Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT

Rail Occurrence Investigation

RO-2010-001

Final

Derailment of freight train 2224
Exeter, NSW
24 January 2010

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Abstract

At about 1856 on 24 January 2010 a loaded freight train designated 2224, travelling from Medway Junction to Berrima Junction, derailed one bogie on the second-last wagon at Exeter, New South Wales.

It was determined that wagon NPZH 35700U derailed due to a 'screwed journal' as a result of a wheel bearing failure. As the bearing failed, it generated and transmitted sufficient heat to the axle journal, to make it 'plastic' and allow the end carrying the failed roller bearing assembly to 'screw off'.

There was insufficient evidence to determine the cause of the bearing failure.

The investigation identified two safety issues in relation to:

- the in-service condition monitoring of the wheel bearing which was ineffective in detecting the failing bearing before it led to the derailment, and,
- bulk hopper wagons loaded with limestone which have been regularly operated at speeds up to 15 km/h higher than the mandated limit for some classes of track.

In both cases the train operator has taken safety action to address the issue.

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 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.

1 FACTUAL INFORMATION

1.1 Overview

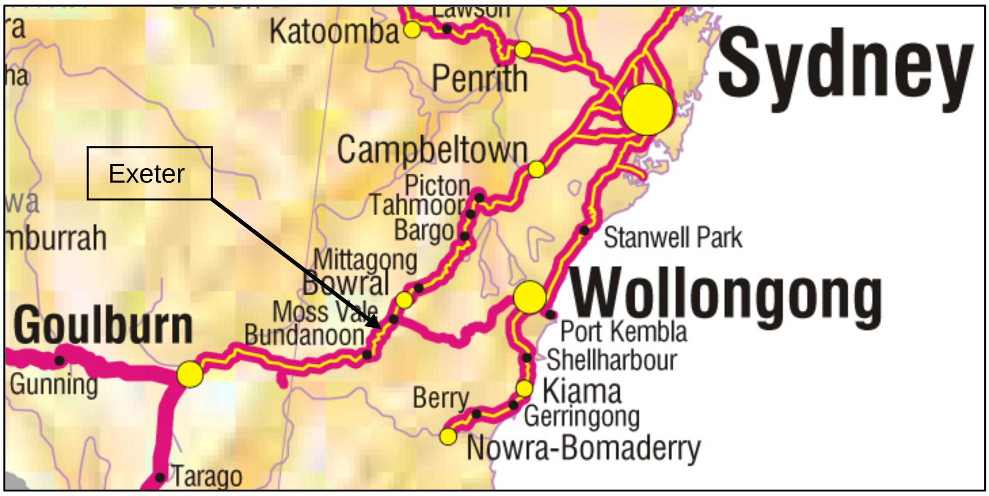
At about 1856[1] on 24 January 2010 a loaded freight train designated 2224 derailed one axle on the second-last wagon, while travelling from Medway Junction to Berrima Junction on the Up Main line near Exeter, New South Wales (NSW).

1.2 Location

Exeter is located on the Main South line between Sydney and Melbourne (Figure 1) about 154 track kilometres from Sydney, part of the Defined Interstate Rail Network (DIRN). This section of the DIRN consists of two standard gauge unidirectional lines, an Up Main[2] and Down Main.

The rail corridor through Exeter is managed and maintained by the Australian Rail Track Corporation (ARTC). Operational control is from the ARTC Network Control Centre – South located at Junee, NSW. The passage of trains through Exeter is managed by one network controller operating the Main South A Board of the Phoenix Control System.

Figure 1: Exeter, New South Wales



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1.3 Train information

Freight train 2224 was owned and operated by Pacific National. It consisted of two locomotives (8146 leading and 8169 trailing) hauling 30 loaded wagons carrying limestone product. The train had been loaded at the Blue Circle Southern Cement facility located at Marulan South. The facility is equipped with overhead loading

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1 The 24-hour clock is used in this report. Australian Eastern Daylight Time (AEDT), UTC + 11 hours. Unless shown otherwise, all times are AEDT.

2 Up is towards Sydney and Down is away from Sydney.

and weighbridge equipment. When a train is to be loaded, the tare mass of each wagon is recorded before they are loaded to an indicated gross mass of about 98 t. Any overweight wagons are removed and reloaded before entering service.

The train was 549 m long and the trailing load weighed a total of 2 940 t. The wagon that derailed, NPZH 35700U, was located in the second-last position of the train consist. The consist, designated unit train BT22, was on a dedicated 'yo-yo'[3] run between Medway Junction and Berrima Junction transporting limestone product each day. The consist was turned every 3 to 6 months via the Moss Vale triangle to prevent directional wear of running components.

The crew of train 2224 consisted of two drivers. Both drivers were appropriately qualified, assessed as competent and medically fit for duty.

1.3.1 Wagon history

Wagon NPZH 35700U (Figure 2) was built in 1977 by A. Goninan & Co. as a coal hopper coded as CHS class then later changed to NHGF and more recently in 1998 to NPZH.

Figure 2: Wagon NPZH 35700U, in storage at Moss Vale yard

The wagon weighed 27 t tare and up to 100 t gross, was 16.9 m in length and rated as a class 'F' vehicle up to a maximum speed of 80 km/h empty, or 65 km/h loaded, for the section of track on which it was operated. The wagon was fitted with three piece National Super C1 bogies rated at 70 t per bogie. The wagon was originally fitted with axle boxes, but these were replaced with 11 x 6 inch 'E' class tapered roller package bearings circa 1986.

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3 A term used to describe a train consist running exclusively between two locations back and forth.

1.4 Occurrence

Both drivers had signed-on fit for duty at 1100 hours at Moss Vale depot. They worked the empty train, 2223, to Medway Quarry arriving at 1530 without incident, for loading. The shunter at the quarry performed a roll-by inspection as the train arrived and did not detect any abnormal wagon operation. Before departing the quarry loaded, the train was again inspected. No abnormalities were detected.

Train 2224 departed Medway Junction on the Up Main line at 1808 and travelled towards Exeter without incident. At about 1901:28 the train passed an ARTC wayside Dragging Equipment Detector (DED) located at 155.398 track kilometres[4], near Exeter, with one axle on the second-last wagon derailed. The derailed wheels destroyed the DED resulting in an alarm message being transmitted to the ARTC train control centre in Junee. The network controller contacted the train crew, who had already begun to stop the train.

The train crew, who had noticed dust from the rear of the train, stopped the train at 1902:55. The second driver walked back to find the derailed wagon and notified the network controller who then made response arrangements.

1.4.1 Post occurrence

The train crew were breath tested onsite at 2030 returning zero readings.

Wagon NPZH 35700U was re-railed with a replacement bogie, moved from the site, and stored at Moss Vale yard. The damaged bogie and related components were placed in protective storage for further examination.

About 6 km of track structure was damaged. During the restoration work all trains were diverted to travel over the Down Main line (single line working). The Up Main line was re-opened at 1821 on 25 January 2010 with a 60 km/h speed restriction in place until the track structure was completely repaired.

4 Measured from Sydney Central Station.

2 ANALYSIS

On 24 January 2010 the Australian Transport Safety Bureau (ATSB) received notification of a derailment involving a loaded limestone train at Exeter in New South Wales. Following an initial review of the incident, the ATSB decided to undertake a formal investigation, particularly to identify any systemic issues that should be addressed.

As part of the process evidence was sourced from the train drivers, Pacific National, the Australian Rail Track Corporation, and the Independent Transport Safety Regulator of NSW. Evidence included interviews, train running information, voice and data logs, locomotive data logs, engineering documentation including maintenance history, bearing failure history, loading records, and other material.

2.1 Sequence of events analysis

An analysis of the Hasler data log[5] from leading locomotive 8146 was conducted. The analysis determined that wagon NPZH 35700U passed the Dragging Equipment Detector (DED) at 1901:28 as the train had been steadily accelerating. Five seconds later, the train brakes began to apply (1901:33). The train reached a maximum speed of about 79 km/h at 1901:44 (while derailed) before slowing to a stop at 1902:55.

2.1.1 Site examination

An examination of the derailment site was conducted and revealed an axle journal stub lying adjacent to the track about 1530 m (160.800 km point) before the point of derailment at 159.270. The axle journal stub had originated from the only wagon to derail, NPZH 35700U, position R3[6].

It was evident that one axle on the leading bogie of the second last wagon NPZH 35700U on train 2224 derailed the trailing wheel-set[7] at the 159.270 km point. The wagon travelled another 3872 m before striking the DED at 155.398 km, and then continued another 1898 m until it stopped at 153.500 km,with the front of train at about 153.000 km. In total the wagon had travelled about 5770 m in a derailed condition.

It was clear from on-site evidence that the derailment was caused by a 'screwed journal' as a result of the R3 wheel bearing failing on wagon NPZH 35700U. As the bearing failed, it generated and transmitted sufficient heat to the axle journal to make it 'plastic' and allow the end carrying the failed roller bearing assembly to 'screw off'.

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5 All Hasler times adjusted by minus 8 minutes and 12 seconds to align with DED times.

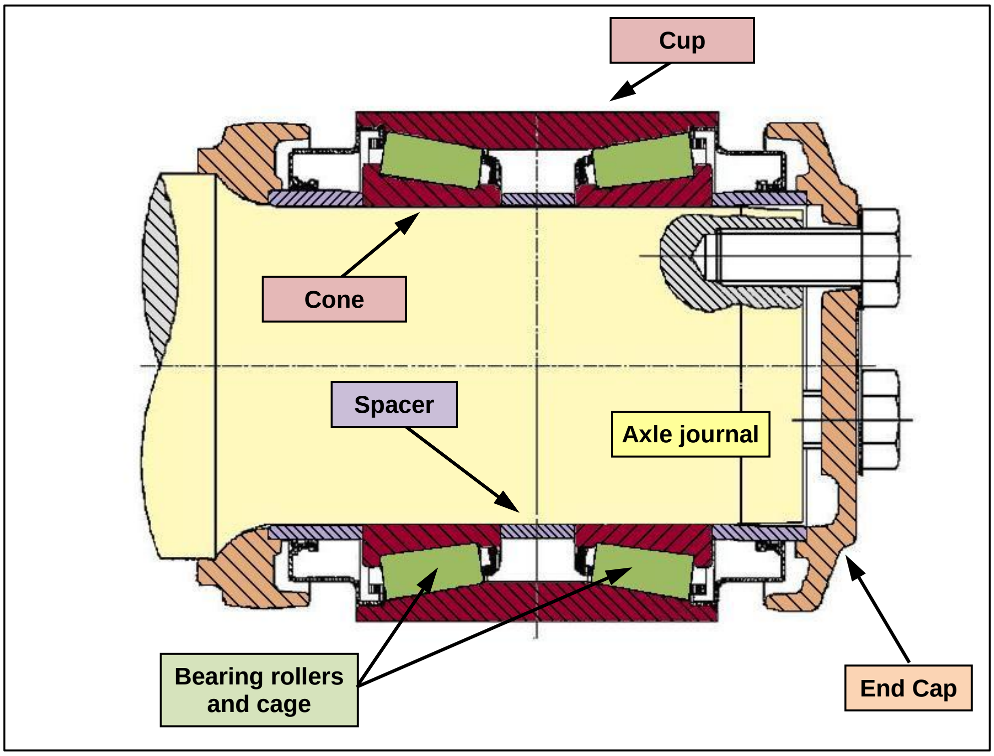
6 Third axle, right-hand side.

7 An assembly consisting of axle, wheels, bearings, and where applicable associated components such as brake discs, traction gears, traction motor support bearings, gearbox etc.

2.2 Component inspection

An independent materials failure expert was engaged to inspect and test the failed bearing, the L3[8] bearing on that wheel-set, and other bearings within the same bogie.

Figure 3: Packaged bearing nomenclature



The failed package bearing R3 was manufactured in 1986 by Svenska Kullagerfabriken (SKF). The bearing was requalified[9] and installed into the wagon on 23 April 2008 and had travelled 98,028 km from the time of requalification until it failed in service. The bearing had been destroyed so that no evidence was found that could be used to determine the likely cause of the failure (Figure 4). However, the L3 bearing from the same wheel-set was examined closely to identify any faults or defects that may have suggested any factors that could have contributed to the failure of the R3 bearing.

8 Third axle, left-hand side.

9 A process of disassembly, cleaning, inspection and repair if necessary, and reassembly of the roller bearing components.

Figure 4: Remains of R3 bearing

The bogie that contained the failed bearing (bogie number NDBA17601) was inspected at MainTrain (a rail maintenance facility at Auburn, NSW) with representatives present from Pacific National, MainTrain, and the ATSB. Wear and damage at service contact points was inspected and determined to be within normal limits. Other damage such as gouging, distortion, and heavy wear were probably a consequence of the derailment.

Pacific National engaged independent experts to inspect bogie NDBA17601 and report on its condition and any likely contributing factors. The report concluded that:

> It is considered that bogie NDBA 17601 prior to the derailment would have fully complied with Pacific National's standard WMM 11-10_06 *Three Piece Bogie Inspection*.
>
> All the damage found on the bogie and attachments could be explained by the knowledge that the bogie had travelled almost six kilometres in the derailed condition or was due to post derailment recovery operations.
>
> With 3-piece bogies it is not considered possible that a single bearing could be abnormally loaded to the extent that would be instrumental in causing a bearing to fail.

Based on available evidence, it is likely that there were no pre-existing defects within the bogie that may have contributed to the failure of the R3 bearing.

The adjacent bearing L3 (manufactured by SKF in February 1996), was found to rotate freely and smoothly without notching. The bearing components were stripped down, cleaned, and inspected. The components were found to be in serviceable condition and within specification showing no evidence of fretting, nor was there any evidence of improper fitting of components. There was no evidence of pre-existing damage and it had adequate lubrication.

Samples of grease from bearing L3 inboard, outboard, and spacer were analysed. The examination of the three used grease samples, and comparison with the new grease sample (Table 1), indicated that the bearing was wearing normally, at a light rate of wear. The visual and microscopic inspections on the used and new grease indicated that these grease samples were in reasonable condition with the bearings wearing normally, showing a light to moderate amount of polishing wear.

Table 1: Grease analysis results.

Position	Fe	Pb	Cu	Al	Cr	Si	Na	Mo	Mg	Zn	Ca	PQ
Spacer	363	1	1	22	4	403	2050	84	37	7	3352	1255
Inboard	436	<1	1	26	5	473	2350	100	43	8	3999	1436
Outboard	502	1	1	25	6	460	2180	97	42	8	3917	736
New	8	<1	<1	8	<1	288	1250	<1	14	<1	3042	21

The report also noted:

> The area of light concern is the elevated Fe and PQ (Conductivity increase due to ferrous wear) registered in the chemical labs ICP Spectrographic grease analysis. Although these samples were OK with consistency being close to normal if the above the results were viewed without the information on the grease consistency and bearing condition there could be concern about reliability... recommends that bearing temperature be closely monitored on these axles with any lightly elevated temperature bearings inspected for condition and the grease checked for consistency to ensure there are no other housings where the grease has been damaged reducing the bearing reliability.

Based on the examination and condition of the L3 bearing, and that both bearings were requalified by the same company and installed at the same time, it was likely that the R3 bearing:

- was requalified in accordance with procedures
- was adequately lubricated at the time of requalification
- was appropriately assembled, handled, and installed correctly.

2.3 Bearing failure

All bearings have a finite life. In a laboratory test environment, most bearings will 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.

The failed bearing assembly was so damaged that an examination of its components provided no evidence to determine the likely cause of the failure. Consequently, the investigation looked at the common failure modes for railway bearings to provide stronger support for any possible conclusions.

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 mm^2 (refer to Rolling surface damage).

The bearings used on the NPZH class wagon were 'Class E' tapered roller bearings and are commonly used on railway rolling stock throughout Australia. A typical fatigue life specification for a Class E bearing indicates an L_{10} life is equivalent to about 2,600,000 km (wheel diameter of about 840 mm) when operating at maximum bearing load for 50% of its time. However, 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.

Tapered roller bearings are designed to support both radial loads (weight of wagon and other vertical forces) and thrust loads (cornering and other lateral forces). Bearing manufacturers sometimes provide both radial and thrust load ratings for their bearings when operating at specific rotational speeds (usually 500 revolutions per minute, which equates to about 80 km/h for wagons with a wheel diameter of 840 mm). An examination of manufacturers' specifications found that the Class E bearing rating was about 19 t for radial loads, which equates to an axle load of about 38 t. This is well above the axle load limit for wagons operating on the Main South line at 25 t. Consequently, even at maximum wagon loads, the bearings are operating well below their maximum rating. This means that the fatigue life for Class E bearings operating on the DIRN is likely to be much higher than the L_{10} life specified in the manufacturer's documentation.

Records showed that wagon NPZH 35700U travelled an average of about 66,000 km per year[10], was usually only loaded when travelling away from Medway Junction and often empty when travelling towards Medway Junction. At this rate, bearings fitted to wagons on this train would need to be in service for more than 39 years before reaching the manufacturer's L_{10} life specification. When considering the actual loading of the bearing, its theoretical fatigue life is likely to be considerably more than 39 years.

In this case, the bearing that failed had been manufactured in 1986 and therefore had been in periodic service for approximately 24 years. Its operating history could not be accurately determined because records of total time (or kilometres) in service are not kept. However, is is considered typical of railway bearings, that their serviceable life is usually limited by factors other than simple bearing fatigue. While actual kilometres and loadings are not known for this bearing, it was considered unlikely that the bearing on wagon NPZH 35700U failed due to simple fatigue alone.

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 bearings, used in the railway industry, are usually pressed out of metal plate.

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10 Based on current usage and does not consider prior usage due to a lack of service history.

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 bearing on the adjacent 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, multiple wheel lives before bearing overhaul. Pacific National remove and requalify bearings every time a wheel is removed or re-profiled. Consequently, bearings are not in-service for excessive periods without the cage being examined for excessive wear.

In this case, the bearing was fitted in April 2008, having been requalified about 4 times previously. The partner bearing had been fitted at the same time and examination of its cages showed no evidence of excessive wear. Considering the evidence available, cage failure due to normal in-service wear was considered unlikely.

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 failed bearing was extensively damaged such that much of the direct evidence was destroyed and examination of the rolling surfaces provided no useful information. The adjacent bearing showed no signs of indentations on the rollers or races.

Bearing failure caused by foreign material ingested into a bearing 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 bearing had been in service for about 2 years since requalification.

If sufficient lubrication existed, rolling surface damage and bearing deterioration is likely to be progressive and detectable by track side condition monitoring equipment. In this case, there was no trackside monitoring systems installed to trend monitor passing rail traffic. Refer to section *2.5 Bearing condition monitoring*.

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.

The failed bearing and associated axle journal could not be examined for evidence of fretting due to the damage caused during the failure sequence. The adjacent bearing showed no evidence of fretting. Considering there was no evidence of excessive loading on this wagon and no fretting was evident on the adjacent bearing, it is unlikely that fretting contributed to the failure of the bearing.

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 ‘B’ end of the axle was the correct grade but it had degenerated slightly during the service life of the bearing. No lubricant could be recovered from the failed bearing. However, since the bearings 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 bearings.

Contamination of the lubricant can occur during assembly, servicing, or by ingress of foreign material in service. Contamination during assembly or servicing will usually affect both bearings and will usually show signs of failure in the earlier stages of service life. In this case, no evidence of contamination was found in the adjacent bearing. Considering the axle had been in service for approximately 2 years, it is unlikely that the lubricant had been contaminated during assembly or servicing, however it is not possible to rule out lubrication loss or contamination in the time leading up to the failure.

2.3.2 Summary of bearing failure

The recovered bearing components were examined in relation to the common failure modes for railway bearings. The poor condition of its components made it impossible to accurately determine the cause of the bearing failure. The bearing had been in periodic service for the previous 24 years but as no records were kept in relation to total time in service (total kilometerage), it is was not possible to conclude whether or not age (high cycle fatigue) was a factor in the failure, although this seems unlikely. Similarly the loss or contamination of the bearing’s lubricant in the time leading up to the failure cannot be ruled out.

2.4 Bearing requalification

The requalification process involves stripping, cleaning, a visual inspection, measurement, reassembly, and regreasing before a bearing is refitted to a wheel-set and returned to service – often not on the same wagon. Bearing running surface defects, such as spalls, are visually assessed and graded based on defect size. Certain sized spalls, as specified by client contracts and or industry standards, may be blended out as part of the requalification process.

Visually inspecting a bearing during the requalification process can only detect surface defects. The majority of high cycle bearing fatigue occurs sub-surface meaning that the requalification process cannot detect sub-surface fatigue cracks or defects that eventually propagate and lead to spalls and resultant bearing failure.

No records are kept with the cumulative distance for each bearing, nor is the total service age or history of the bearing considered during the requalification process. More often than not, bearings will continue to be requalified until they are unable to be reused after failing the requalification process. In the absence of a maximum time in service criteria (time or distance based) for determining life expiry of railway bearings or an effective process for detecting sub-surface fatigue cracks, the risk of a bearing failure between requalifications must be managed by monitoring the condition of bearings whilst in-service (refer to section *2.5 Bearing condition monitoring)*. With regard to record keeping and bearing age, Pacific National stated in submission that it is something they are looking at but they have not identified a trend relating bearing age to failure rate Futhermore, they have observed many bearings that are in service for over a million kilometres are found to be in as good, or better, condition than other bearings with less kilometres.

Based on the previous three years of data, Pacific National have an in-service bearing failure rate of about 0.0035 percent, indicating the risk of in-service bearing failure is very low. However the consequences of a bearing failure can be very significant in terms of rollingstock and infrastructure damage as a result of a significant derailment.

The R3 bearing on wagon NPZH 35700U was manufactured in 1986. It is estimated that it had been requalified on 4 separate occasions. The bearing was last requalified on 23 April 2008, before it failed on 24 January 2010 after travelling 98 028 km. The bearing was closely examined as part of the requalification process without any consideration of past use. No defects were noted as part of this examination. No records could be provided detailing previous requalification inspections or distance travelled since the date of manufacture.

It was also noted during an onsite visit to the Pacific National bearing maintainer's office, that grease was applied using a hand gun onto the outer rim of raceways during assembly, unlike other practice of injecting the grease under pressure onto the running surfaces. Not injecting under pressure could potentially lead to initial metal on metal contact during the run-in period, therefore leading to bearing damage.

2.5 Bearing condition monitoring

There are a number of methods used by Pacific National and ARTC to monitor the condition of bearings whilst in-service.

Pacific National regularly inspects and maintains its fleet in accordance with the Pacific National *Train Inspection Manual* and *Wagon Maintenance Manual*. Roll-by checks, performed by passing train crews and other on-track staff, can also detect possible issues with rollingstock, such as grease leakage from bearings. There were no reported issues as a result of previous roll-by inspections with train 2223.

The ARTC have a hot box detector (HBD) and dragging equipment detector (DED) located at Exeter on the Up Main line. These devices are not used for bearing trend monitoring, instead they provide a final defence against bearing failure, albeit once it is in the final stages of failure. The data in this device is stored locally and not available for further analysis by operators.

Other types of condition monitoring include RailBAM[11] and WILD[12] which are not installed on the main south line between Sydney and Melbourne. Although plans had been made to have an operational installation by circa 2007, this did not happen. Operators have direct access to the data collected by RailBAM and WILD for use in their preventative maintenance systems. Due to rake BT22 being dedicated to run primarily between Medway Junction and Berrima Junction, the rake was not trend monitored and only passed HBD and DED. From 31 January 2010 Pacific National began running the 'yo-yo' rakes on special trips through the RailCorp RailBAM facility at Kingswood in the RailCorp network. Pacific National subsequently removed wagons that indicated a medium level alarm or above, for inspection and maintenance.

Data was extracted from the HBD at Exeter and the previous 12 journeys of rake BT22 were compared and examined[13]. The data between 19 January 2010 and 24 January 2010 was examined showing clear repeatable patterns in elevated bearing operating temperatures above ambient air temperature[14], Figure 5. The highest recorded running temperature was the failed R3 bearing on wagon NPZH 35700U at 61.5 °C (47.4 °C above ambient) on 24 January 2010 at 0834, the morning journey, but was not high enough to trigger a warning alarm set at 90[15] °C. The data showed that this bearing was running significantly hotter than the opposite bearing and the average for the rest of the train. Seven other bearings where identified as running hotter than the opposite bearing and the train average, although not all bearings have an escalating temperature signature.

[11] Rail Bearing Acoustic Monitoring.

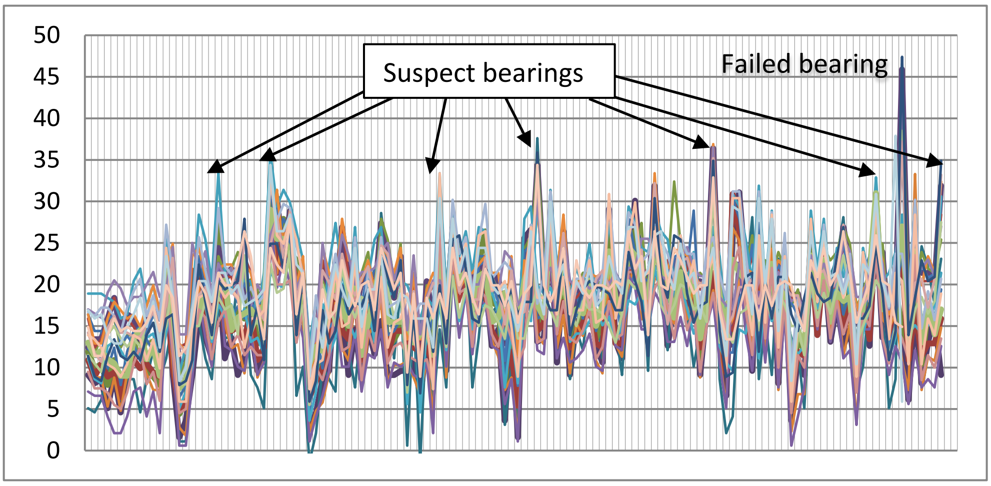
[12] Wheel Impact Loading Detector.

[13] 12 loaded journeys to Berrima Junction.

[14] Actual ambient air temperature sourced from the Bureau of Meterology at Moss Vale.

[15] Based on ambient temperature of 20 °C.

Figure 5: Graph of bearing running temperatures above ambient air temperature



On 9 April 2010 the ATSB investigation team placed non-reversible surface temperature indicating strips[16] on the seven wheel-sets identified as having bearing(s) operating significantly hotter than the average for the rest of the train. The indicating strips were located on the bearing cup. The purpose of the strips was to verify the data extracted from the HBD and to establish the bearings' highest operating temperature during the journey.

On 16 April 2010 the investigation team returned and recorded the maximum temperature achieved for each bearing. The results concluded that:

- The recorded temperatures from the HBD at Exeter were accurate
- The maximum temperature achieved was consistent with the recorded temperatures from the HBD
- The bearings were not heating up significantly more after passing the HBD and would cool down enough before the cycle started again.

As a consequence of the temperature analysis and RailBAM results, all seven of the hottest bearings identified were removed from service, only two of which were inspected further by Pacific National. One bearing examined had a large spall (48x34 mm) and heat scoring, the other failed a rumble test[17] and was almost seized.

Hot box detectors are primarily used as a final defence against bearing failures. The HBD equipment at Exeter only records temperatures for each bearing and stores the data locally. Remedial action by network controllers and train crews is only initated when the bearing is hot enough to trigger an alarm. Newer HBDs exist that compare bearing temperatures across axles and with averages and these systems can provide track managers and operators with better data for monitoring trends provided the data is available to operators for regular analysis.

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16 An adhesive label with a black indicator adjacent to the activated temperature.

17 A manual test for rotation and audible irregularities.

2.6 Train operations

The ARTC Train Operating Conditions (TOC) manual, dated August 2004, contains the instructions and standards for train operations which are used by Train Operators, Network Controllers, Train Planners and others. When addressing the requirements for track speed and wagon loading, the manual makes reference to ARTC document TDS11, Standard Classification of Lines, dated 11 April 2007 (Appendix A). Alterations to the TOC manual are promulgated on the ARTC website.

General Instruction Section 1 *Route Standards*, and the *Southern Sectional Pages*, of the TOC manual indicate the section of track over which train 2224 travelled as class 1 track. However, the ARTC confirmed that the track had been upgraded to class 1C track, but the TOC manual had not been amended. General Instruction Section 10 *Locomotive and Rolling Stock Data* of the TOC manual lists NPZH wagons as class 'F', rated to 100 t loads. The document also makes note that, when operating on class 1 or 1C track, NPZH wagons are restricted to a speed of 65 km/h when loaded to 100 t or 80 km/h when empty (Appendices B and C). When loaded to 92 t, the wagons are permitted to travel at up to 80 km/h on class 1 or 1C track. The *Southern Sectional Pages* of the TOC manual indicate that the maximum allowable speed for class 'F' freight wagons is 65 km/h regardless of whether they are loaded or not. Therefore there is an inconsistency between the speed limits for these wagons specified in the *Locomotive and Rolling Stock Data* section of the TOC manual and those specified in the *Southern Sectional Pages*.

Notwithstanding the contradictory requirements, wagon NZPH 35700U was loaded to about 98 t, which requires a speed limit of 65 km/h in both documents. Data from the Hasler tapes revealed that train 2224 had been consistently operated at speeds of up to 80 km/h, which is up to 15 km/h over the maximum allowable limit.

NPZH wagons were first approved to operate on the then Rail Access Corporation Network on 15 September 1998 via ROVA Mech authority 103-406, and subsequently in the TOC manual on November 1998. The same restrictions applied, in that they were speed restricted to 65 km/h when loaded up to 100 t on class 1 or 1C track. Consequently, it is likely that loaded NPZH wagons have been running up to 15 km/h over speed on the main south line between Medway Junction and Berrima Junction since 1998, and possibly on all other class 1 and 1C lines in New South Wales. Moreover, other wagons (NPIH) used on train 2224 have the same speed restriction placed on them as NPZH wagons. Therefore, it is likely that all other wagons on train 2224 had been operating at up to 15 km/h above their permitted speed.

It should also be noted that other limestone bulk hopper wagons with a loaded capacity of 100 t (NPFH, NPIH, NPJH, NPKH, NPZH) have the same speed restrictions applied when travelling on class 1 or 1C track. It is probable that these wagons have also been operated at speeds in excess of the specified limits.

Given these wagons can travel at 80 km/h when loaded up to 100 t on higher classed track, it is unlikely that the over-speed contributed to the failure of the R3 bearing on wagon NPZH 35700U. However, the risk of a derailment due to vehicle/track dynamics may increase.

The train crew were unaware of the speed restriction applicable to their train, as were Pacific National operational staff generally. It was accepted that class F wagons were restricted to a maximum speed of 80 km/h, without any caveats on operation. Given that the operational caveats on these wagons had been carried over from State Rail, then National Rail, and finally Pacific National, it is reasonable to conclude that the actions of the train crew were consistent with the practice of the rest of the organisation and therefore were not deliberate violations of the rules.

As a result of this investigation, Pacific National have taken action to address this safety issue and stated in submission:

> On completion of our internal report a depot action plan was immediately initiated to alert all train crew of their obligation to ensure these services do not exceed appropriate speed. Further to the initial notification to train crew post the incident, the management team continue to monitor the conformance of train running for the said services.

2.6.1 Timetable

The timetable of train 2224 contained in the ARTC Master Train Plan (MTP) dated 3 January 2010 (refer to Appendix D), was analysed to determine what running times were used and if the timetable was adequate. The timetable for train 2224 was based on the sectional running times documented in the applicable ARTC TOC Waiver 1193 dated 26 August 2005 (refer to Appendix E) for locomotive power (2 x 81 class locomotives), vehicle class (F class wagons), and trailing load (up to 3 000 t).

Based on the ARTC MTP dated 3 January 2010, the travelling time between Medway Junction and Moss Vale is 58 minutes. The travelling time documented in schedule 2 of the TOC Waiver is 57 minutes, the difference being a 1 minute standing start allowance. However, the train control graph allows 70 minutes for train 2224 to travel between Medway Junction and Moss Vale, 12 minutes more than the time listed in the MTP.

Therefore, by virtue of network controllers adding an extra 12 minutes of running time when programming train 2224, the running times documented in the MTP and TOC Waiver were inadequate. Even with the additional 12 minutes running time, train 2224 still needed to achieve speeds of up to 80km/h, (and did based on an examination of actual train running times), to maintain the schedule. Therefore the train control graph programming did not recognise the required speed limit of the train of 65km/h, when the gross weight of the wagons exceed 92 t.

Since the derailment, Pacific National have applied a loading limit of 92 t for the wagons hauled by train 2224, thereby permitting the train to travel at up to 80 km/h and allowing it to operate to the time schedule provided by the train control graph.

The ARTC have stated that:

> While there may have been an error in the MTP it was at best a network capacity issue ... the safety of the train was not dependent on the time table but a signal system, the maintenance of the vehicles involved and correct operation by the train crew. Timetables are train planning and service delivery documents not safety documents.

Since the ARTC have indicated that the MTP is a planning document and not a scheduling document to which trains are expected to operate, the finding that the MTP was inadequate was not considered a safety issue.

3 FINDINGS

3.1 Context

At about 1856 on 24 January 2010 a loaded freight train designated 2224, travelling from Medway Junction to Berrima Junction, derailed at Exeter, New South Wales. It was determined that wagon NPZH 35700U, the second-last wagon in the consist, derailed due to a 'screwed journal' as a result of a wheel bearing failure.

From the evidence available, the following findings are made with respect to the derailment of train 2224 and should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

- Train 2224 derailed as a result of a failed wheel bearing on wagon NPZH 35700U.

3.3 Other safety factors

- The wheel bearings on train 2224, consist BT22, were only being monitored in-service by periodic inspections, roll-bys, and hot box detections. These measures were ineffective in detecting the failure of the bearing on train 2224 before it led to the derailment. *[Minor Safety issue]*
- All limestone bulk hopper wagons have been operated up to 15 km/h higher than speeds specified in the Train Operating Conditions Manual, when loaded above 92 t and operated on class 1 or 1C track. *[Significant Safety issue]*

3.4 Other key findings

- The failed bearing had been destroyed so no evidence was found that could be used to determine the likely cause of failure.
- Based on available evidence, it is unlikely that wagon NPZH 35700U was overloaded.
- Based on available evidence, it is unlikely that there were any pre-existing defects within the bogie that may have contributed to the failure of the R3 bearing.
- Based on the examination and condition of the L3 bearing, and that both bearings were requalified by the same company and installed at the same time, it was likely that the failed R3 bearing:
  - was requalified in accordance with procedures
  - was adequately lubricated at the time of requalification
  - was appropriately assembled, handled, and installed correctly.

- No records are kept with the cumulative distance for each bearing, nor is the bearing age or service history considered during each requalification process.
- The HBD equipment at Exeter is a final defence against wheel bearing failure. It records temperatures for each bearing and stores the data locally. The data is not readily available for further analysis by train operators and therefore it cannot be used to monitor in-service bearing temperature trends.

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 Pacific National

4.1.1 Bearing condition monitoring

Minor Safety issue

The condition of the bearings on train 2224, consist BT22, were not being trend/predictive monitored in-service other than by periodic inspection, roll-bys, and hot box detections.

Action taken by PN

From 31 January 2010, Pacific National began running consist BT22 (and the other similar consists) on special trips through the RailBAM facility at Kingswood in the RailCorp network. Pacific National also advised that additional equipment is being programmed for installation on this corridor.

ATSB assessment of action

The ATSB is satisfied that the action taken by Pacific National adequately addresses the safety issue.

4.2 Train handling

4.2.1 Significant Safety issue

All limestone bulk hopper wagons have been operated up to 15 km/h higher than speeds specified in the Train Operating Conditions Manual, when loaded above 92 t and operated on class 1 or 1C track.

Action taken by PN

Pacific National have alerted all train crew operating limestone trains of their obligation to ensure these services do not exceed appropriate speed.

ATSB assessment of action

The ATSB is satisfied that the action taken by Pacific National adequately addresses the safety issue.

APPENDIX A : STANDARD CLASSIFICATION OF LINES

Main lines include crossing loops, refuge loops and 'sidings' where operating speed in excess of 25 km/hr is possible.

Main lines are classified according to the rail use. The rail may be new or approved second hand.

Track Class 4 and 5 are for existing lines only.

The nominal details of each standard class of main line track is as follows:

Table 2: ARTC (TDS11) main line track standard classification

Track class	Rail Section (kg/m)	Type (Weld)	Nominal ballast depth (mm) [note 1]	Sleeper type	Ballast grade
1XC	60	CWR	300	Concrete	Standard
1X	60	CWR	300	Timber	Standard
1C	53/60	CWR	270	Concrete	Standard
1	53/60	CWR/LWR	270	Timber/steel [note 5]	Standard
2	47	LWR	270	Timber/steel [note 5]	Standard
3 [note 2]	40	LWR	200	Timber/steel [note 5]	Standard
3G [note 3]	53	LWR/CWR	150-200	Timber/steel [note 5]	Standard
4	36	Loose rail	150	Timber/steel	Standard/fine
5	30	Loose rail	150	Timber/steel	Standard/fine

Note 1:- Existing track may not necessarily achieve the target ballast depth. New track is to be designed and constructed to the Nominal Ballast Depth shown in the table except that where the line is predominantly for light passenger lines with low levels of freight traffic (less than 2MGT) a ballast depth of 250mm is satisfactory.

Note 2:- Class 3 is considered to be welded rail. In some documents this is confirmed by use of the coding 3W.

Note 3:- Class 3 is considered to be welded rail. In some documents this is confirmed by use of the coding 3W.

Note 4:- The Muswellbrook-Gulgong line was built to 1XC standards but with 53Kg rails.

Note 5:- Steel sleepers may be inserted only with the approval of the General Manager Infrastructure and Asset Management or nominated representative who will specify the requirements for their insertion.

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❐ Pacific National – *Freight Rolling Stock*

CODE	DESCRIPTION	CLASS	MAX GROSS MASS TONNES	TARE TONNES	LENGTH METRES	DRAW CAPACITY MN	BRAKE TYPE	NOTES See Page 1
Open Wagons								
NOBF	Without doors	C	76	22	15.0	0.75	B3	
			80	22	15.0	0.75	B3	**a**
	When conveying containers all possible positions for containers within wagon must be occupied by either empty or loaded containers i.e. 2 x 6 m or 1 x 12 m container (s)							
NOBX	Open	C	76	22	15.0	0.75	B3	
			80	22	15.0	0.75	B3	**a**
NOCY	Open	A	78	28	20.1	1.80	B3	
			80	28	20.1	1.80	B3	**a**
NODY	Open	A	78	24	15.1	1.80	B3	
			80	24	15.1	1.80	B3	**a**
NOEF	Concentrate	C	74	18	11.0	0.90	B3	
NOFF	Ore	C	76	18	11.0	1.80	B3	
NOHF	Concentrate	C	72	21	13.1	0.75	B2	
NOPF	Concentrate wagon, no doors ex NOHF	C	72	21	13.1	0.90	B2	
ROBX	Open	C	76	23	14.9	1.30	B1	
			80	23	14.9	1.30	B1	**a**
ROCY	Open	A	78	28	20.1	1.80	B3	
			80	28	20.1	1.80	B3	**a**
ROHF	Open Coil **(## See Note page 20 – *Coiled steel wagons*))**	C	78	17	10.3	1.30	B2	
			92	17	10.3	1.30	B2	**b,d**
ROKX	Open	C	76	28	23,7	1.30	B3	
			80	28	23,7	1.30	B3	**a**
ROOX	Open	C	76	28	23.7	1.30	B3	
			80	28	23.7	1.30	B3	**a**
ROQF	Open	C	78	17	10.3	1.30	B3	
			80	17	10.3	1.30	B3	**a**
ROSX	Open	C	76	23	14.9	1.30	B1	
			80	23	14.9	1.30	B1	**a**
Bulk Hopper Wagons								
NPCF	Cement	C	74	18	15.0	0.90	B3	
NPEF	Cement clinker	C	76	20	15.1	1.80	B3	
NPFH	Limestone	F	100	23	17.1	1.80	••B3	**g**
			92	23	17.1	1.80	••B3	**b**
			80	23	17.1	1.80	••B3	**f,i**
NPHH	Cement	C	100	24	14.5	1.80	••B3	**h**
		B	Empty	24	14.5	1.80	••B3	**h**
NPIH	Limestone	F	100	27	16.9	1.80	••B3	**g**
			92	27	16.9	1.80	••B3	**b**
			80	27	16.9	1.80	••B3	**f,i**
NPJH	Limestone	F	100	23	17.1	1.80	••B3	**g**
			92	23	17.1	1.80	••B3	**b**
			80	23	17.1	1.80	••B3	**f,i**
NPKH	Limestone	F	100	23	17.1	1.80	••B3	**g**
			92	23	17.1	1.80	••B3	**b**
			80	23	17.1	1.80	••B3	**f,i**
NPPF	Limestone	C	76	18	15.1	0.90	••B2	
NPRF	Cement	B	78	20	12.6	1.80	B3	
NPRY	Cement	B	78	20	12.6	1.80	B3	
NPSF	Flyash	C	74	18	14.5	0.90	B2	
NPZH	Limestone	F	100	27	16.9	1.80	••B3	**g**
			92	27	16.9	1.80	••B3	**b**
			80	27	16.9	1.80	••B3	**f,i**

APPENDIX C : TOC MANUAL SECTION 10 NOTES

EXPLANATION OF NOTES:

FOR LOCOMOTIVE AND ROLLING STOCK DATA

a These vehicles when loaded beyond their published gross mass up to a maximum of 80 tonnes are restricted to routes and speeds as follows when so loaded:

At a maximum speed of 80 km/h	At a maximum of 70 km/h	At a maximum of 60 km/h
Sydney – Brisbane Sydney - Broken Hill Sydney – Albury Sydney - Port Kembla – Moss Vale Maitland - Muswellbrook - Gulgong Orange – Dubbo	Gulgong - Merrygoen – Dubbo Dubbo - Narromine - Parkes Cootamundra - Stockinbingal - Parkes Stockinbingal - Griffith	Joppa Junction - Queanbeyan

b These vehicles must operate on Class 1, 1C or 1XC only, when loaded to **92 tonnes** (for 4 axles) gross or 23 tonnes per axle at a maximum speed of **80 km/h**. Wheel tread hollowing shall not exceed 2mm.

c These vehicles must operate on Class 1, 1C or 1XC only, when loaded to **84 tonnes** (for 4 axles) gross or 21 tonnes per axle at a maximum speed of **100 km/h**.

d These vehicles are permitted to operate at a maximum gross mass of **92 tonnes** on the Class 2 line Cootamundra to Griffith via Temora at a maximum speed of **60 km/h**, also a maximum speed of 15 km/h is to be observed for these vehicles Cootamundra North to Cootamundra West and Cootamundra to Cootamundra West.

e When loaded from **78** up to a maximum of **81** tonnes gross mass **Class E** speeds will apply.

f When loaded with coke to count as 80 tonnes

g Maximum speed when loaded to maximum gross mass-
Class 1 track 65 km/h, **Class 1C track** 65 km/h, **Class 1XC** track 80 km/h Maximum speed when empty 80 km/h

h Not permitted to run on Classes 2,3,4,5 track.

i When loaded to a gross mass of 80 tonnes Class 'C' speed classification can be used.

j Fuel/oil tanks 70 km/h unless stencilled for 80 km/h

k Bogie tank wagons – maximum gross mass and length. Individual vehicles may vary. The following NTAF wagons only have a rivetted underframe and must therefore be classified as Low DRAW CAPACITY (0.75) when calculating trailing loads :- Nos. 5193, 5194, 6006, 6010, 6011, 6019, 6034, 6046, 6055, 6063, 6065, 6066, 6069, 6073, 7276.

l These wagons are not allowed to pass sheep and cattle races, loading platforms, loading banks, stages and other structures erected at platform clearances to heights exceeding 1.372 metres above rail level. They are not permitted to pass through enclosed goods sheds and sheds or buildings erected over hoppers in private sidings or be placed in sidings or on other tracks where the track centres and clearances are known to be restricted.

m As these locomotives are not fitted with de-sanding equipment, when operating as single units or as trailing units in multiple unit consists, **(in track circuited areas only)** the sanding equipment **must be isolated**. If adhesion conditions requires the use of sand, the sand equipment may be cut in and the train worked under block working conditions until the sand equipment is again isolated. If sand equipment is applied continuously or excessively, Train Control must be advised immediately and the procedures of **NGE232** followed.

n Each individual wagon of the pair shall have a gross mass not exceeding 76 tonnes. The maximum mass at rail for either the centre bogies in the wagon pair shall not exceed 38 tonnes at rail.

o Only to operate in approved areas as outlined in **SECTION 1 – Route Standards Page 1**.

p These vehicles can operate loaded beyond their published gross mass up to a maximum of **80 tonnes** on the following Class 2 lines at the maximum speed of **70km/h:**
Gulgong – Merrygoen – Dubbo; Dubbo – Narromine – Parkes; Cootamundra – Stockinbingal – Parkes; Stockinbingal – Griffith.

q When loaded to a gross mass exceeding 84 tonnes up to 87 tonnes, these vehicles may operate up to a maximum speed of 80km/h on Class 1 Main line. Wheel tread hollowing shall not exceed 2mm.

r These vehicles may operate when loaded up to 84 tonnes (for 4 axles) gross or 21 tonnes per axle to a maximum speed of **115km/h** between:

- **Sydney and Albury** *(except between Bundanoon and Marulan)*
- **Parkes and Broken Hill**

On all other Class 1, 1C or 1XC track the vehicle may operate up to a maximum speed of **100km/h** when loaded up to **84 tonnes** (for 4 axles) gross or 21 tonnes per axle.

s This container wagon can be loaded to a maximum height of **4050mm** above rail and operate within the area of operation assigned to Diagram 3 as outlined in **SECTION 5 – Loading Restrictions Page 7**

APPENDIX D : SOUTH ARTC MASTER TRAIN PLAN

TRAIN NO		3912	ST24	SN78	SP36	D221	TM93	7YN2	SN84	2235	2224
LENGTH (Metres)		660	0	0	0	0	800	900	0	385	550
DAYS		SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN
SCHEDULE		C3	XPT	CRail 1	XPL	LOCO	1CE	C1	CRail 1	1	2
STATUS		S	M	M	M	T	T	T	M	T	T
OPERATOR		ARTC	CLK	CTYR	CLK	PNB	PNC	PND	CTYR	PNB	PNB
COMMODITY		SPAREPA	CNYPASS	CNYPASS	CNYPASS	LGHTENG	COALSMT	GENFRGT	CNYPASS	MINLCMT	MINLCLD
Canberra	dep				17:03						
Queanbeyan	arr				17:12						
	dep				17:16						
Bungendore	arr				17:42						
	dep				17:45						
Crisps Creek	dep				18:07						
Tarago	arr				18:09						
	dep				18:13						
Joppa Junction	arr										
	dep	16:04	17:06		18:31			18:23			
Goulburn	arr	16:11	17:09		18:39			18:29			
	dep	16:15	17:12		18:42			18:56			
Medway Quarry	dep										19:30
MAIN SCHEDULE		C3	XPT	CRai	XPL	LOCO	1CE	C1	CRai		2
Medway Junction	arr										19:56
	dep	16:47	17:32		19:03			19:25			20:06
Wingello	arr										
	dep	17:02	17:39		19:11			19:37			20:25
Bundanoon	arr				19:18						
	dep	17:16	17:47		19:19			19:49			20:41
Exeter	arr										
	dep	17:25	17:51		19:24			19:56			20:51
Moss Vale	arr		17:59		19:31			20:06			21:04
	dep	17:40	18:01	18:08	19:32	19:53		20:13	20:41		22:04
Moss Vale Junction	arr										
	dep	17:41	18:02	18:09	19:34	19:54	20:01	20:16	20:42		22:05
BRANCH SCHEDULE		1									
Calwalla	arr										
	dep	17:57									
Robertson	arr										
	dep	18:14									
Mount Murray	arr	18:35									
	dep	19:20									
Summit Tank	arr	19:49									
	dep	20:23									
Dombarton	arr										
	dep	21:01									
Unanderra	arr										
	dep	21:23									
SCHEDULE			XPT	CRai	XPL	LOCO	1CE	C1	CRai	1	2
Berrima Junction	arr					19:58					22:10
	dep					20:03				21:47	22:15
Berrima Cement Works	arr					20:24				22:04	22:32
	dep					------				------	------
Berrima Junction	arr										
	dep		18:03	18:10	19:35		20:05	20:19	20:43		
Mittagong	arr			18:20	19:43				20:52		
	dep		18:10	18:21	19:44		20:15	20:27	20:53		
Bargo	arr			18:43					21:16		
	dep		18:30	18:44	20:04		20:39	20:51	21:17		
Tahmoor Colliery Jct	arr						20:47				
	dep		18:34	18:48	20:10		------	20:57	21:22		
Tahmoor	arr			18:50					21:23		
	dep		18:34	18:51	20:10			20:58	21:24		
Picton	arr			18:58					21:31		
	dep		18:42	18:59	20:16			21:05	21:32		
Maldon	arr										
	dep		18:44	19:02	20:18			21:07	21:35		
Glenlee Junction	arr										
	dep		19:02	19:21	20:33			21:26	21:53		
Macarthur	arr			19:26				21:29	21:56		
	dep		19:04	19:27	20:34			21:33	21:57		
FORMS OR DESTINATION		IHB	CTN	CTN	CTN	TERM	TERM	MDO	CTN	TERM	TERM

APPENDIX E : ARTC SECTIONAL RUNNING TIMES

MEDWAY – BERRIMA - MALDON

UP	CLASS	LOAD TONNES		TRAIN DATA		NOTES
		SINGLE	DOUBLE	Vehicle Class	Sect Run Times	
Berrima Junction – Maldon	81 / 82	1824		ABCD	1	Loaded Clinker
Medway Junction – Maldon	81 / 82		2800	F	2	Loaded Limestone
Medway Junction – Berrima Junction	81 / 82	1824		ABCD	3	Loaded Limestone
Medway Junction – Berrima Junction	81 / 82		3000	F	2	Loaded Limestone

UP Sectional Running Times	1	2	3
Medway Quarry to Medway Junction		26	26
Medway Junction – Wingello		19	22
Wingello – Bundanoon		16	15
Bundanoon – Exeter		10	11
Exeter – Moss Vale		12	11
Moss Vale – Berrima Junction		2	3
Berrima Junction – Mittagong	11	11	
Berrima Junction to Berrima Cement works	17	17	
Mittagong – Bargo	22	27	
Bargo – Picton	14	16	
Picton – Maldon	4	4	

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APPENDIX F : SOURCES AND SUBMISSIONS

Sources of Information

Australian Rail Track Corporation

Bureau of Meteorology

MainTrain Auburn, New South Wales

Pacific National (Asciano Ltd)

RailCorp New South Wales

Schaeffler Group (Bearing Engineering Solutions)

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 Pacific National, Australian Rail Track Corporation, Independent Transport Safety Regulator NSW, and a number of individuals.

Submissions were received from Pacific National, the Australian Rail Track Corporation, and the Independent Transport Safety Regulator of New South Wales. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Derailment of freight train 2224, Exeter, NSW, 24 January 2010