out and the coupler shank to disengage from the wagon. The coupler shank fell into the four foot of the track and damaged the underbelly discharge doors on 10 wagons as the train progressed over the coupler. Approximately 10 tonne of barley was released from the wagons as a result.

The trailing wheelset on the thirteenth wagon was derailed when the fallen coupler struck the wagon's fourth axle. The wheelset ran in a derailed state for approximately 45 metres before both parts of the train came to a stop. A number of track sleepers were damaged during the incident.

The driver notified the Network Control Officer Upper Hunter 2 (NCO) that 5422N was stopped approximately 80 m from signal 06-12M. The driver told the NCO, he had experienced a sudden loss of air from the train which led him to believe the train had parted.

The second person conducted a walking inspection of the train and radioed the driver that the train had parted behind the sixth wagon and he could not see the remainder of the train.

The driver advised the NCO that an adjacent train in the Parkville crossing loop was not to move as he could not confirm the location of his detached train. The NCO told the driver of 5422N that he would warn the other train of the incident. The NCO also advised the driver that based on his indicator board, the two portions of the train were between the two yard signals and the line was clear for the other train to come out of the crossing loop.

With that knowledge, the NCO cleared the signal for the other train to depart from Parkville crossing loop. The second person continued his inspection and found the detached portion of 5422N and the flashing tail light marker² on the final wagon, confirming the train was clear of the yard signals.

The driver asked the NCO for confirmation of track protection for 5422N. The NCO confirmed that protection of the train was being provided by the yard signals being blocked³.

The second person secured the detached portion of 5422N by applying the handbrakes on all wagons. The driver secured the locomotives and the front wagons of the train.

At approximately 0400 the NCO informed the driver that a Condition Affecting the Network (CAN) had been issued.

The driver and second person were post incident drug and alcohol tested and ceased duties for the rest of their shift in accordance with PN procedures. Both crew members returned a negative result from the post incident testing.

Site clean up started at approximately 1500. PN arranged for the damaged wagons and the spilled barley to be cleared from the site. PN then shunted the two portions of 5422N and re-railed the derailed wagon.

At 0210 on 7 April 2016 Australian Rail Track Corporation (ARTC) track maintainers were able to commence emergency track repairs and were completed by 0600. In accordance with ARTC procedures, a temporary speed restriction of 40 km/h was placed on the main line through Parkville to allow operations to continue.

¹ Distances are measured from platform 1 at Sydney's Central station.

² A flashing tail light marker is placed on the end of all PN trains to indicate the end of a train consist.

³ The term "blocked" signal indicates the signal has been protected from the signal being changed.

Context

Incident location

Parkville is located between Scone to the south and Murrurundi to the northwest (see Figure 2). Train 5422N was travelling from Werris Creek to Carrington Grain Terminal near Newcastle on the Main North Line. The incident occurred adjacent to the township of Parkville in the Upper Hunter region of NSW.

Figure 2: Incident location map

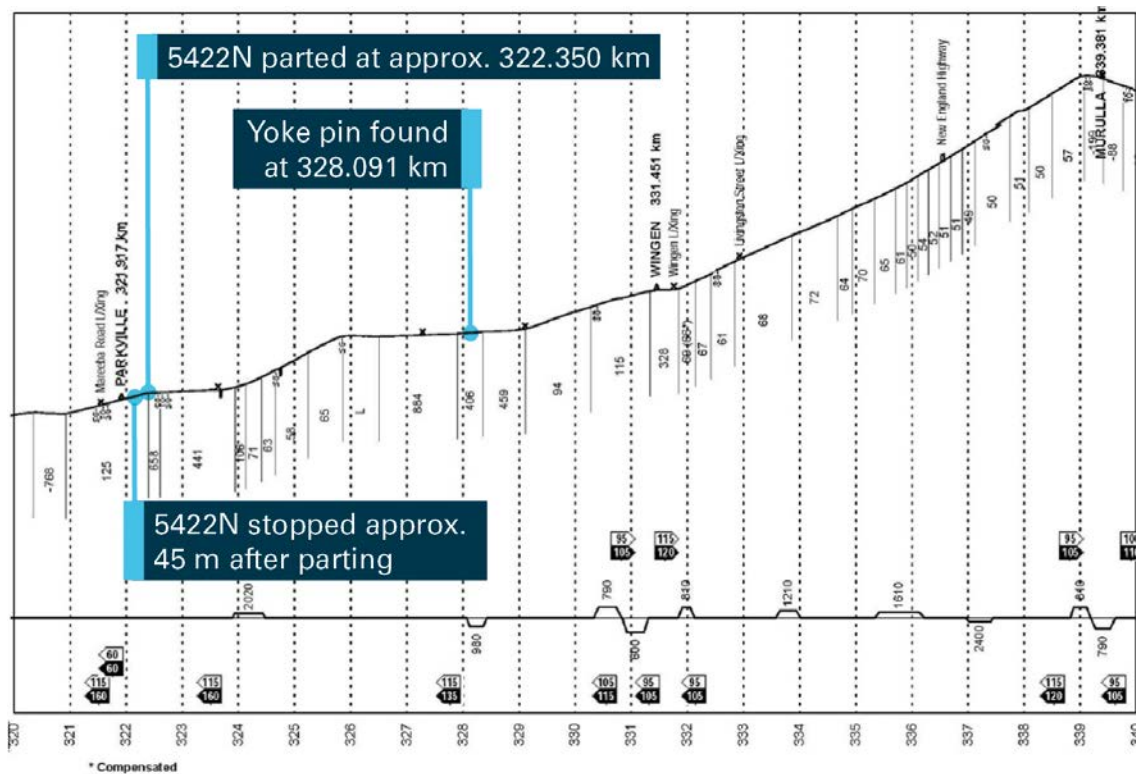


Source: Geoscience Australia, annotated by ATSB

Rail infrastructure information

There are two tracks at Parkville, namely a main line and a crossing loop. A single, bidirectional line connects Parkville and Murulla to the north. The track from Murulla to Parkville is predominantly on a falling grade or downhill (see figure 3). Murulla sits between Murrurundi and Parkville at approximately 339.4 km.

Figure 3: Curve and Gradient diagram of track between Murulla and Parkville



Source: ARTC, annotated by ATSB

Safeworking system

The safeworking system in place was Centralised Traffic Control (CTC). In this system, lineside signals and associated track circuits allow the NCO, from the control centre at Broadmeadow, see the location of any given train operating along the Main North Line.

Train information

5422N was a loaded grain train consisting of 40 wagons and hauled by three locomotives. It was approximately 636 m long with a mass of 3040 tonne excluding the locomotives. It was typical of many grain trains working throughout NSW.

The yoke and draw gear assembly

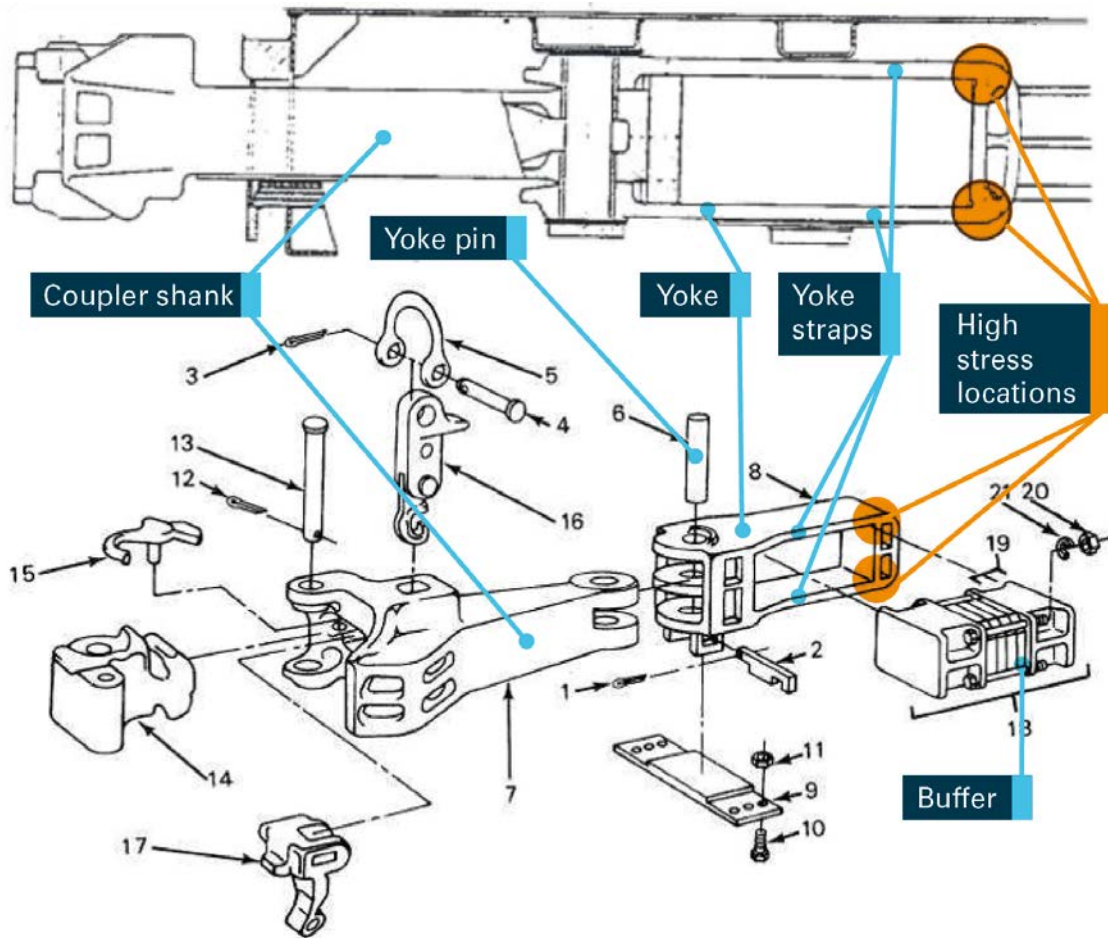
The yoke is an integral component of a wagon's draw gear assembly. While a number of different designs are in service, they are all designed to retard the train's longitudinal draft and buffering⁴ forces. The major components of a draw gear assembly are typically: coupler shank, buffer package, yoke and yoke pin (see Figure 4).

The yoke houses the buffer and is connected to the coupler by a pin or key (in this case a pin). The yoke is a part of the draw gear and transmits draft and buffering forces between wagons. Under compression, the force is transferred between the back-strap of the yoke and the wagon. In operation, the back-strap is subjected to repetitive loads. To mitigate against this effect, later yoke designs (post-1980) have internal rounded smooth radius fillets at high stress locations which are better able to withstand the cyclic stresses that are imposed on these areas. The later yokes are manufactured from a higher tensile steel.

⁴ Draft and buffering forces refer to the tensile and compressive forces between wagons.

The yoke in this incident was a pre-1980 design made from a lower tensile steel and without rounded smooth radius fillets in the high stress locations.

Figure 4: Draw gear assembly - fixed view (above) and exploded view (below)



Source: ATSB

Maintenance systems

PN has maintenance systems in place to manage its total wagon fleet of approximately 15,000⁵ wagons, across several locations in Australia.

PN was aware that the early design yokes (in grain wagons manufactured before 1980) needed to be removed from their fleet and replaced with later design yokes made from higher tensile steel and with internal rounded smooth radius fillets.

As such, specific instructions in PN's Wagon Maintenance Manual (WMM) had been developed to provide instruction to PN's wagon maintainers to identify and change out the early-design yokes as the wagons came in for preventative maintenance.

⁵ This figure includes grain, coal and container wagons. Approximate figure provided by Pacific National.

Site observations

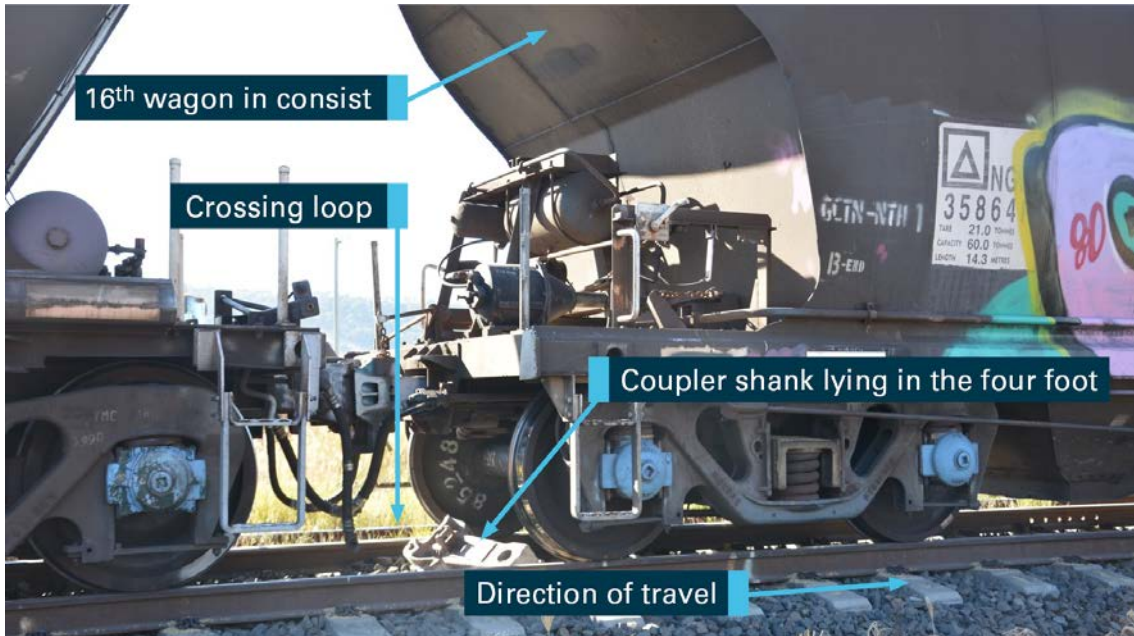
ATSB observed the train had parted five wagons behind the locomotive (see Figure 1). The draw gear assembly was missing from the rear of the fifth wagon, NGKF 35898X (see Figure 5). The coupler shank was found under the rear axle of the rear bogie of the sixteenth wagon, NGKF 35864R (see Figure 6).

Figure 5: Location for draw gear assembly



Source: ATSB

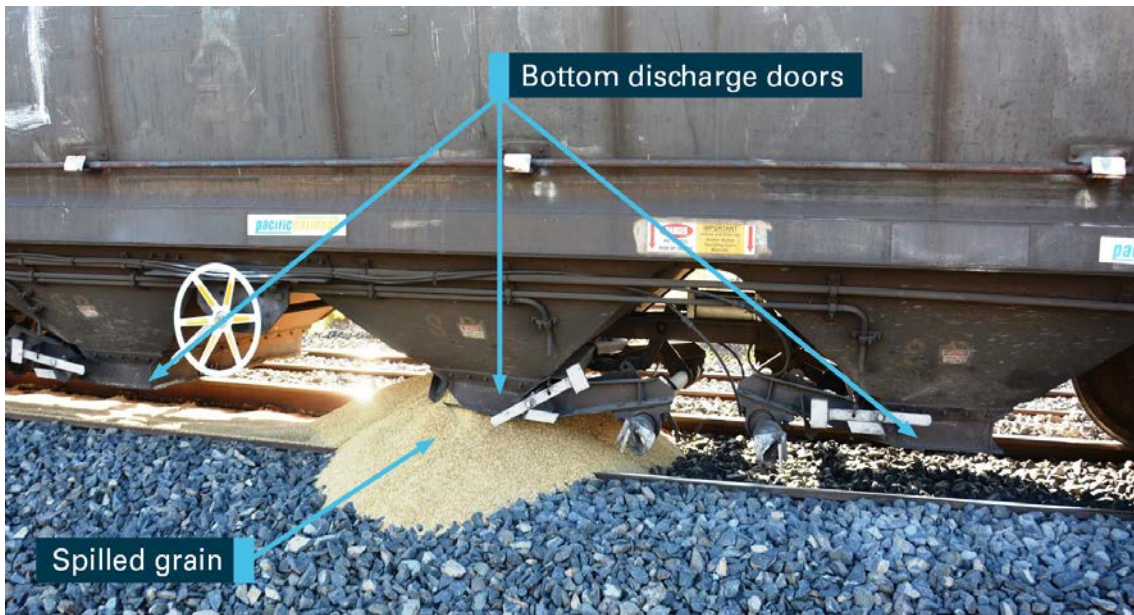
Figure 6: Coupler shank in four foot



Source: ATSB

The bottom discharge doors on 10 wagons had been damaged. Approximately 10 tonne of barley had spilled from the wagons (see Figure 7).

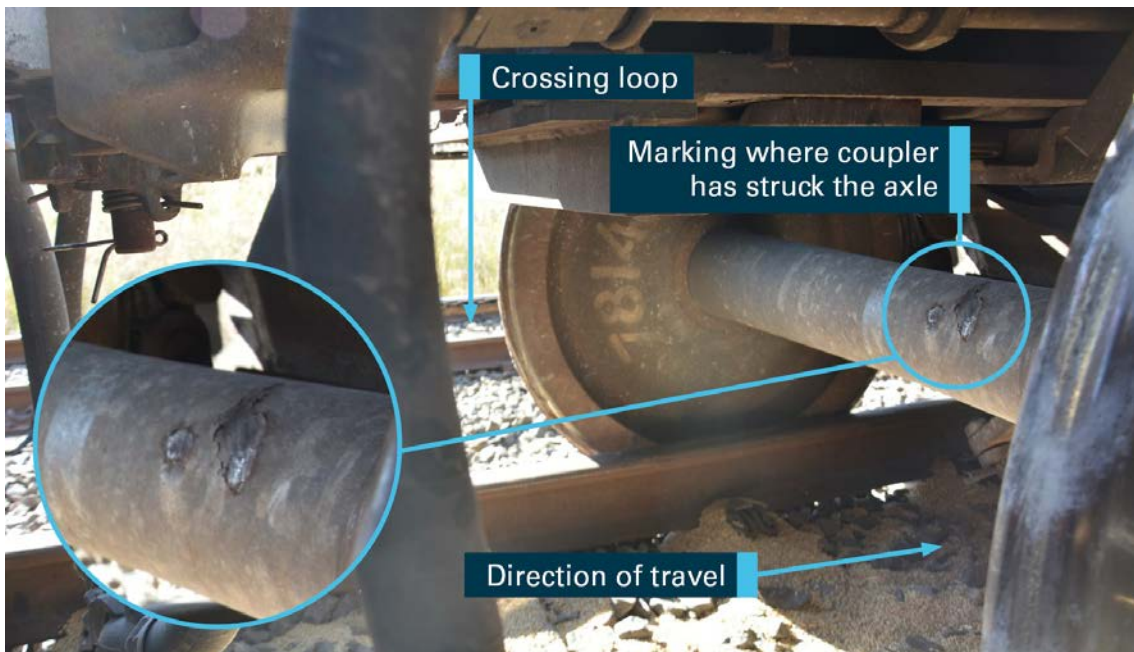
Figure 7: Wagon doors and spilled grain



Source: ATSB

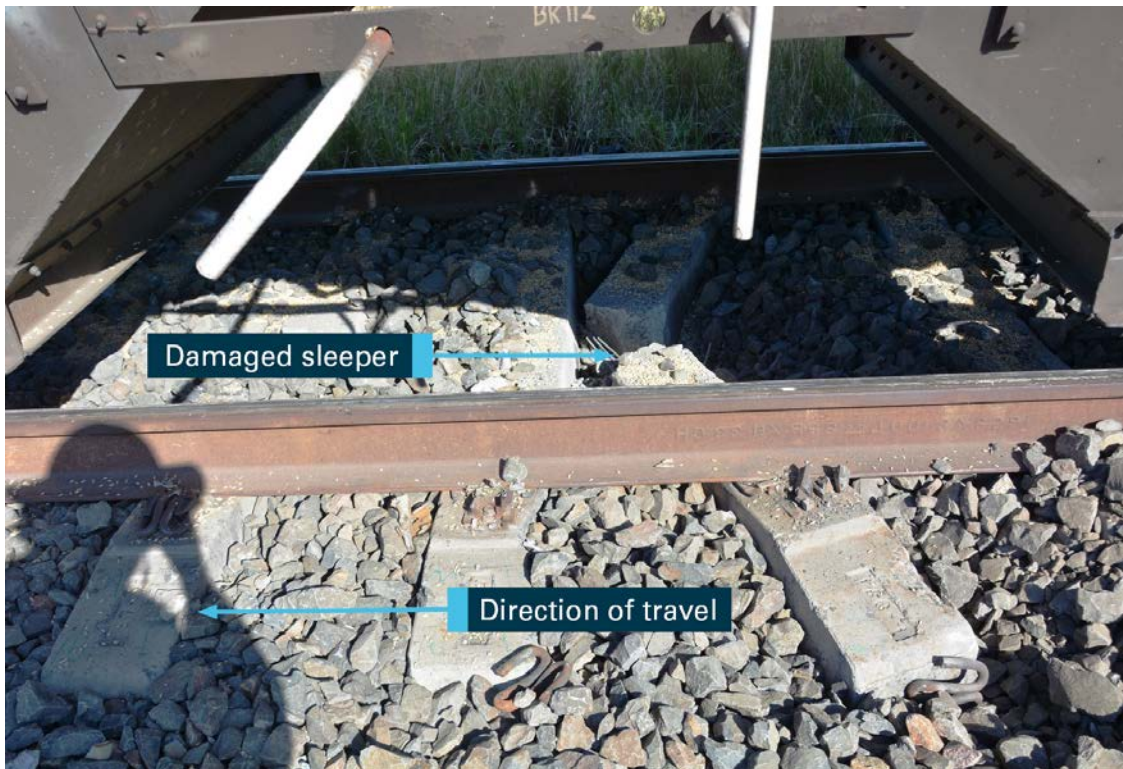
The coupler shank struck the axle of the trailing wheelset on the thirteenth wagon, NGPF 36032J. This resulted in the wheelset derailing near the crossing loop (see Figure 8). The wheelset travelled in a derailed state for approximately 45 m, damaging a number of concrete sleepers, before coming to a stop. (see Figure 9).

Figure 8: Derailed wheelset



Source: ATSB

Figure 9A: Damaged concrete sleepers



Source: ATSB

Figure 9B: Other damaged concrete sleepers



Source: ATSB

Safety analysis

The ATSB found that a draftgear component (an older design yoke), that was not compliant with a Pacific National (PN) maintenance standard, and not identified during a periodical wagon maintenance inspection and the yoke re-entered service undetected.

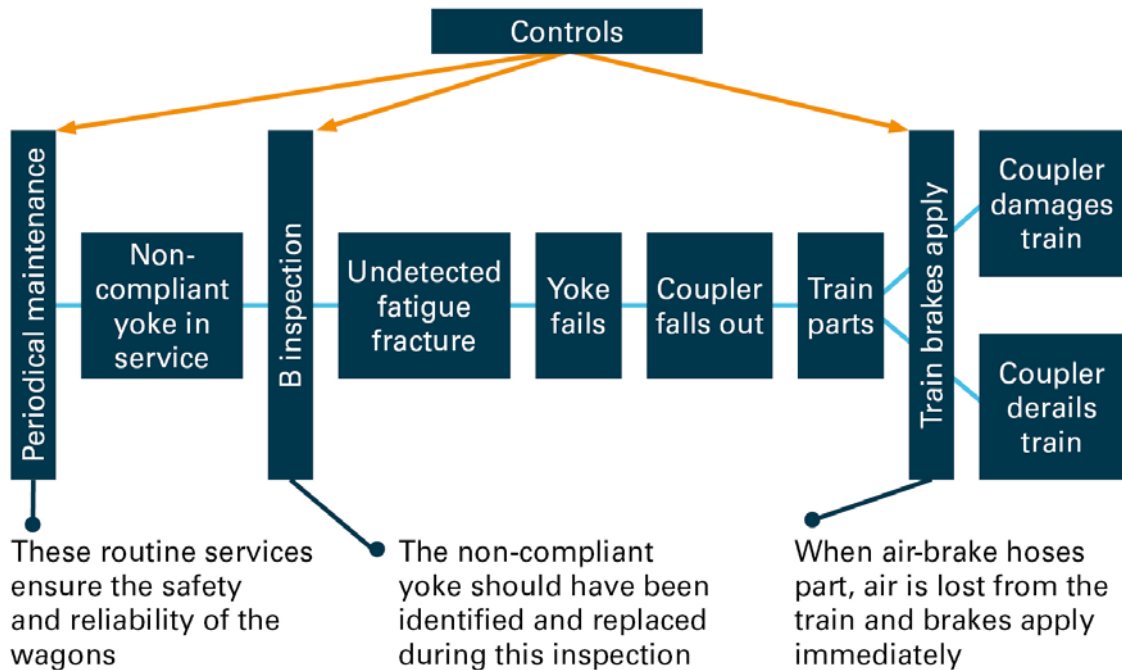
PN had a system in place to remove this early design yoke from their grain wagon fleet and replace it with a later design yoke better suited to the application. However, this yoke had been overlooked by the wagon maintainers and consequently continued in service up until its failure on 6 April 2016.

The yoke fitted on the rear of the fifth wagon, NGKF 35898X, was of an early design and was known to be susceptible to fatigue failure. The undetected older style yoke eventually failed in-service and led to the train parting and the subsequent derailment (see Figure 10).

While the train data logger information indicated that some brake applications on 5422N did not comply with PN procedures, ATSB concluded train handling did not contribute to the incident. After the yoke pin fell out of the assembly, the downhill operation most likely kept the two portions of the train together until the train negotiated a slight uphill gradient at Parkville. Here the train experienced a longitudinal tensile load that allowed the two portions of the train to separate.

The track leading to the incident site was inspected by a track specialist on behalf of PN. It was concluded there were no track defects or anomalies that could have contributed to the incident.

Figure 10: Event sequence



Source: ATSB

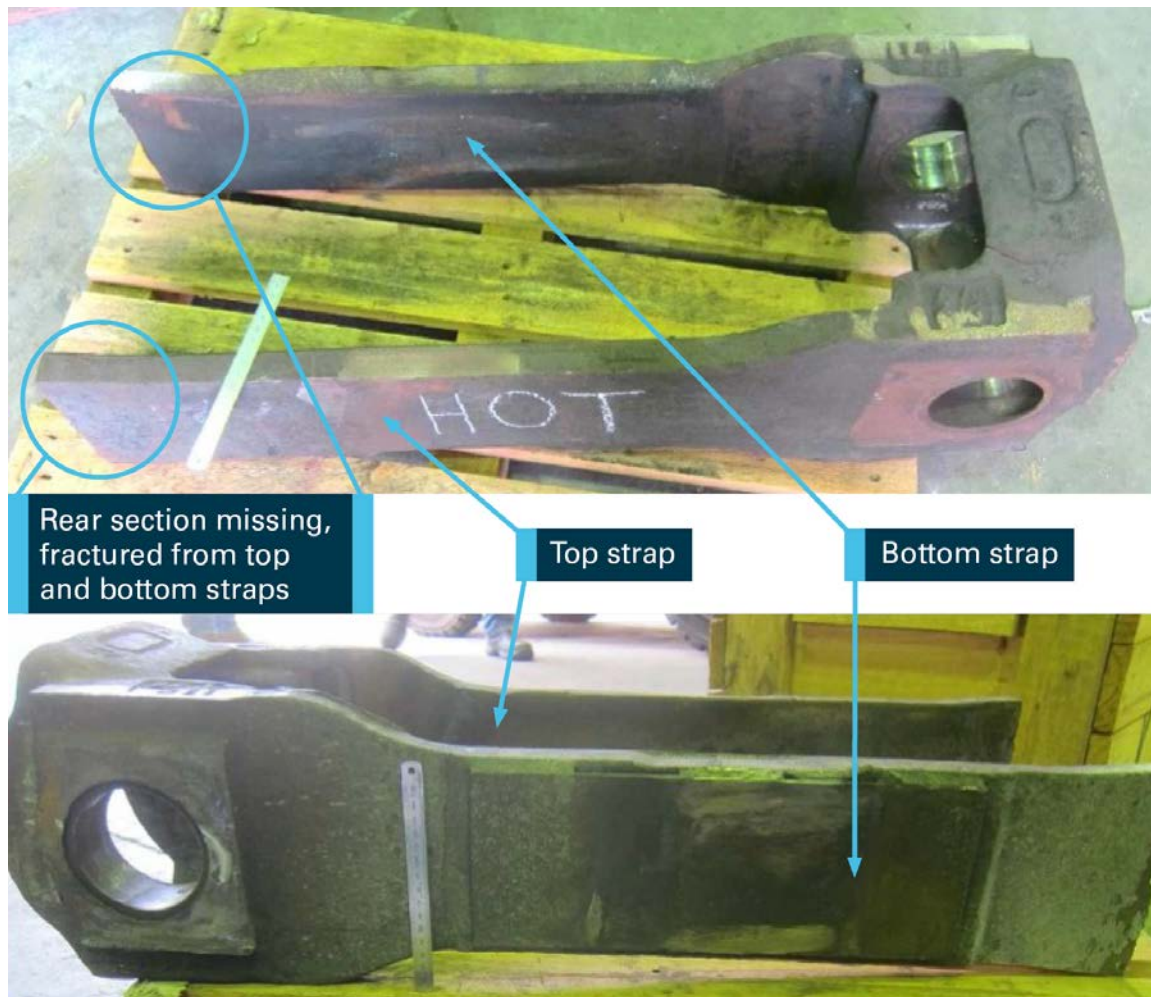
Yoke failure

The yoke from wagon NGKF 35898X had a manufacture date stamp '10/71'. NGKF wagons were manufactured in 1976. The yoke was approximately five years older than the wagon itself. It was therefore, likely that this yoke was the original yoke fitted to this wagon.

The yoke design had recently been identified by PN as having a finite life due to a propensity to fatigue failure. The tensile strength of the parent metal and the lack of internal rounded relief fillets in high stress areas of the yoke contributed to this issue.

The yoke had fractured at the rear section where the top and bottom longitudinal straps connected with the backing face (see Figure 11).

Figure 11: Fractured yoke



Source: Bureau Veritas, annotated by ATSB

PN commissioned Bureau Veritas (BV) to conduct a metallurgical examination to identify the nature of yoke’s failure mechanism. The examination identified that the yoke had failed due to fatigue cracking which had initiated at multiple points on the inner face of the top yoke strap (see Figure 12). Fatigue cracking had progressed through approximately 85 per cent of the material’s cross-section before the ductile failure of the remaining material. The bottom yoke strap subsequently failed with approximately 10 per cent of the material’s cross-section subject to fatigue cracking before the ductile fracture, failing after the top arm failed.

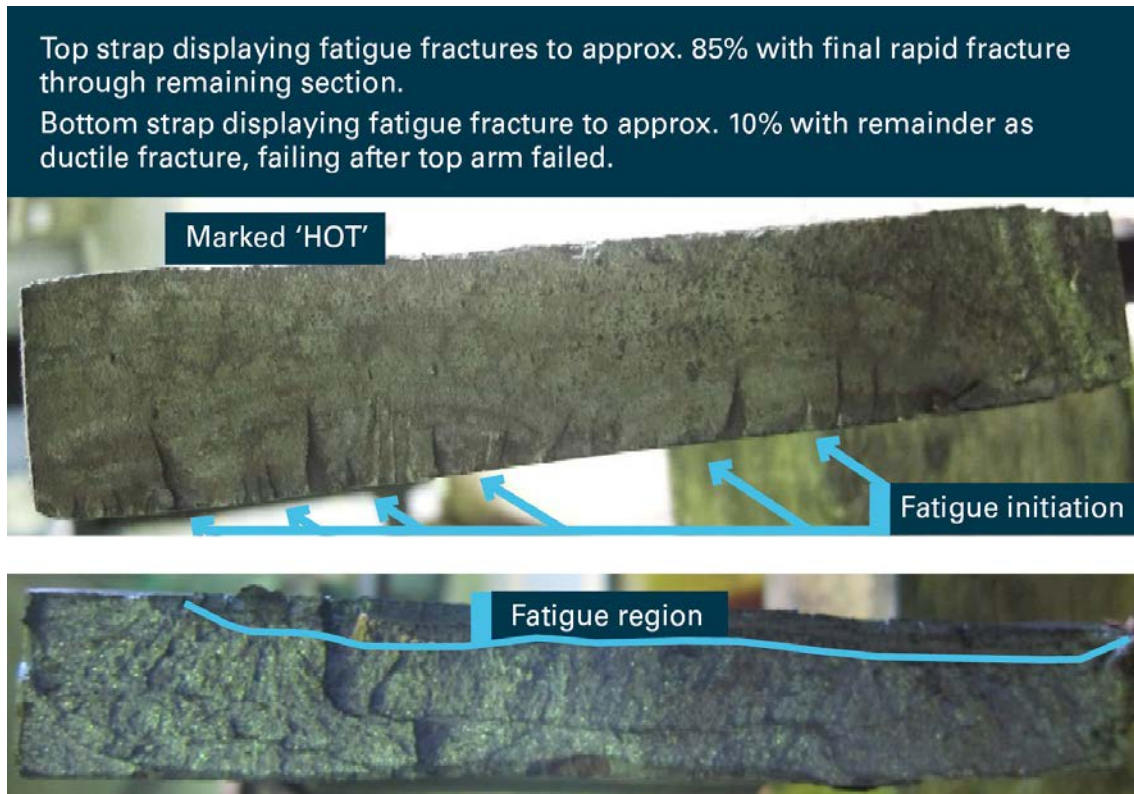
The BV report stated that

‘it was suspected that the fracture may be due to a material with low toughness properties⁶ being in service for a long time, which was exposed to cyclic stress.’

The BV metallurgical examination focussed on the material properties and while it did not review the design of the component, the report did note that “stresses are concentrated at the critical regions (e.g. radius relief groove, curves, thickness change)”.

⁶ Toughness properties: The ability of a material to absorb energy and plastically deform without fracturing.

Figure 12: Fracture faces of yoke



Source: Bureau Veritas including annotation

Fatigue cracking in yokes

Other research has been conducted into fatigue cracking and stresses in yokes in heavy haul services⁷. Cookson et al 2013, identified a propensity for fatigue cracking in yokes due to the vertical oriented bending of the draft system. This vertical oriented bending in yokes was considered most likely due to misalignment in the draft system. As such, identifying misalignment in the draft system was considered important as it could affect the overall service life of the yoke.

It was noted that PN's Wagon Maintenance Manual (WMM) 07-02_09 (dated 7 May 2009) *Couplers and Draft Gear Maintenance* makes reference to checks for alignment when inspecting various parts of the draft system, including; the knuckle, coupler shank, the yoke strap and drawgear carriers.

Wagon maintenance

The periodic maintenance program in place for PN's grain wagons was developed to ensure reliable and safe operation of the wagons.

WMM 07-02_09 sets out the maintenance requirements for wagon couplers and draft gear. Section 1.9 deals with yokes and it includes the following:

- Yoke straps are to be inspected for cracking
- Where video/borescopes are available these shall be used to detect cracking in yoke straps.
- If cracking is found (in the internal radius locations) the yoke shall be scrapped

⁷ *Fatigue Cracking and Stresses in Yokes in Heavy Haul Service* 10th International Heavy Haul Association Conference, 2013; Cookson J.M., MacNish A., Baartz M. Institute of Railway Technology, Monash University, Melbourne Australia

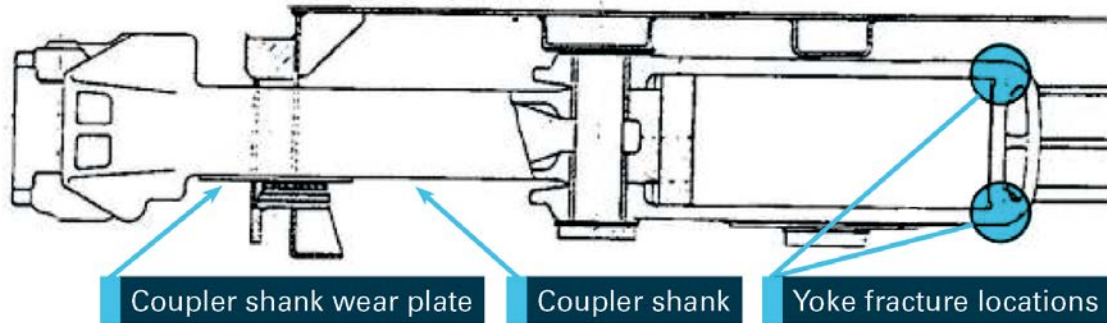
Further, Section 1.9.4 makes specific reference to earlier design yoke straps:

‘Wagons manufactured before 1980 used lower grade steel in the draft gear castings and do not have a relief fillet in the rear top and bottom inside corners as identified in the picture below (see Figure 13) (i.e. sharp radius). Replace these when found.’

Additionally, while wagons with a draft capacity of less than 1.3 MN were excluded from this last requirement, NGKF 35898X had a draft capacity of 1.8 MN.

These requirements specified in PN’s WMM suggests the yoke on wagon NGKF 35898X should have been identified and replaced at the last maintenance intervention.

Figure 13: Yoke inspection areas



Source: PN WMM 07-02

It is worth noting the task requirements on wagon maintainers when required to inspect a unit train consist⁸. When a unit train consist is scheduled for maintenance, such as the B inspection⁹, the consist is scheduled into a maintenance centre for usually 24 hours before being scheduled onto its next service.

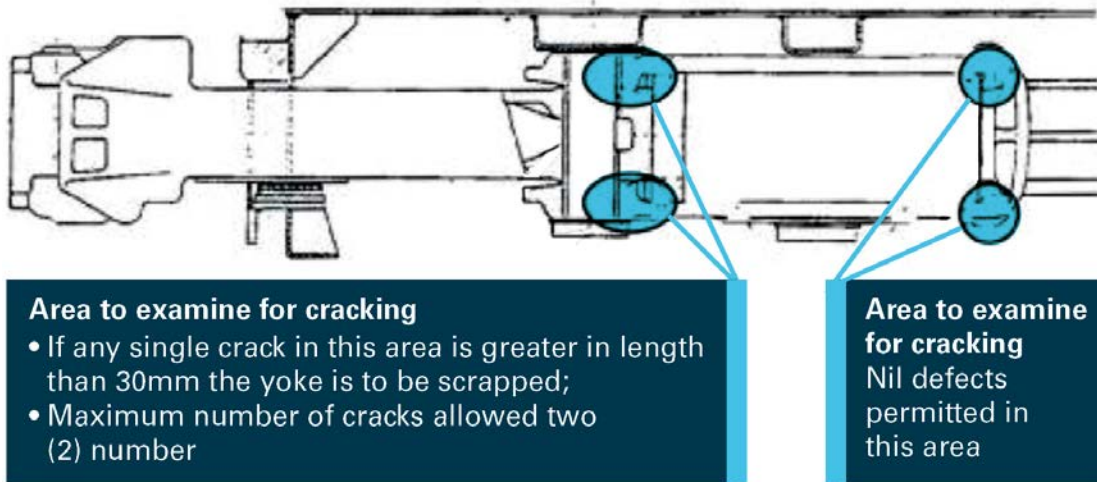
In this time the wagon maintainer would need to attend to a list of items and either, test, service or lubricate, replace, adjust, gauge, measure or inspect each of these items on each wagon (for grain unit train consists, 40 wagons). The list of items to attend to on the B inspection sheet is 92 items.

Additionally, the location of the yoke in situ makes it challenging for the wagon maintainer to identify cracking in the yoke. As pictured in Figure 14, the wagon maintainer is required to inspect the highlighted areas. As Figure 15 shows, the access to view these areas while the yoke is in situ is difficult and potentially restricted by time constraints in the maintenance opportunity.

⁸ A unit train consist is the entirety of the train, less the motive power. For grain unit train consists, there was typically 40 wagons. These wagons would remain together for operational and maintenance efficiencies.

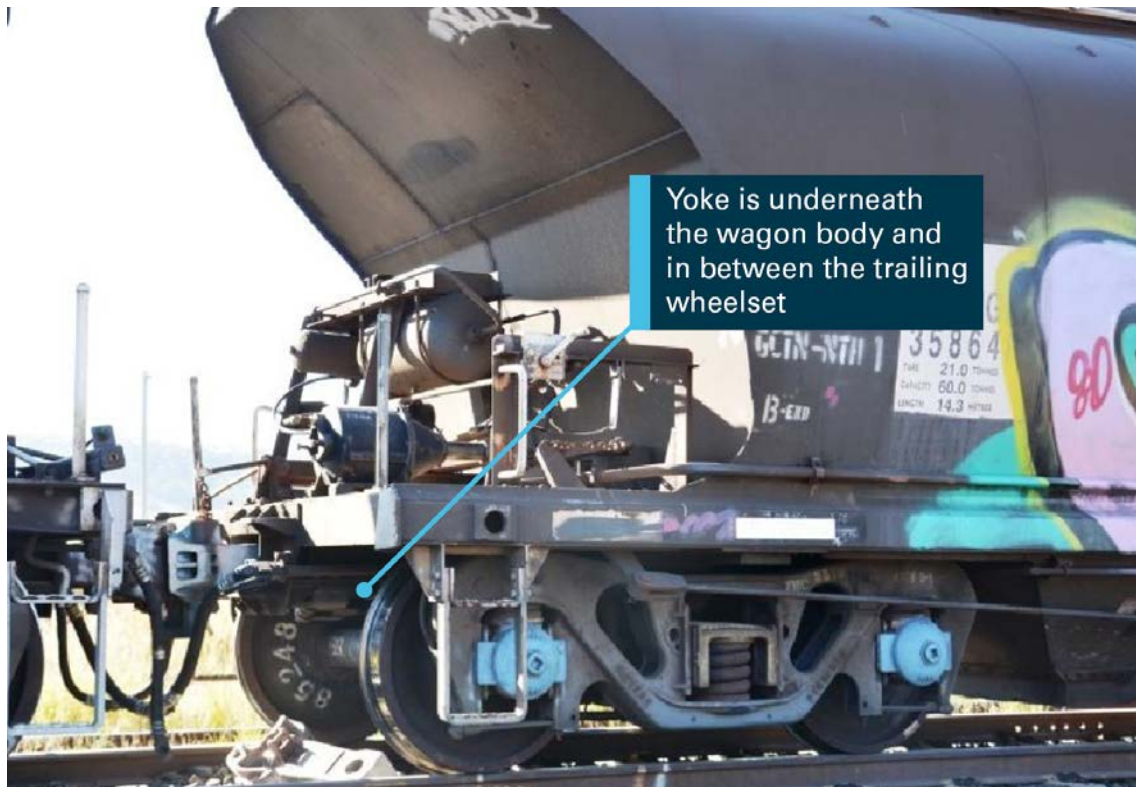
⁹ The B inspection is a maintenance opportunity to apply PN’s maintenance standard WMM 01-05.

Figure 14: Yoke inspection areas



Source: PN WMM 07-02

Figure 15: Yoke in situ



Source: ATSB

Train handling

The yoke pin was found nearly 6 km before Parkville. There was a constant falling grade towards Parkville and the train driver was using dynamic braking to control train speed. Therefore, the wagons of the train generally remained in a compressed state ensuring the train did not part.

On account from the driver, there is a slight incline after Wingen just prior to the downhill into Parkville. At this point the driver allowed the train to roll freely through the section of track to maintain speed. This coincides with a releasing of the buffering or compressive forces in the draw gear. The yoke pin most likely fell from the train at this point which is where it was found during inspection post incident (see Figure 16).

The train was able to continue without a mechanical connection through to Parkville as compressive forces kept the train and brake air hoses together on the downhill into Parkville. However, as the train rolled into Parkville at approximately 60 km/hr, the driver reduced dynamic braking to account for the slight incline to the middle of the yard which is when the train parted, separating the air hoses. This enabled the brakepipe to vent to atmosphere, triggering an emergency brake application which brought both parts of the train to a stop.

The train handling in the lead-up to the incident was not considered a contributing factor to the incident.

Figure 16: Yoke pin lying in the four foot



Source: ARTC including annotation

Previous incidents

PN reported that, over the five years preceding the incident, there were 14 incidents of trains parting due to defective yokes. These incidents occurred between 2011 and 2016. There were a further 13 wagons that had their yokes replaced during maintenance between 2011 and 2012. No older style yokes were detected after that date until this incident in 2016.

Pacific National investigation

PN conducted a safety investigation into the incident at Parkville. PN's internal Investigation Report (Form PN-FOR-SAF) dated 10 May 2016 identified that the incident wagon (NGKF35898X)

'underwent regular maintenance and inspection as per WMM 01-01b_05 Bulk Services Division Services Schedule of Inspections; however, the early model yoke strap on this wagon was not identified or replaced (as per WMM 07-02_09).'

Two of the preventative actions in the report were:

- To develop and issue a Rolling Stock Notice (RSN) to all wagon maintenance and engineering teams to reiterate required inspections on early model yokes on wagons and replacement of specified parts.
- Develop a safety alert detailing the contributing factors for derailment and distribute to NSW/Vic operations.

ATSB requested PN to demonstrate that the actions had been completed. PN notified the ATSB that the first two items had been closed out by issuing a single RSN (see Appendix A) to wagon maintainers.

Findings

From the evidence available, the following findings are made with respect to the derailment of grain train 5422N at Parkville NSW on 6 April 2016. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The yoke was an earlier design prone to failure through fatigue cracking.
- The presence of the earlier design of yoke on wagon NGKF 35898X was not detected during preventative maintenance activities.

Other factors that increased risk

Nil

Safety issues and actions

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety actions in order to reduce their safety risk. The ATSB has been advised of the following safety actions in response to this occurrence.

Preventative maintenance systems

Number:	RO-2016-004-SI-01
Issue owner:	Pacific National
Operation affected:	Rail Operations
Who it affects:	Pacific National

Safety issue description:

The presence of the earlier design of yoke on wagon NGKF 35898X was not detected during preventative maintenance activities.

Action number: RO-2016-004-NSA-01

Pacific National has advised of the following proactive safety actions to address the issue:

- Develop and distribute Rolling Stock Notice to all wagon maintenance and engineering teams to reiterate required inspections on early model yokes on wagons and replacement of specified parts.
- Develop a Safety Alert detailing the contributing factors for derailment and distribute to NSW and Victorian operations.

ATSB comment/action in response

Current status of the safety issue

Issue status: *PN confirmed all 140 older style yokes in the grain fleet had been changed out*

Justification: *Risk is controlled when all older style yokes are out of service*

General details

Occurrence details

Date and time:	06 April 2016 – 0236 AEST	
Occurrence category:	Incident	
Primary occurrence type:	Derailment	
Location:	Parkville, NSW	
	Latitude: 31° 58' 44" S	Longitude: 150° 51' 53" E

Rail Infrastructure details

Rail Infrastructure Manager	The Australian Rail Track Corporation Ltd.
Line	Main North
Section	Parkville Yard
Track Details	Single track, with passing loop, with 60 kg/m head hardened rail on heavy-duty concrete sleepers.

Train details

Train operator:	Pacific National	
Train No.	5422N	
Type of operation:	Bulk grain	
Persons on board:	Crew – 2	Passengers – Nil
Injuries:	Crew – Nil	Passengers – N/A
Damage:	Moderate	

Sources and submissions

Sources of information

The sources of information during the investigation included:


- The Australian Rail Track Corporation Ltd.
- Office of the National Rail Safety Regulator
- Pacific National

Submissions

Nil

Appendices

Appendix A – Pacific National Rolling Stock Notice



ROLLING STOCK NOTICE

TOPIC: Wagon Defect

Issue Date: 26/04/2016

Issue Number: RSN E 16-024

Notice Category: C

Expiry Date: 26/10/2016

Early Model Yoke Inspection

Distribution: All Wagon Maintenance Teams, A & I Engineering

Background

A recent wagon inspection has identified a yoke manufactured in 1971 installed on a wagon with a Drawgear rating of 1.8 MN. WMM 07-02 clause 1.9.4 details requirements for early model yoke straps.

1.9.4 Early Model Yoke Straps

Wagons manufactured before 1980 used lower grade steel in the draft gear castings and do not have a relief fillet in the rear top and bottom inside corners as identified in Figure 12 (i.e. sharp radius). Replaced these when found.

Exception:

For wagons with draft capacity of less than 1.3 MN this requirement to replace yokes manufactured prior to 1980 may be waived.

Refer to Wagon Data for train Operation document for draw gear rating of all wagons.

This notice is to re-iterate the requirements for early model yoke straps.
Note Figures 3 and 4 included to show detail from WMM 07-02 figure 12.

Important information / action to be taken

- All wagons are to be inspected in accordance to WMM 07-02 clause 1.9.4
- The manufacture date of the yoke is found on the yoke strap. Examples as per figures 1 and 2. The date of manufacture is often not visible when yoke is installed in pocket.
- The draft capacity is available in the WDO "Wagon Data for Train Operations" on SafetyNet.
- The relief fillet can be seen without removing the draw gear or bogie.

Additional Information

-

Safety Management System documentation,

- WMM 07-02 "Couplers and Draft Gear Maintenance"
- WDO "Wagon Data for Train Operations"

pacificnational **ROLLING STOCK NOTICE**

Photos



Figure 1 Yoke manufacture date



Figure 2 Yoke manufacture date



Figure 3 Yoke with no relief fillet



Figure 4 Yoke with relief fillet

Contact Person		Position	Wagon Engineer
Approved By		Position	Fleet Services Engineer

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB 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 factors related to the transport safety matter being investigated.

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.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report Rail Occurrence Investigation

5422N train parting and derailement in Parkville,
New South Wales on 6 April 2016

RO-2016-004

Final – 4 June 2018