Report 08-111: Express freight Train 524, derailment, near Puketutu, North Island Main Trunk, 3 October 2008

Final Report

Rail inquiry 08-111

Express freight Train 524, Derailment near Puketutu, North Island Main Trunk, 3 October 2008

Approved for publication: June 2011

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

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Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1980 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.

Location of accident

Source: mapsof.net

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Abbreviations

Commission	Transport Accident Investigation Commission
DB	dynamic brake
km	kilometre(s)
km/h	kilometre(s) per hour
LPG	liquid petroleum gas
m	metre(s)
mm	millimetre(s)
NIMT	North Island Main Trunk
POD	point of derailment
t	tonne(s)
UTC	universal co-ordinated time
ROCOCD	rate of change of cant deficiency

Glossary

cant	the amount by which one running rail is raised above the other rail
cant deficiency	the difference between actual cant and the theoretical cant that would have to be applied to maintain equilibrium at a nominated speed
circular curve	a curve of constant radius
curve speed	the speed that is permitted on a curve with associated transitions when radius, cant, cant deficiency and rates of change of cant deficiency (ROCOCDs) have all been taken into consideration together with the characteristics of the trains
rate of change of cant deficiency	the rate at which cant deficiency is increased or reduced relative to the maximum speed of a vehicle travelling around the curve
track twist	the variation in cross level over 4 metres (m) along a track
void	the vertical movement under a track structure when a load is applied

Data summary

Vehicle particulars

Train type and number:	express freight Train 524
Classification:	DFT and DC class locomotives hauling 28 wagons
Operator:	KiwiRail

Date and time	3 October 2008 at 0222[1]
Location	between Puketutu and Te Kuiti on the North Island Main Trunk (NIMT)
Persons involved	one
Injuries	nil
Damage	moderate

[1] Times in this report are New Zealand Daylight Times (UTC + 13 hours) and are expressed in the 24-hour mode.

1. Executive summary

1.1 On Saturday 3 October 2008, the second-to-last wagon on express freight Train 524, wagon UK9007, conveying 2 loaded liquid petroleum gas (LPG) tanks, derailed between Puketutu and Te Kuiti on the NIMT while travelling around a 260-metre (m) radius right-hand curve at the posted line speed of 60 kilometres per hour (km/h).

1.2 The locomotive engineer stopped the train after hearing an automated voice alert from a dragging equipment detector, located about 500 m past the point of derailment (POD). The derailed wagon remained upright and connected to the train. None of the other 27 wagons on the train derailed.

1.3 The LPG tanks were examined and certified as safe by Fire Service personnel and a representative of the consignee before recovery work got underway.

1.4 The cause of the derailment was attributed to a combination of the wagon condition and track condition.

1.5 The Transport Accident Investigation Commission (Commission) has made previous safety recommendations to the regulator to adjust the allowable track and wagon maintenance tolerances to reduce the potential for derailments caused by dynamic interaction.

1.6 The Commission has made one new safety recommendation in this report relating to the way with which temporary speed restrictions are set when multiple track geometry faults within a common section of track are identified.

2. Conduct of the inquiry

2.1 On 7 November 2007, the Commission launched an inquiry (Commission report 07-115) into a derailment near Tokirima on the Stratford - Okahukura Line, involving a bogie flat-top wagon conveying 2 empty, 6 m long LPG tanks.

2.2 Recurring derailments resulting from a combination of track geometry and wagon condition, the quality and consistency of documented standards, rules and codes relating to the handling of derailed wagons conveying LPG tanks, and the emergency response to the derailment were issues identified in report 07-115. On 19 August 2009, 3 safety recommendations were made to the NZ Transport Agency to address these issues.

2.3 While inquiry 07-115 was still underway, wagon UK9007, conveying two 6 m tanks full of LPG, derailed near Puketutu on the NIMT. Because of some similarities with inquiry 07-115, the Commission opened an inquiry under Section 13(1) (b) of the Transport Accident Investigation Commission Act 1990, and appointed an investigator in charge, who travelled to Puketutu to view the incident site, gather information and interview key personnel.

2.4 The event recorder from the train was downloaded and data from it was used to establish the train and driver performance leading up to and during the derailment sequence.

2.5 The draft final report was approved for circulation to interested parties on 20 April 2011.

2.6 Submissions were received from the regulator and the operator. The submissions were considered and included within the final report where appropriate.

3. Factual information

3.1. Narrative

3.1.1. On Thursday 2 October 2008, Train 524 was an express freight train travelling from New Plymouth to Auckland via the Stratford - Okahukura Line. After placing 3 empty wagons at Taumarunui, the train departed at 0044 the next day with a consist of 2 locomotives DFT7329 and DC4346 in multiple hauling 28 loaded wagons, with a gross weight of 1183 tonnes (t) and a total train length of 479 m. A Te Rapa-based locomotive engineer took up the running of Train 524 from Taumarunui after changing over from southbound express freight Train 533.

3.1.2. The locomotive engineer had engaged the dynamic brake (DB) at 0219 to control the train speed while travelling down an 8-kilometre (km) 1 in 70 grade from Puketutu crossing loop.

3.1.3. The locomotive event recorder showed that at 0221:54, the throttle was moved from DB5 to DB6 and at 0222:20 it was moved from DB6 to DB6.5 to maintain a train speed that complied with the posted curve speed of 60 km/h.

3.1.4. At 0222:34 the rear bogie of wagon UK9007 derailed at 468.580 km NIMT. The derailed wagon was second from the rear on the train and was conveying 2 loaded LPG tanks.

3.1.5. At 0223:04 the derailed bogie was detected by a dragging equipment detector unit located at 469.140 km (see Figure 1). The dragging equipment detector sent an alert to train control and broadcast an alert on the local channel 1 radio. At 0223:15 the locomotive engineer initiated a full service brake application in response to the alert, and while the train was slowing the train controller radioed the locomotive engineer to advise him of the alert received at train control.

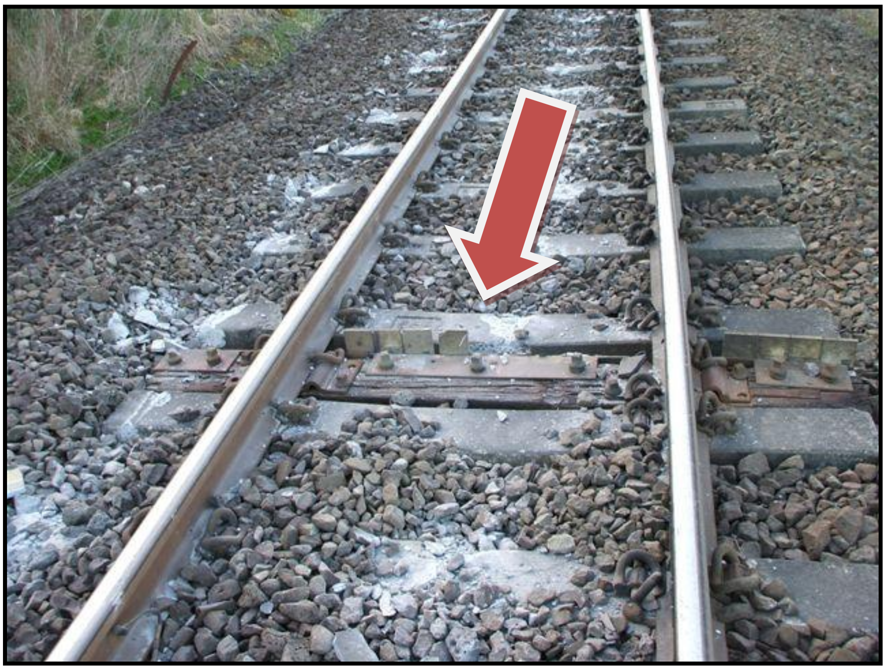

Figure 1
Damaged dragging equipment detector

3.1.6. The train stopped at 0223:55 with the derailed bogie on wagon UK9007 at 469.772 km, some 1192 m past the POD and 632 m past the dragging equipment detector.

3.1.7. After inspecting the train, the locomotive engineer radioed the train controller advising that the trailing bogie of the second-to-last wagon UK9007 conveying 2 LPG tanks had derailed, but that the wagon was upright and remained connected to the train. He reported that there was no apparent leakage from the LPG tanks.

3.1.8. The locomotive engineer and the train controller agreed that the locomotive engineer would firstly secure the train and then remain near the locomotive cab until the LPG tanks had been assessed by Fire Service personnel.

3.1.9. KiwiRail infrastructure staff met the Fire Service personnel at the public road crossing closest to the derailment site and directed them towards the disabled train. The derailed wagon was inspected and the Fire Service personnel confirmed that the LPG tanks were not leaking and were safe to lift and move.

3.1.10. The overhead power feed was turned off at the train control centre before traction field staff were called to attend. The overhead power was earthed and isolated before any recovery work got underway.

3.2. Site information

3.2.1. The NIMT ran from 0.0 km at Wellington to 680.76 km at Auckland. The maximum authorised line speed for express freight trains operating on the line was 80 km/h. Freight trains operating between Waikanae (56 km) and Hamilton (542 km) were signalled by train control under Centralised Traffic Control regulations.

3.2.2. The track materials leading up to the POD consisted of 50-kilogram-per-metre continuous welded rail fastened to concrete sleepers with Pandrol clips. The 22-year-old rail and the 13-year-old concrete sleepers were fit for purpose.

3.2.3. The POD was confirmed as 468.580 km. Wagon UK9007 derailed to the right-hand side (low-leg) in the body of a 260 m radius right-hand curve, 25 m past the start of the circular curve (see Figure 2).

3.2.4. The witness mark on the low-leg rail indicated that the leading axle of the trailing bogie on wagon UK9007 derailed to the inside of the right-hand curve. The mark from the flange ran along the rail-head for 5.254 m before dropping off to the field-side of the rail. A second mark, from the trailing axle of the trailing bogie on the wagon, started to climb on to the head of the right rail, 3.02 m past the POD, and dropped off at 8.654 m past the POD.

3.2.5. The transition length[2] to the curve was 48 m, which was between the minimum 35 m and standard 70 m transition length set out in KiwiRail's Track Supplement 33 (Curves: Design criteria, speeds and records). For curves with a radius of between 251 m and 300 m, the standard track gauge was 1068 millimetres (mm) and the cant was 70 mm.

3.2.6. The cribs and ballast shoulders were full at the POD, with more than 200 mm of ballast under the sleepers. However, the formation was not well drained. An engineering inspection carried out on 13 August 2008 had identified 5 separate mud spots, each up to 30 m long, on both the derailment curve and the adjoining 250 m long reverse curve of the same radius.

3.2.7. The derailment curve had been de-stressed during 2002 and the curve had not been mechanically tamped and lined since November 2003.

[2] The transitional length is the distance from straight track to the start of the circular curve, providing a uniform rate of increase in cant from zero to the full curve cant.

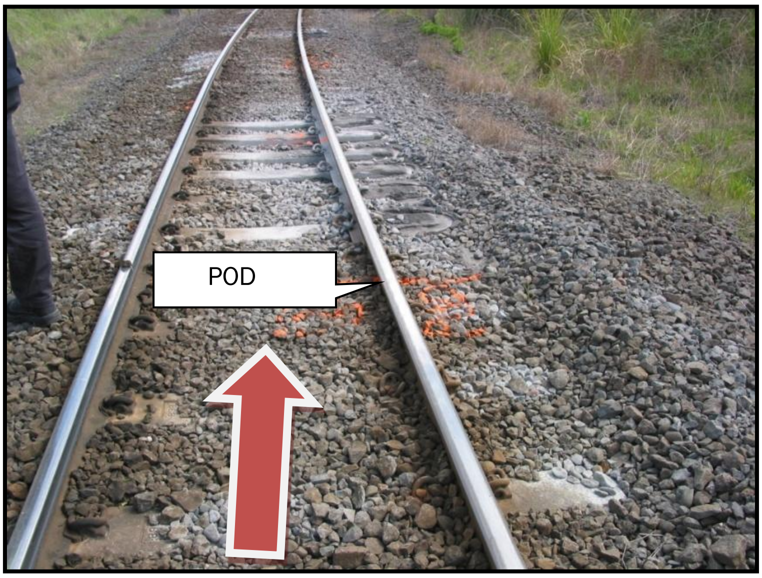

Figure 2
Location of the derailment

Track measure-up

3.2.8. The post-derailment measure-up of the track geometry was carried out manually under static loading conditions[3]. At the time of the measure-up, there was a 5 m long soft spot under the right rail (low-leg) from the POD (see Figure 3) to the drop-off point. A void meter was not used to measure the extent of vertical displacement, but it was estimated to be between 10 and 15 mm.

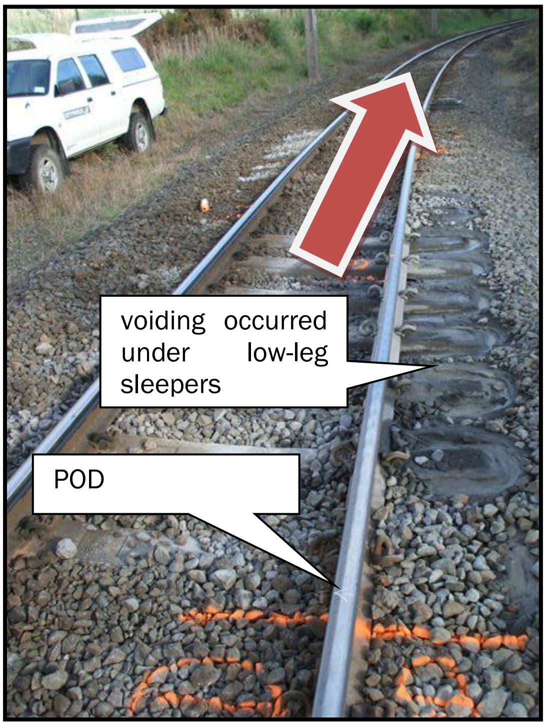

Figure 3
Soft spot near the POD

[3] Without the load of a train or EM80 car on the track.

3.2.9. The static measure-up identified minor twists near the POD. The twists were individually less than the priority 3 maintenance tolerance limits of 16 mm and therefore would not have been assessed as requiring immediate remedial action. However, the assessment did not make any allowance for track displacement due to the voiding at the soft spot and did not take into account the cyclic nature of the twists, which were recorded as:

- a positive 12 mm twist at 6 m before the POD
- a negative 9 mm twist at 6 m past the POD
- a negative 13 mm twist at 18 m past the POD.

3.2.10. Calculations using the data from the track measure-up confirmed that the ROCOCD was generally within code tolerance limits, so the imposition of a temporary speed restriction was not required. However, the peak values for the ROCOCD were cyclic in that they were negative 212 at 10 m before the POD, positive 261 at 2 m before the POD and negative 284 at 3 m past the POD.

3.2.11. Track inspections were supplemented by an EM80 track evaluation car run over the NIMT at least twice per year. The 4-wheeled, self-propelled rail service vehicle, with a 15 t axle load, measured and recorded track geometry including gauge, cant and line, and compared the actual readings with predetermined tolerance limits. An exception report was generated that identified the location, type and priority for every geometry exceedance. When measuring gauge, the EM80 applied one tonne of side pressure as well as vertical loading to simulate dynamic loads created by a moving train.

3.2.12. To account for the dynamic loading from the EM80, the track geometry maintenance tolerances for the track inspector's static track inspection differed, and so did the priority rating system.

3.2.13. The most recent EM80 run over the Taumarunui to Hamilton section had been carried out on 10 June 2008, 4 months before the derailment. The computer-generated Class 1 and 2 exception report was found to be reporting in error by exactly one kilometre. Exceedances between 468 km and 469 km (where the derailment occurred) were reported as being between 469 km and 470 km. A 17 mm twist was reported at 469.554 km (it should have been 468.554). Similarly, track gauge exceedances of 1088 mm, 1089 mm and 1088 mm near the POD were reported at 469.554 km, 469.577 km and 469. 600 km respectively, instead of one kilometre less. The EM80 run did not identify any out-of-code ROCOCDs on the derailment curve.

3.2.14. The track gauge exceedances fit into a Class 2 category, which meant they should have been repaired within 3 months (one month before the derailment). At the time of the derailment there was no outstanding track maintenance work recorded for the section of track where the derailment occurred.

3.3. Code requirements for track inspections

3.3.1. KiwiRail's Track Code, T003, required the mainline and crossing loops on the NIMT to be inspected twice per week, with a maximum 5 days between inspections. The objective of these inspections was to identify defects and programme corrective actions such that the track was maintained within defined limits for track geometry and material condition.

3.3.2. The requirements of a track inspection included:

- looking for any significant change to top or line and checking they were satisfactory
- checking that drains and waterways were clear
- observing trackside signs to ensure they were in place and visible
- checking areas that had been specially listed in the essential features list
- checking for any other matters that could affect the safe running of trains.

The track inspector recorded each inspection and all findings on an approved form. The report included essential data such as date of inspection, length inspected and the priority of all defects and out-of-code items requiring attention to prevent further deterioration.

3.4. Wagon inspections

3.4.1. KiwiRail's Mechanical Code M2000, Issue 7, effective 1 April 2007, required all freight wagons to have pre-departure checks. These checks were carried out by operational yard staff to ensure that the made-up trains were secure and complete and to observe the condition of brake blocks and air hoses and the status of hand brakes. Each person carrying out a check signed a Train Inspection Certificate to confirm that the train was in a proper condition for safe running. This certificate was attached to the Train Work Orders and remained in the locomotive cab until the train arrived at its destination.

3.4.2. B-checks and C-checks were performed in accordance with KiwiRail's code supplement M9202. B-checks covered safety-critical items and were performed each time 2 or more brake blocks were replaced. The more detailed C-check was performed at nominal 24-month intervals with an upper limit of 27 months. A C-check was brought forward when a wagon was involved in a collision or derailment or had a fault with the braking system.

3.4.3. The C-check requirements for the bogie/suspension included the following checks:

Springs:	In place, secure and intact.
Bearing keeps:	Held securely in place.
Liners:	Secure and not broken. Not worn more than 50% of original thickness.
Wedge heights:	Within code limits.
Bearing adapters:	In place and not damaged or worn.
Side bearer:	Not damaged or worn.
Bearings:	No sign of overheating. Cap bolts in place. Backing rings secure. No excessive grease leaks.

3.4.4. Narrow bearing adapters as shown in Figure 4 were fitted to the Type 14 bogies associated with the UK class wagon fleet. The bearing adapters are machined components necessary for the correct fitting of a package bearing to a bogie and the distribution of the load. The adaptors can be inspected for wear in service but must be inspected whenever a wheel-set is removed from a bogie, and during each B-check and scheduled C-check.

3.4.5. A bearing that has been operating satisfactorily in a narrow adaptor will "creep" in service, causing 2 wear bands to appear on the outer race of the bearings and the bearing seat pads. These 2 wear bands should have no visible depth, be consistent and extend completely around the bearing.

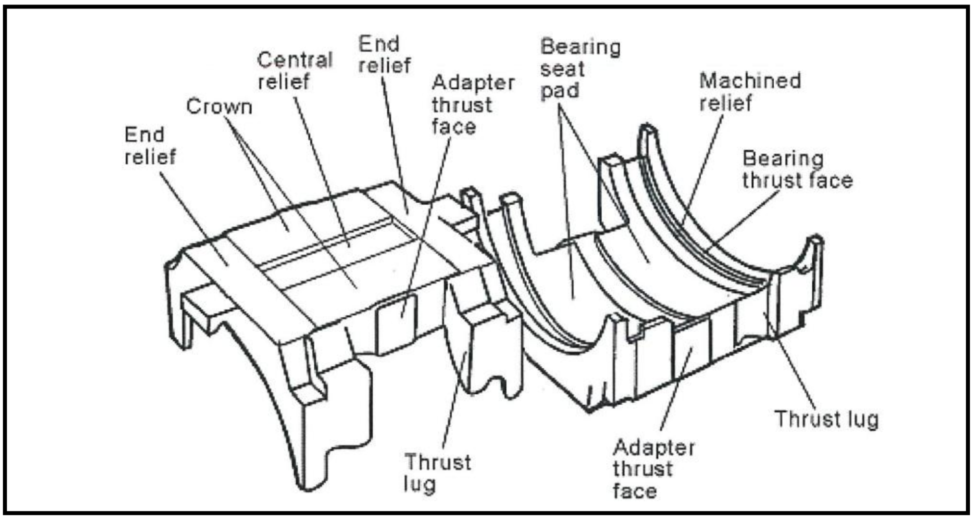

Figure 4
Nomenclature for narrow bearing adapter

3.4.6. KiwiRail's TG-BO-108 Revision A1, dated 14 November 2003 stated in part:

> *For in-service inspections, bearing adapters must be removed from service when:*
>
> *The adapter is cracked or broken.*
>
> *The wear band on the bearing is wider than normal, extending towards the end of the bearing [indicating excessively worn adapter thrust face].*
>
> *A separate narrow (up to 1 mm) wear band is visible around the edge of the outer race.*
>
> *The adapter is displaced or crooked on the bearing. Note this may also result in damage to bearing requiring the wheel set to be removed from service.*
>
> *The crown has worn to less than 1.6 mm.*

3.5. Wagon UK9007

3.5.1. The UK class bogie wagon was a general-purpose, low-deck wagon used to convey a combination of different-sized containers. The wagon had a tare weight of 14.3 t and was designed to carry a payload of 43 t, giving a maximum gross wagon weight of 57.3 t.

3.5.2. The UK wagons were fitted with standard 3-piece bogies commonly used on freight wagons throughout the world. The 3 main pieces were one bolster and 2 side frames (see Figure 5).

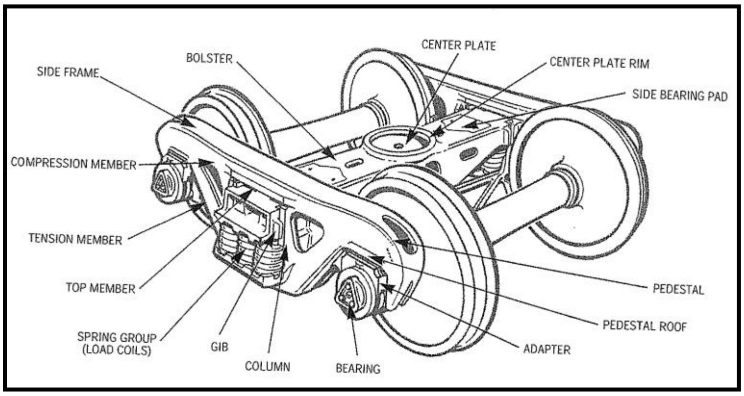

Figure 5
Bogie component nomenclature

3.5.3. Wagon UK9007, conveying 2 LPG tanks, was travelling with its handbrake trailing. The declared weight was 41.2 t (see Figure 6).

Figure 6
Wagon UK9007 with LPG tanks

3.5.4. On 3 September 2008, wagon UK9007 had derailed at the frog of number 60 points within Timaru freight yard during a propelling movement. The cause of the derailment was attributed to wide gauge.

3.5.5. On 25 June 2008, a B-check had been carried out on UK9007 at Westfield maintenance depot. During this check all 8 brake blocks had been replaced, the triple valve and draw-gear repaired and cracks on the underframe repaired. Wheel-sets 1 and 2 were worn and required either re-profiling on the wheel lathe or replacement. Similarly, wheel sets 3 and 4 exhibited spalling and required re-profiling. Rather than wait for access to the wheel lathe, all wheel sets on the wagon had been replaced with refurbished units. Maintenance records indicated that all the bearing adaptors had been replaced with second-hand components.

3.5.6. The 2-yearly wheel bearing survey, scheduled for 28 March 2008, had been completed on 25 June 2008 with the B-check.

3.5.7. The most recent C-check had been completed on 1 November 2007. Maintenance work included changing the triple valve, re-profiling wheel-sets 3 and 4, repairing the brake rigging, repairing a hand-grab, draw-gear and coupling pins and replacing all 8 brake blocks. The C-check recording sheet confirmed that all 8 bearing adaptors on wagon UK9007 had passed the inspection criteria in that they were seated correctly, were not cracked and the gap visible between the adaptor crown and liner exceeded 0.5 mm.

3.5.8. Maintenance records confirmed that the previous 2-yearly C-check had been completed on 9 July 2005. All 8 bearing adaptors had been replaced at that time.

Post-derailment examination of wagon UK9007

3.5.9. The derailed wagon was dragged about 1.2 km before the train stopped. The bearing adapter from the left side of the leading axle on the trailing bogie (first wheel-set to derail) was missing, the bearing had been leaking and grease was observed on the field side of the bearing and splattered on the side-frame horn (see Figure 7).

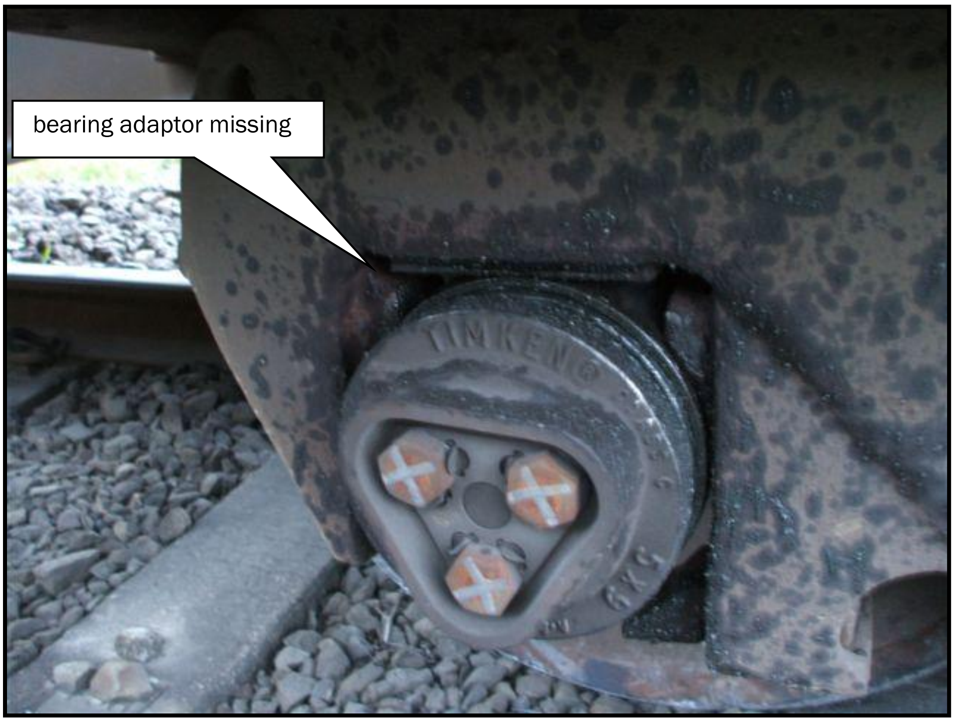

Figure 7
Journal bearing arrangement on A2 wheel-set

3.5.10. The bearing adaptor had failed through a region that included the thinnest section of material. The MLD1 Report[4] showed that one section of the bearing adapter was found on the vehicle access road at 468.570 km, 10 m before the POD. KiwiRail contended that this section of the bearing adaptor was found 10 m past the POD. In discussion, 2 years later, with the KiwiRail Network employee who had recovered the failed section, he could not recall whether it had been picked up 10 m before or after the POD. Nevertheless, the diagram accompanying the MLD1 showed that it was recovered 10 m before the POD. The other section was recovered 94 m past the POD and 6 m from the left rail. These recovered bearing adapter sections were taken to an independent metallurgy laboratory for analysis. The laboratory report is summarised in Appendix 1.

3.5.11. Friction wedge liners were missing from the derailed bogie, and despite an extensive search they were not located. Without the liners, the friction wedge height could not be measured. The most recent wedge height measurements had been recorded during the B-check on 15 June 2008 (about 4 months before the derailment) and had been recorded as 30 mm on both the A-side and B-side at the handbrake end, and 24 mm on the A-side and 25 mm on the B-side at the non-handbrake end of the wagon. For Type 14 bogies the wedge height measurement was required to be less than 42 mm.

3.5.12. A UK class wagon with refurbished Type 14 bogies had wedge height readings of between 18 mm and 21 mm. The wedge height measurement would normally increase by about 3 mm per year on a wagon travelling an average distance.

3.6. Movement of hazardous substances

3.6.1. LPG tanks, whether empty or loaded, were classified as Dangerous Goods Class 2.1 and restrictions relating to their conveyance were included in KiwiRail's Rail Operating Code, Clause 1.45. Wagon UK9007 was correctly marshalled on Train 524 in accordance with these restrictions.

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[4] The MLD1 Report is the mainline derailment report prepared by KiwiRail Network.

3.6.2. The train documentation carried in the locomotive cab included a train information sheet, which identified wagons conveying hazardous goods, including the class of goods and the position of the wagon on the train. Wagon UK9007 was listed correctly and identified on the train manifest as conveying Dangerous Goods Class 2.

3.6.3. The locomotive engineer's AH6 certification, issued pursuant to Section 82 of the Hazardous Substances and New Organisms Act 1996, was current and he was authorised to transport Dangerous Goods Classes 1 to 5.

4. Analysis

4.1 There was nothing in the manner in which Train 524 was being driven that could have contributed to the derailment. The locomotive engineer had been using DB for about 6 minutes before the derailment and was maintaining the maximum line speed while descending a steady 1 in 70 grade.

4.2 An analysis of the event recorder download confirmed the locomotive engineer had been alert since taking over the running of the train from Taumarunui. He responded promptly and properly to the channel 1 alert broadcast from the dragging equipment detector positioned 560 m past the POD. After making a full service automatic brake application 11 seconds after the derailed wagon passed over the detector, the train was stopped within 39 seconds and no other wagons derailed. The train stopped 502 m after the brake application was initiated.

4.3 Had the derailed wagon not damaged the dragging equipment detector and activated the automated voice alert, the train could have continued to Te Kuiti some 8 km further north, where the derailed wagon would almost certainly have caught up in the facing points with more severe consequences, which highlights the benefit and importance of dragging equipment detectors.

4.4 The morphology of the fracture in the bearing adaptor indicated that it started at the underside curved section and broke from the bearing side towards the top surface. The largest castellations were close to the thinnest material section where stresses would be expected to be higher. No material imperfection was detected that might have initiated fatigue cracking. However, there were indications that a fatigue failure had occurred: the presence of numerous castellations, from large ones at the thin region to smaller ones towards the sides in the thicker sections; and the gradually coarser appearance of the grains towards the top surface.

4.5 Considerable wear was present on several surfaces of the bearing adapter. Wear on the thrust face and inner thrust lugs indicated that the bearing adaptor had moved axially. Wear on the adapter thrust faces and on the bearing seat pad was not as severe. Nevertheless, this indicated that rotational movement had occurred to a limited extent.

4.6 Apart from the angled scratches on one of the faces of the bearing seat pad, which were likely to have been made after the bearing adapter failed, the wear pattern was consistent with normal in-service wear.

4.7 The several similar and severe indentations on the crown near the end relief, shown on Figure 12 (a), indicated that a foreign object had probably become entrapped, but it could not be determined when this would have happened.

4.8 Wagon UK9007 had derailed in Timaru freight yard one month before it derailed at Puketutu. It was possible that the A2 bearing adaptor had been in a displaced position since the wagon was lifted back onto the track at Timaru. Foreign material could have been entrapped above the bearing adaptor at that time.

4.9 The proximity of the indentations to the fracture and the largest castellations suggests that the entrapment of foreign material and repeated loading and unloading may have influenced the initiation of fatigue cracking within the bearing adaptor.

4.10 No material imperfection was observed to be associated with the fatigue failure, and hardness values indicated that the matrix of the material had reasonable strength.

4.11 The secondary cracking observed in the centre relief near the end relief, associated with the character "0" in Figure 16 a, was considered to have been additional cracking due to the final overload failure and not indicative of a load applied to the top surface of the bearing adaptor. Because the crack was fairly open, there was probably mainly tensile force present at the time of the overload fracture.

4.12 Failure of bearing adaptors is not unknown, which is recognised in the maintenance schedule requiring checks to be made; however, in-service failure of a bearing adaptor leading to a derailment is not a common event. Of the 438 derailments recorded on the controlled network between 6 April 2000 and 18 September 2008, none was attributed to a bearing adaptor failure.

4.13 The perplexing aspect of this derailment was the question of whether the failure of the bearing adaptor caused the derailment in this case, or whether the bearing was already fractured but simply fell out due to the dynamics leading up to the derailment.

4.14 The failed bearing adaptor came from the leading axle on the trailing bogie, the only bogie on Train 524 that derailed. Part of the failed adaptor was recorded as having been recovered from the vehicle access road 10 m before the POD, which could lead to a belief that this failure contributed to the derailment. However, the bearing adaptor sits within the side frame pedestal, above the roller bearing, and is only held in place by gravity: the weight of the wagon through the pedestal above. Even if the bearing adaptor had fractured beforehand, it would appear unlikely, but not impossible, that it fell out from between the roller bearing and the pedestal above, not without some easing (lifting) of the downward force from the wagon flat bed and its load above. Such an easing of downward force can result from the dynamic movement of the wagon as it negotiates irregularities in the track, often referred to as dynamic interaction.

4.15 If the derailment was the result of dynamic interaction, the question then is, why didn't any of the bogies on the 26 wagons that had just passed over the same section of track derail or the trailing wagon derail? The answer could lie in the condition of the wagon itself. Wagon UK9007 had been inspected in accordance with KiwiRail's mechanical code. The maintenance records were complete and there were no recorded outstanding maintenance issues at the time of the derailment. However, the missing friction wedge liners prevented post-derailment measurement of the wedge heights, one of the most significant wagon tolerances that contribute to a derailment.

4.16 The timing of when the friction wedge liners separated from the bogie could not be determined. They could have separated as a consequence of the derailment or possibly during the previous yard derailment at Timaru.

4.17 The Commission has reported previously on derailments that it has attributed to dynamic interaction between a wagon and the track (report 07-115). The phenomenon can occur when neither the condition of the track nor the condition of the wagon on their own should have caused the derailment, but in combination and at certain speeds the wagon can oscillate, causing wheel lift and derailment. The Commission has made a recommendation previously (recommendation 029/09) for the industry to regulate the allowable maintenance tolerances in both track and wagons to reduce the likelihood of dynamic interaction causing derailments. This recommendation still had an "open" status at the time of this derailment.

4.18 From the post-derailment measure-up of the track geometry and subsequent derailment analysis, there was no single standout track condition that alone should have caused the derailment. The maximum amplitude of each twist was less than priority 3, which meant that no remedial action was required; however, the twists were cyclical in direction over a short distance around the POD, and in the same area where voiding was present.

4.19 Similarly, the maximum ROCOCD values recorded at 10 m and 2 m before the POD and 3 m past were near the upper limit that would have required imposing a 60 km/h temporary speed restriction. However, because of the 260 m curve radius, the line speed on the derailment curve was permanently restricted to a maximum 60 km/h, so no additional speed restriction had been applied.

4.20 Voiding can cause the track to "pump", which could accentuate a twist or ROCOCD. This means that when the effect of the voiding under the right-rail (low-leg) at the POD is taken into account, the true cant, twist and ROCOCD values near the POD would have been greater than measured under static conditions, so in combination they could therefore have contributed to the derailment.

4.21 In summary then, the number and severity of different track faults around and at the POD would seem to have warranted more urgent action following the engineering inspection than had been assigned to it, with an additional speed restriction being in place until the condition of the track had been improved.

4.22 Speed restrictions are imposed for many reasons, including the general deterioration of track condition, to manage the safe operation of trains. KiwiRail's current guidelines for imposing such temporary speed restrictions only consider track geometry exceedances individually, rather than collectively. The overall condition of the track where the derailment occurred suggests that a review of the guidelines and the maintenance tolerance limits should be undertaken by the network provider.

4.23 Derailment due to dynamic interaction was a real possibility. The laboratory report on the bearing adapter failure showed that it had begun to fail in fatigue. It would seem unlikely, however, that it failed and caused the derailment for the reasons given above. The final failure of the bearing adaptor may have occurred as a result of the wagon oscillating as it passed over track that was, in the opinion of the Commission, outside maintenance tolerances, which could explain why a broken section of the bearing adaptor was found beside the track before the POD.

Emergency response

4.24 The train control centre was the receiving point for notifying an emergency on the controlled rail network. When the locomotive engineer notified the train controller that the derailed wagon was conveying LPG tanks, a full emergency response was initiated in accordance with documented procedures. The locomotive engineer retreated to a safe distance outside the designated buffer zone until the LPG tanks had been examined by specialists.

4.25 The response to this emergency was well co-ordinated and in accordance with the correct procedures, in contrast to the previous derailment involving LPG wagons (report 07-115) that resulted in the Commission recommending improvements in the rail response to such emergencies (recommendation 30/09). The status of this recommendation has since been changed to "closed acceptable", partly due to changes made in emergency response procedures and partly due to the well co-ordinated response to this derailment.

5. Findings

The following findings are not listed in any order of priority:

5.1 Express freight Train 524 was being operated in accordance with standard operating procedures and within the speed limits set for the area where the derailment occurred.

5.2 The track at and near the POD had a number of conditions that exceeded the standard track parameters, including an ROCOCD that according to track maintenance procedures would have been required to be rectified had they been identified.

5.3 None of the individual track deficiencies on their own required immediate rectification, but the cyclic nature of the track twists and ROCOCD, combined with the voiding in the same area, should have been addressed as a matter of urgency and a temporary speed restriction put in place until this could be done.

5.4 Because of the disruption of wagon components during the derailment, the condition of the derailed wagon could not be assessed with any accuracy, but it is highly likely that the principal cause of the derailment was dynamic interaction between wagon and track where wagon rolling oscillations were compounded by the cyclic changes in track geometry, resulting in wheel lift and derailment.

5.5 The failed bearing adaptor from the bogie that derailed had fatigue cracking prior to the derailment. It could not be established if the final overload fracture that caused the bearing adaptor to fail totally occurred before or as a consequence of the derailment, but nevertheless the failure was unlikely to have contributed to the derailment.

6. Safety actions

General

6.1. The Commission classifies safety actions by 2 types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission during an inquiry that would otherwise result in the Commission issuing a recommendation

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Commission issuing a recommendation.

6.2. No safety actions have been identified in this inquiry

7. Recommendations

7.1. General

7.1.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, a recommendation has been issued to the regulator with notice of this recommendation given to the operator.

7.1.2. In the interests of transport safety, it is important that this recommendation is implemented without delay to help prevent similar accidents or incidents occurring in the future.

7.2. Recommendations

7.2.1. Temporary speed restrictions are used to manage the safety of train operations when a general deterioration in track condition is identified. KiwiRail Network's codes and standards consider track geometry faults such as cant, twist, line, top and rate of change of cant deficiency separately when determining the appropriate speed value.

The Commission recommends that the Chief Executive of the NZ Transport Agency work with KiwiRail to make changes to the codes and standards relating to imposing temporary speed restrictions. Multiple track faults within the same section of track should be considered collectively when determining if a temporary speed restriction needs to be imposed before track repairs are made. (018/11)

On 14 July 2011, the Rail Safety Manager of the NZ Transport Agency replied, in part:

> *We intend to work closely with KiwiRail with an aim to implementing and closing this recommendation as soon as practicable.*
>
> *Discussion on it will commence on publication of the final report and will be ongoing.*
>
> *When implementation is effected and the appropriate evidence has been gathered, we will be liaising with TAIC with a view to closing this safety recommendation.*

Appendix 1: Laboratory report on the failed bearing adapter from wagon UK9007

1.1. Visual examination

1.1.1. The bearing adapter (see Figure 8) was visually examined and the following noted:

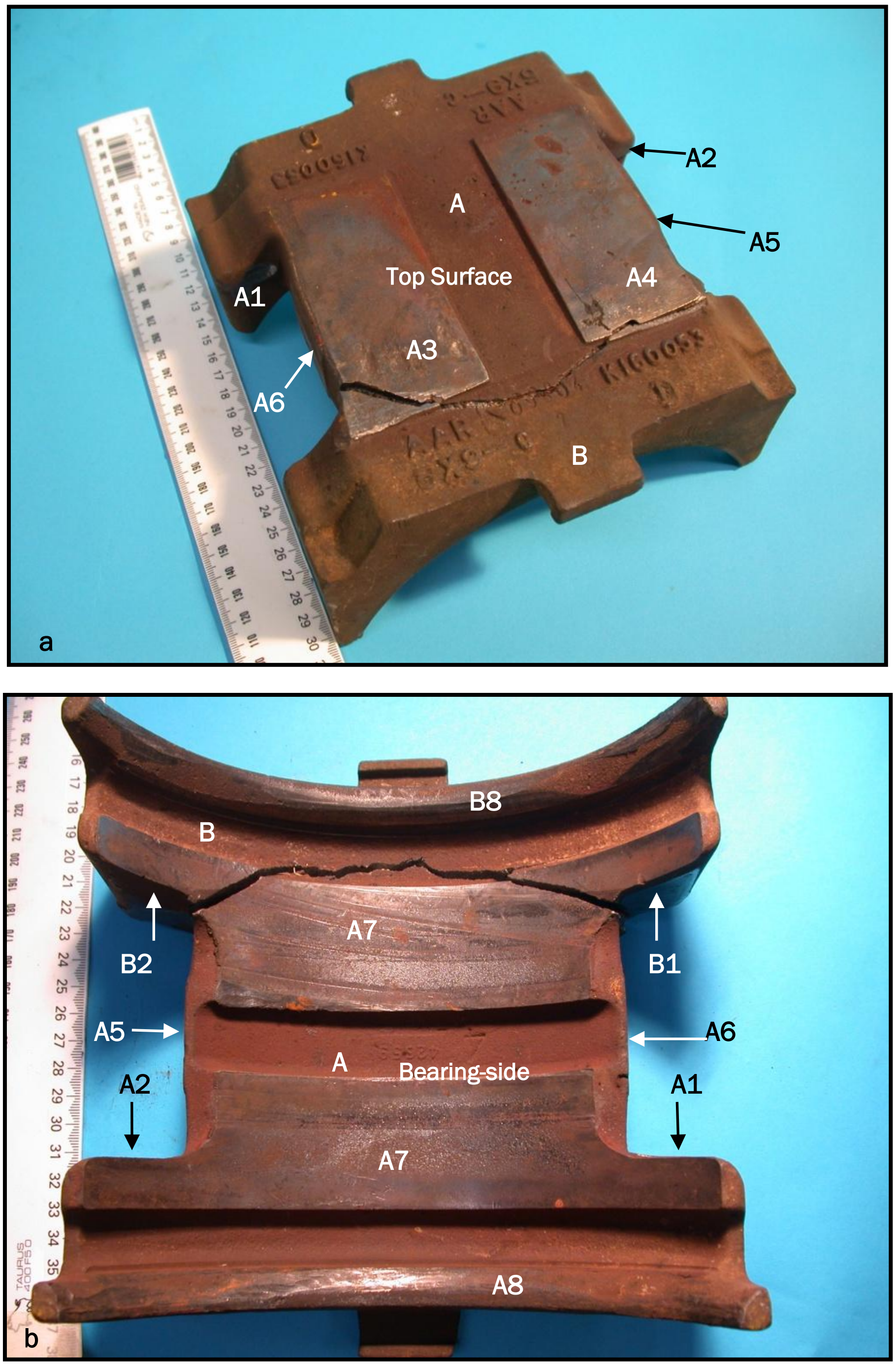

Figure 8
Failed bearing adapter

1.1.2. The bearing adapter had fractured at one end (see Figure 8), through a region that included the thinnest section of material (see Figure 9).

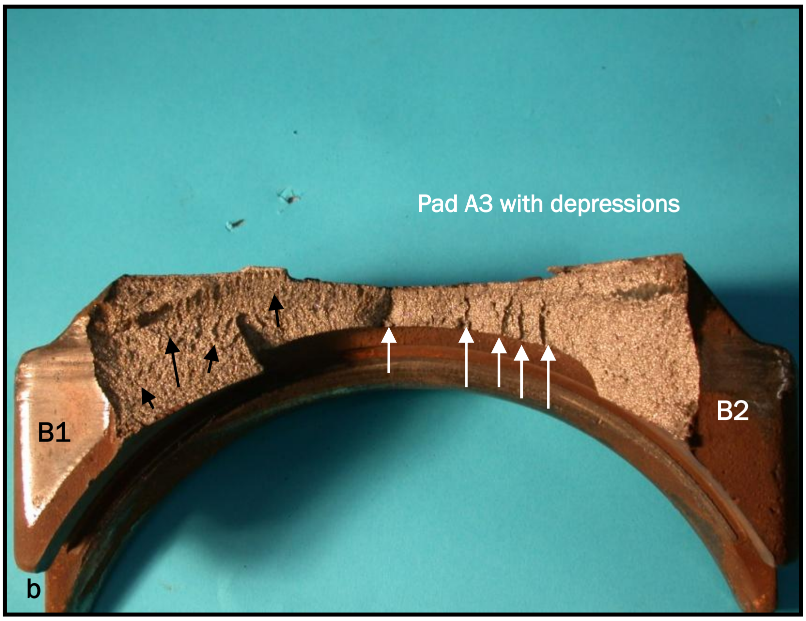

Figure 9
Fracture face on portion B

1.1.3. The fracture was generally fairly coarse, brittle and mostly reflective but with a slight grey tinge (see Figure 9). White arrows indicate steps and black arrows indicate the apparent direction of fracture. The grains tended to become coarser from the curved edge to the relatively flat edge (see Figure 10).

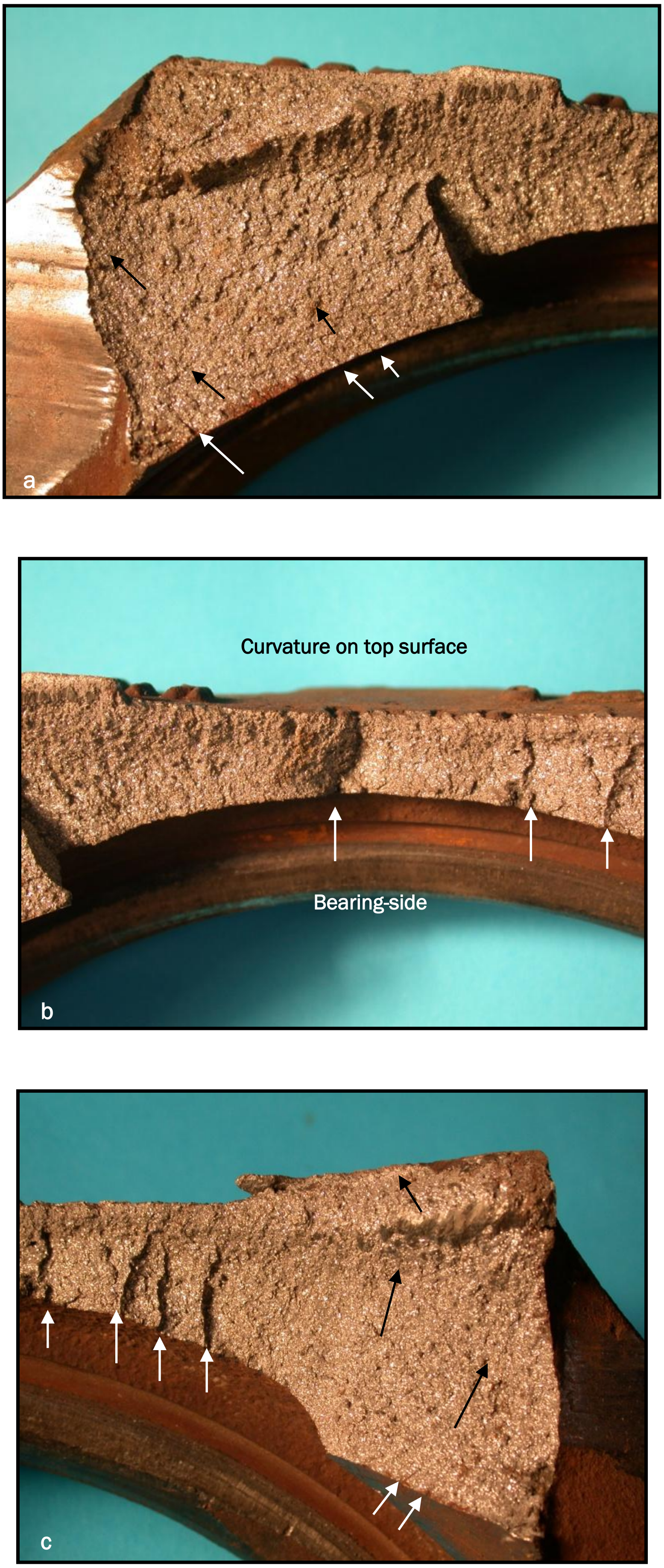

Figure 10
Close-up of the fracture face on portion B

1.1.4. The fracture face had a series of steps that met the curved edge but not the relatively flat edge. Faint ridges could also be seen on the fracture on a macro scale. These and the steps, or castellations, indicated that the fracture initiated at the curved surface. The castellations were largest close to the thinnest section, Figure 10b. Smaller castellations were present on the curved edge at the thicker sections, also indicated by white arrows in Figures 10a and 10c.

1.1.5. The location of the castellations indicated that the fracture initiated at the curved edge and propagated rapidly towards the sides, Figures 10a and 10c, but generally towards the relatively flat edge, the black arrows in Figure 9 and 10 indicating the approximate direction of propagation.

1.1.6. The fracture of portion A contained contaminants. The fracture on portion B was relatively free of contaminants. Both fracture faces were relatively free of corrosion products; portion B being clearer than portion A. Light brown corrosion product on portion A was considered to be a result of corrosion after the fracture occurred.

1.1.7. The edges of the fracture were sharp, Figure 10.

1.1.8. There was a slightly convex curvature on the flat surface of the bearing adapter that appeared to reach a maximum departure from straight near the thinnest section, Figure 10b.

1.1.9. Varying amounts of wear were observed in regions on the block. These regions were labelled A1-A8 and B1, B2 and B8, Figure 8 and identified as follows:

- A1, A2, B1 and B2 inside surfaces of the 'arms' that experience contact with adjacent component(s) through movement parallel to the axis of the bogie.
- A3 and A4 referred to as 'pads' experiencing vertical loads from the sideframe.
- A5 and A6 the 'side pads' experiencing loads due to rotational movement of the block and/or adjacent component(s).
- A7 the bearing surface in general.
- A8 and B8, the shoulders, constituted the inner and outer limits of the block beyond which axial movement of the bearing would not normally be possible.

1.1.10. Severe wear, including loss of material had taken place on regions A1, A2, B1 and B2, Figure 11. All of the severe wear included deep scoring with distinct material loss and polishing. The light-moderate wear was mostly polishing wear with slight pitting.

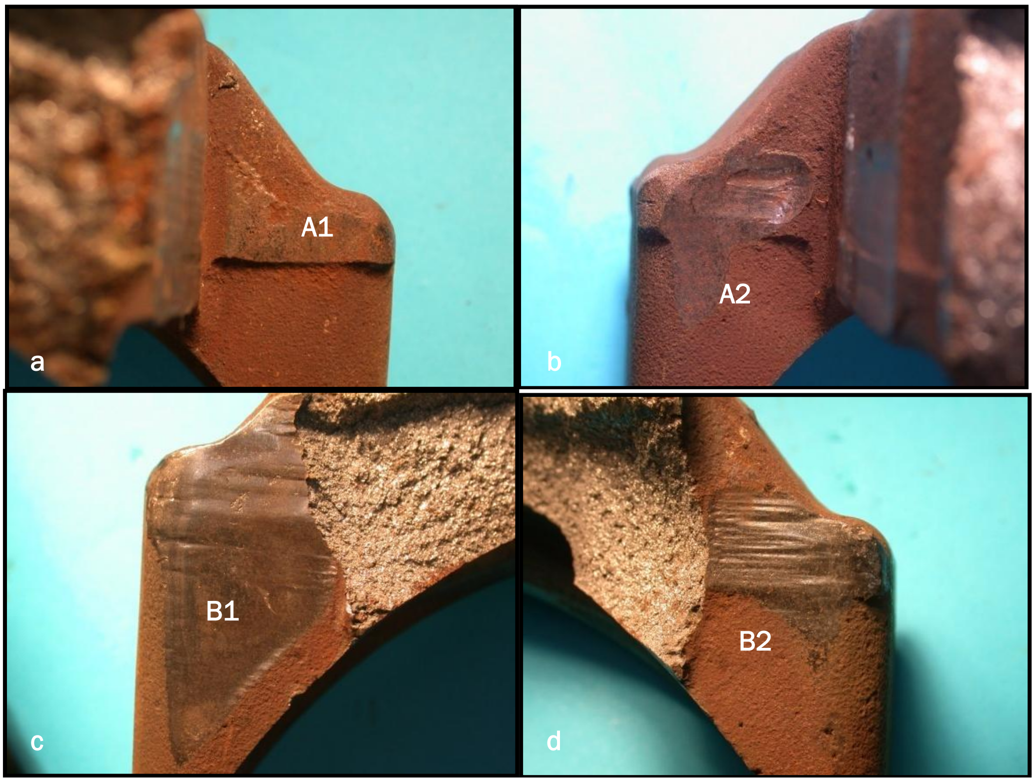

Figure 11
Regions A1, A2, B1 and B2 from Figure 8

1.1.11. Wear on A3 included repeated, fairly deep deformation of a similar shape, Figure 12 that appeared to have been made by an entrapped foreign object. This may have also removed some material. These depressions were close to the fracture and on the same side of the fracture as the most severe castellations, seen in Figures 10b and 10c. Wear on A4 was much less severe but included much smaller and occasional, fairly deep depressions. Both pads had lost material; in A3 this was lost due to fracturing, in A4 a nick was present at the end of the pad.

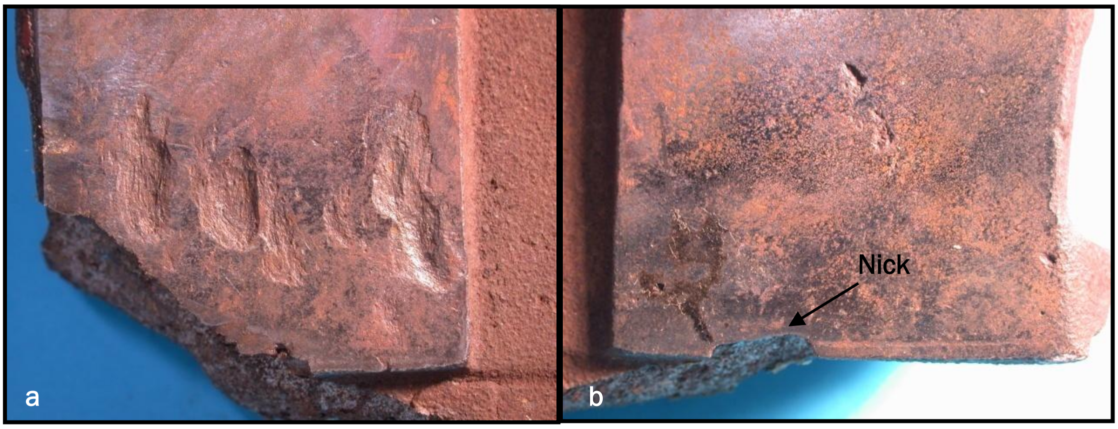

Figure 12
Regions A3 and A4 from Figure 8

1.1.12. Light to moderate wear had occurred on A5. Severe wear, similar to that described for regions A1, A2, B1 and B2 was present on A6, Figure 13.

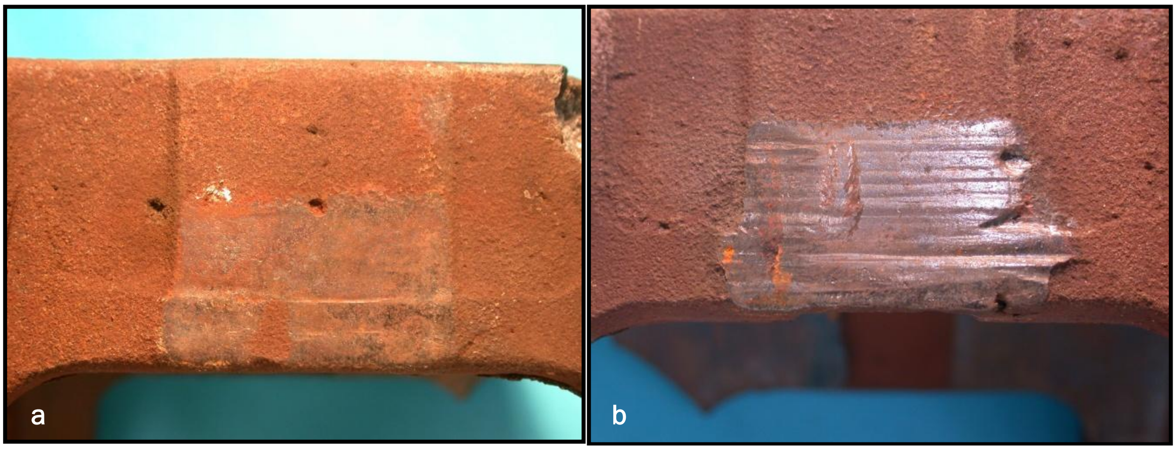

Figure 13
Regions A5 and A6 from Figure 8

1.1.13. The bearing surface, A7, exhibited numerous shallow pits with light corrosion product, Figure 14. In the area nearest portion B, there were angled scratches, Figure 8b. These did not extend on to portion B and are considered to have been made after the block broke.

Figure 14
Surface A5 from Figure 8

1.1.14. A crack was associated with the main fracture, indicated by the yellow arrow in Figure 15a. This would have occurred at the time of fracture.

1.1.15. Wear, causing material loss was evident on shoulders, A8 and B8, Figures 8 and 15b.

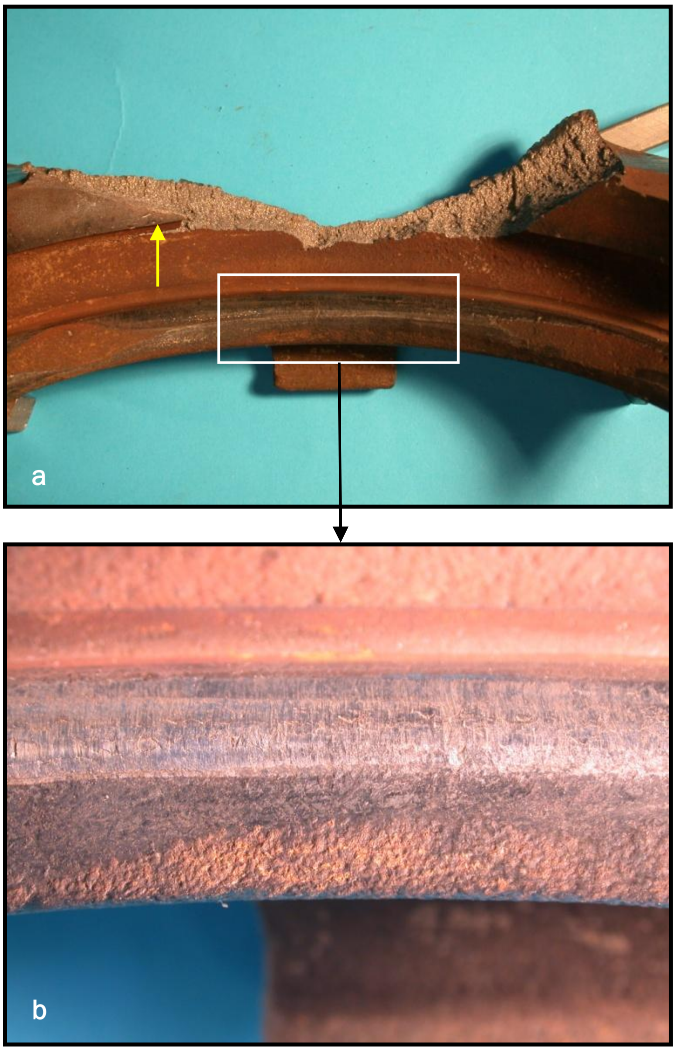

Figure 15
Worn region of the outer rim on portion B

1.1.16. Secondary cracking was present close to the edge of the fracture on portion B, Figure 16a.

1.1.17. On the adjacent fracture surface, there was a small region of relatively old corrosion product, Figure 16b. The fracture was observed to coincide with the trough of the character that resembled the number '0' in what appeared to be an identifier on the casting.

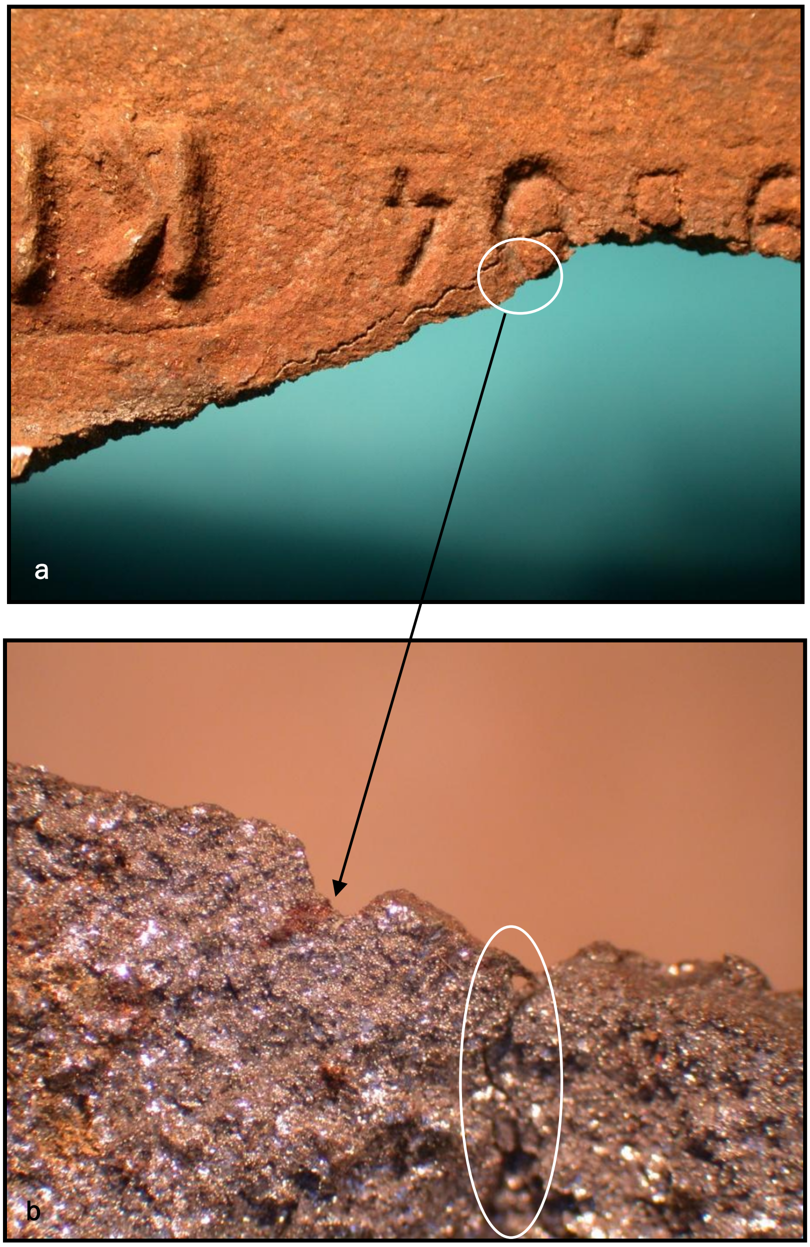

Figure 16
Corrosion at the base of "O" and crack to the right of it

1.1.18. There were occasional small areas of darker corrosion but no substantial corrosion anywhere on the fracture.

1.2. Microscopic examination

1.2.1. A piece of material was taken from the end of one of the arms and prepared metallographically for examination under the optical microscope. The structure was consistent with a nodular (spheroidal graphite) cast iron, Figure 17. There was a high but normal density of graphite nodules, Figure 17a. The graphite nodules were predominantly surrounded by ferrite; however, several nodules were associated with pearlite, Figure 17b. The pearlite was generally fairly dense. The structure was consistent with as-cast material.

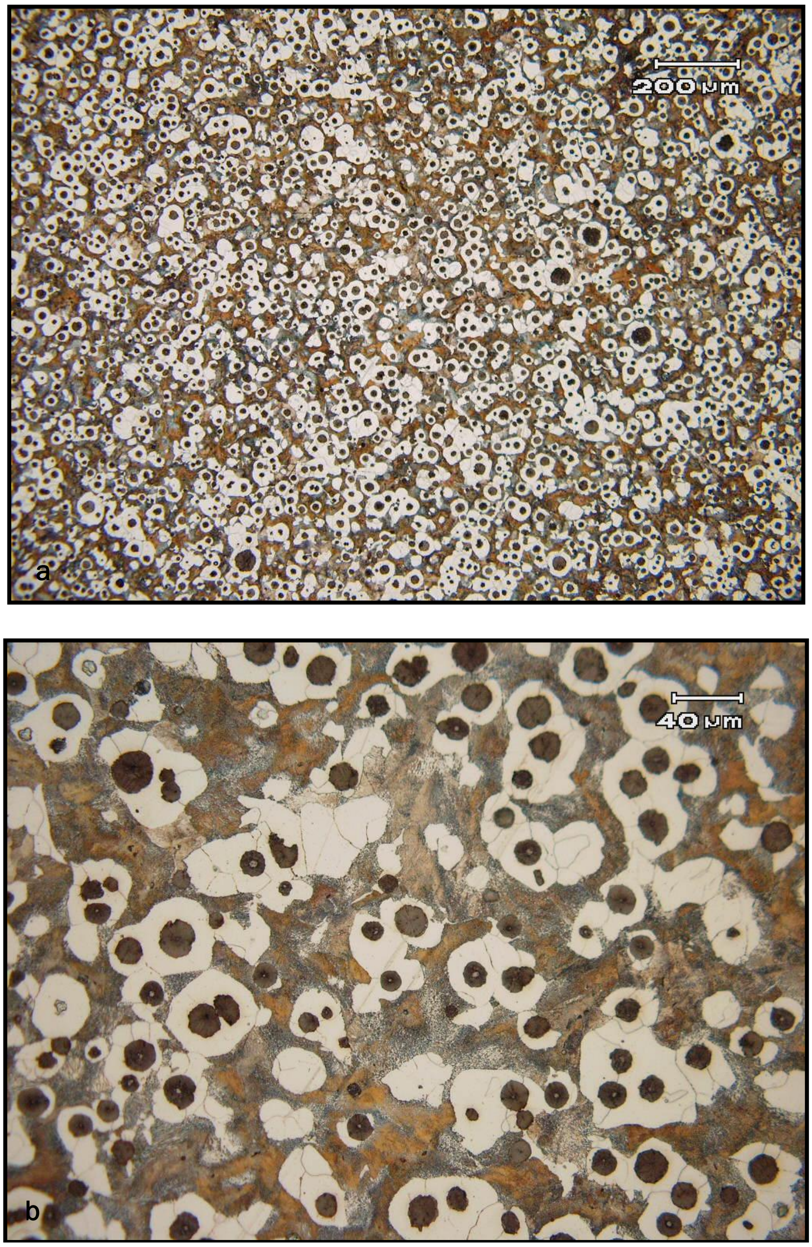

Figure 17
Microstructure of the bearing adaptor

1.3. Scanning electron microscope (SEM) examination

1.3.1. A portion of the fracture at the thinnest section on B, including the region exhibiting corrosion product and notch associated with the number '0', Figure 16b, was examined under the SEM. No evidence of arrest marks or striations indicating fatigue was observed. Cleavage brittle fracture was present in material between many graphite nodules. The absence of evidence of typical fatigue arrest marks is common in cast irons, as cracks may propagate by progressive brittle fracture between graphite nodules (or flakes in flake grey cast iron). In a material with a high density of nodules, such as that observed in the bearing adapter, fatigue may be difficult to detect.

1.4. Hardness tests

1.4.1. Bulk hardness tests were conducted on the material using a Brinell hardness testing machine with a 10 mm ball indenter and 1000 kg load. The hardness values were; 221, 210 and 212 HB.

1.5. Chemical analysis

1.5.1. Chemical analysis was conducted on the metallographic specimen to determine whether the material contained alloying elements. The method used an Energy Dispersive X-ray attachment to an SEM. The method is semi-quantitative and accurate to about 0.1-0.2 weight percent either side of the reported value depending on the element. The method is not sensitive to elements lighter than boron (atomic mass 10.8) and will not reliably quantify carbon. The analysis showed an absence of alloying elements. The material was unalloyed cast iron.

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