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Australian Transport Safety Bureau

Safe Transport

RAIL SAFETY INVESTIGATION
2004/002

Derailment of Freight Train 6SM9V

Alumatta, Victoria
15 March 2004

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ISBN 1 921092 05 X August 2005

This report was produced by the Australian Transport Safety Bureau (ATSB), PO Box 967, Civic Square ACT 2608.

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INTRODUCTION

Following the derailment of train 6SM9V at Alumatta in the early hours of Monday 15 March 2004, the Australian Transport Safety Bureau (ATSB) initiated an investigation under the provisions of the *Transport Safety Act 2003*.

This investigation encompassed an examination of all factors that were either causal or potentially causal to the incident. The investigation methodology included an examination of safety management systems covering rollingstock, track, train handling and train control. In addition, emergency services response and human factor issues were examined and key personnel interviewed.

To ensure the fullness of this investigation, the ATSB engaged the services of specialist independent personnel for the purposes of examining the track, wheels, bogies, wagons and the interface between them as train 6SM9V departed the crossing loop at Alumatta.

EXECUTIVE SUMMARY

At 0335:08[1] on 15 March 2004, the trailing bogie of the second to last wagon of train 6SM9V[2], operated by Freight Australia, derailed as it departed the crossing loop at Alumatta. This train was a scheduled service from Sydney to Melbourne on the standard gauge network.[3] There were no reported injuries as a result of this derailment either in the active or recovery stages, nor was there any adverse environmental impact.

6SM9V came to a stand at 0339:58[4], having travelled 5.579 kilometres from the point of departure at Alumatta. During this time four level crossings and one bridge were traversed and a maximum speed of 69 kph was attained. For 4.795 kilometres of this distance this train was travelling in a derailed state thereby inflicting damage to these installations, track, associated infrastructure and the two trailing wagons. At the final level crossing the derailed bogie became dislodged, causing the last wagon to lift, separate from the train and roll over to the eastern side of the track. The consequential loss of air and the actions of the driver brought the train to a stop about 895 metres beyond this level crossing. The train crew then used the local UHF radio to warn any broad gauge[5] trains that may have been in the vicinity that train line air had been lost and the train may be foul.

Initially, the driver suspected a ruptured air hose and left the cab to find the fault and repair it. Advice of this occurrence and proposed actions were forwarded to the ARTC[6] train controller at 0342:10[7]. At 0353:10 the driver advised the ARTC train controller that he had reached the rear of the train and that the second last wagon was derailed and the last wagon was not in sight. At 0353:40 the ARTC train controller rang the Centrol[8] train controller and instructed that no broad gauge trains be allowed into the vicinity.

This accident occurred on a section of the corridor where standard and broad gauge tracks parallel each other only metres apart. Both of these tracks are operated independently, having separate train control centres and differing safeworking systems with little readily identifiable transparency between them. The investigation has determined that the time taken to notify the Centrol train control centre was not in accordance with the existing safety management system requirements.

The investigation has determined that the probable cause of this derailment was the geometry of the track combined with the excessive speed of the rear of train 6SM9V as it exited the crossing loop. This led the left wheel of the third axle of the second last wagon to climb the eastern stock rail at the toe of the point blade of the cripple

1 All times are in eastern summer time.

2 6SM9V – the train-to-base radio system in Victoria does not recognise alpha numeric numbers. Train 6SM9V was designated train 9644 in Victoria.

3 Standard gauge – a measurement of 1435 mm between the inside rail faces.

4 Recorded by the Hasler data logger – is manually set by a clock mechanism, therefore is not proven.

5 Broad gauge – a measurement of 1600 mm between the inside rail faces.

6 ARTC – Australian Rail Track Corporation Ltd.

7 Recorded by train control logger – is set to within one minute once a fortnight, therefore is not proven.

8 Centrol – the Freight Australia train control centre located in Melbourne.

siding. It is probable though that neither of these two factors was, in itself, sufficient to cause the derailment.

Safety actions recommended as a result of this investigation are aimed at revising track standards and maintenance procedures, ensuring the rear of trains do not exceed speeds of curves or turnouts and improving communications between trains on what are essentially two separate rail corridors in one.

1 OVERVIEW

At about 0340 on 25 March 2004 train 6SM9V came to a halt when air pressure was lost from the brake pipe. Inspection of the train found that the second last wagon had derailed and that the last wagon was missing and could not be seen. It later became apparent that the trailing bogie of the second last wagon had derailed as the train was leaving the Alumatta turnout and travelled 4.795 km in a derailed state.

1.1 Train details, 6SM9V

1.1.1 Description

Train 6SM9V, operated by Freight Australia, had originated at Yennora container terminal, Sydney and was bound for Dynon and the CRT sidings at Laverton, Melbourne. At Yennora a full departure examination, known as an FX1, was conducted. This examination included brake operation and adjustment, wagon bogie and wheel condition and load security. Train 6SM9V had a maximum speed of 110 kph over the section of track between Albury and Melbourne.

The train attached and detached wagons at Cootamundra, Junee and Albury. At these locations the assistant driver carried out a modified examination[9] of the train.

The weight and length of train 6SM9V upon departure from each of these locations was:

Location	*Wagons*	*Length (metres)*	*Weight (tonnes)*
Yennora (Sydney)	13	300.4	827.6
Cootamundra	20	404.7	975.5
Junee	28	565.5	1,484.9
Albury	27	600.0	1,500.6

1.1.2 Locomotives, 6SM9V

Train 6SM9V was hauled by two locomotives, G533 and X51 operating as a multiple unit[10].

G533 is one of 33 locomotives manufactured by Clyde Engineering at Rosewater and Somerton, designated as model number JT26C-2SS. The 'G' class locomotives were first introduced in 1984. The gross power output of G533 is 2,460 kW (3,300 horsepower), length 19.8 metres, weight 127 tonnes.

X51 is one of 24 locomotives and was manufactured by Clyde Engineering at Rosewater. The 'X' class locomotives are designated as model number G26C and were first introduced in 1966. The gross power output of X51 is 1,650 kW (2,200 horsepower), length 18.4 metres, weight 118 tonnes.

9 Modified examination – a visual inspection of wagons to ensure continuity of train line air and operation of wagon brakes.

10 Multiple unit – the operation of two or more locomotives at the head end of a train by a single crew.

1.1.3 Train consist, 6SM9V

At the time of departure from Alumatta train 6SM9V consisted of wagons from the VQCY, VQKY and VQMY classifications. These three classes of wagons are designated as 'container flats' and are used to carry containers of varying dimensions and weight. These three classes of wagons are similar in that all are authorised to travel at 110 kph on the Albury to Melbourne corridor provided the axle load is less than 19 tonnes (76 tonnes gross). VQCY and VQMY wagons are 20 metres long while VQKY wagons are 24 metres long. The tare weight of the VQKY class is five tonnes heavier than the VQCY and VQMY classes and therefore has five tonnes less carrying capacity.

1.2 The Albury to Melbourne corridor

1.2.1 Overview of this corridor

The Albury to Melbourne rail corridor consists of standard gauge and broad gauge rail lines that are immediately parallel to each other for the majority of this route. The broad gauge line from Wodonga to Melbourne was opened in 1873 and the standard gauge line from Albury to Melbourne in 1962. Both lines are operated separately with different safeworking methods and train control, although both lines were originally owned and operated by the Victorian Government Railways.

The ARTC leases the Albury to Melbourne standard gauge corridor. In this role the ARTC is responsible for:

- selling access to train operators
- the development of new business
- capital investment
- all facets of management (including train control)
- infrastructure maintenance.

Freight Australia leased the Albury to Melbourne broad gauge corridor. In this role Freight Australia was responsible for:

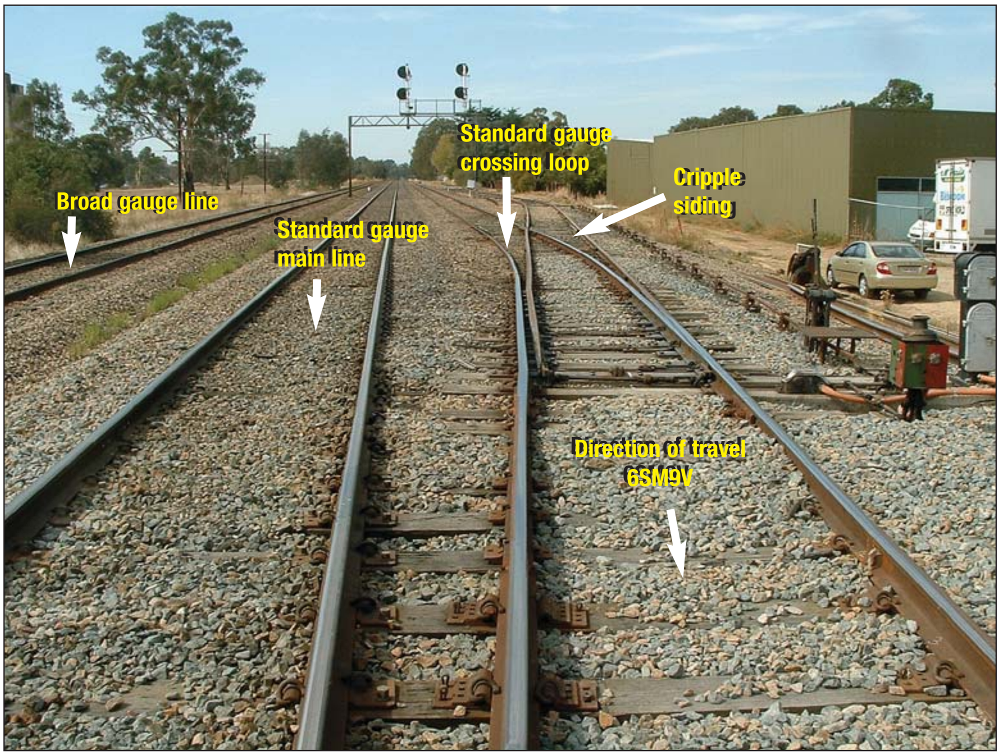
- capital investment
- all facets of management (including train control)
- infrastructure maintenance.

Since this derailment Freight Australia has been purchased by Pacific National, the lease of the broad gauge track and associated responsibilities is now with Pacific National.

1.2.2 Alumatta

Alumatta is situated on the southern outskirts of the Wangaratta township, one kilometre from the Wangaratta passenger station and 232.630 kilometres from Melbourne. Alumatta is a crossing location for standard gauge trains and consists of a main line, crossing loop and two 'cripple' sidings. Trains of up to 891 metres in length can be accommodated in the crossing loop at Alumatta. The 'cripple' sidings are of dead end configuration and can be accessed from the northern and southern ends of this loop respectively. These sidings are used for stowing track maintenance machinery and defective wagons. The broad gauge line runs parallel on the western side of the standard gauge main line at this location.

FIGURE 1: Alumatta, looking north



Signalling at Alumatta is known as centralised traffic control[11] (CTC) and is remotely controlled by train controllers in ARTC train control, Adelaide.

1.2.3 Derailed route

The initial point of climb was at the toe of the eastern point blade at the points to the southern cripple siding at Alumatta crossing loop (231.860 kilometres[12]). Train 6SM9V came to a stand at the 226.485 kilometre mark.

Level crossings and bridges on this portion of track encountered when travelling in a southerly direction are:

- Sandford Road level crossing, 231.132 kilometre
- Shanley Street level crossing, 230.352 kilometre
- Fifteen Mile Creek rail bridge, 229.979 kilometre
- Gravel Pit Road level crossing, 229.073 kilometre
- Dellaro Road level crossing, 227.380 kilometre

11 CTC – A safeworking system of remotely controlling the points and signals at a number of locations from a centralised control room.

12 Kilometres from Melbourne.

The Sandford Road, Shanley Street and Gravel Pit Road level crossings are protected by flashing lights and audible alarms. Dellaro Road level crossing is a passive crossing and is protected by signage alone. The composition of the road crossing at the Sandford, Shanley and Gravel Pit level crossings is asphalt. The composition of the road crossing at the Dellaro Road level crossing is concrete reinforced with rock aggregate.

Fifteen Mile Creek rail bridge is steel girder construction with steel cross bracing and timber transoms[13]. The steel girders are attached to two concrete pylons and are supported at each end by concrete abutments. This bridge is 35 to 40 metres long and is un-ballasted.

The gradient is almost level from Alumatta until Fifteen Mile Creek bridge. The grade then rises gradually, albeit with some slight undulations, from 1:854 to 1:133 from the 226.485 kilometre mark.

The surrounding countryside is gently undulating and mainly made up of grass paddocks that are lightly timbered. There are no heavy earthworks, such as embankments, that separate the general lay of the land from the rail corridor.

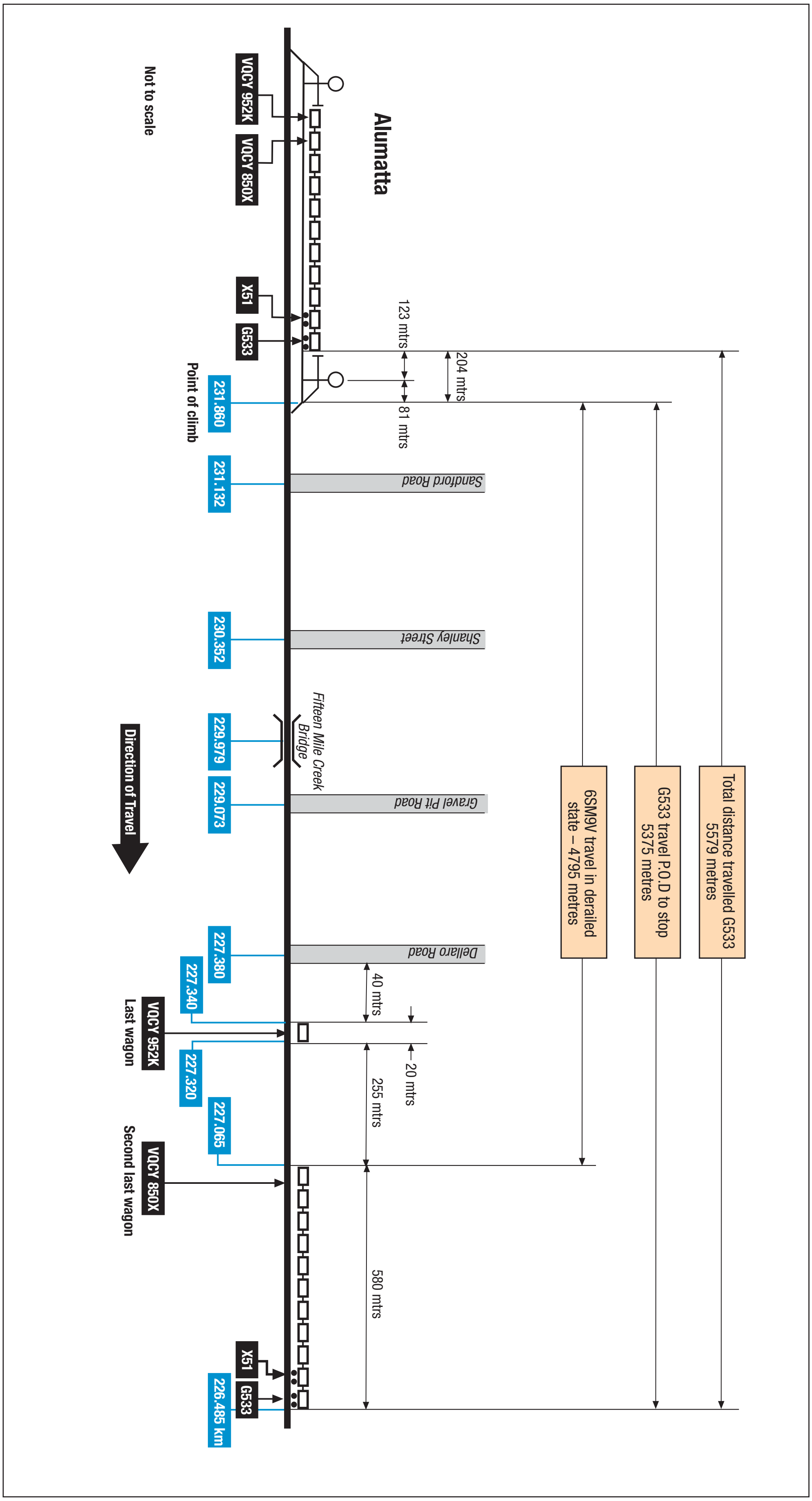
1.2.4 Recovery site

Train 6SM9V came to a stop with the lead locomotive G 533 at about the 226.485 kilometre mark and the trailing end of the second last wagon (VQCY 850X) at the 227.065 mark. The last wagon of the consist, VQCY 952K, was lying on its side to the east of and parallel to the standard gauge track 255 metres from the rear of the second last wagon, some 40 metres from the Dellaro Road level crossing.

The Dellaro Road level crossing is about 500 metres from the junction of the Wangaratta to Glenrowan Road and provided easy access to the recovery site. In addition, an unsealed maintenance road runs parallel to the eastern side of the rail corridor thereby giving further access along the corridor to the south.

13 Transom – essentially a sleeper on an open top bridge structure. Is usually larger than a standard sleeper.

FIGURE 2: Schematic of derailed route



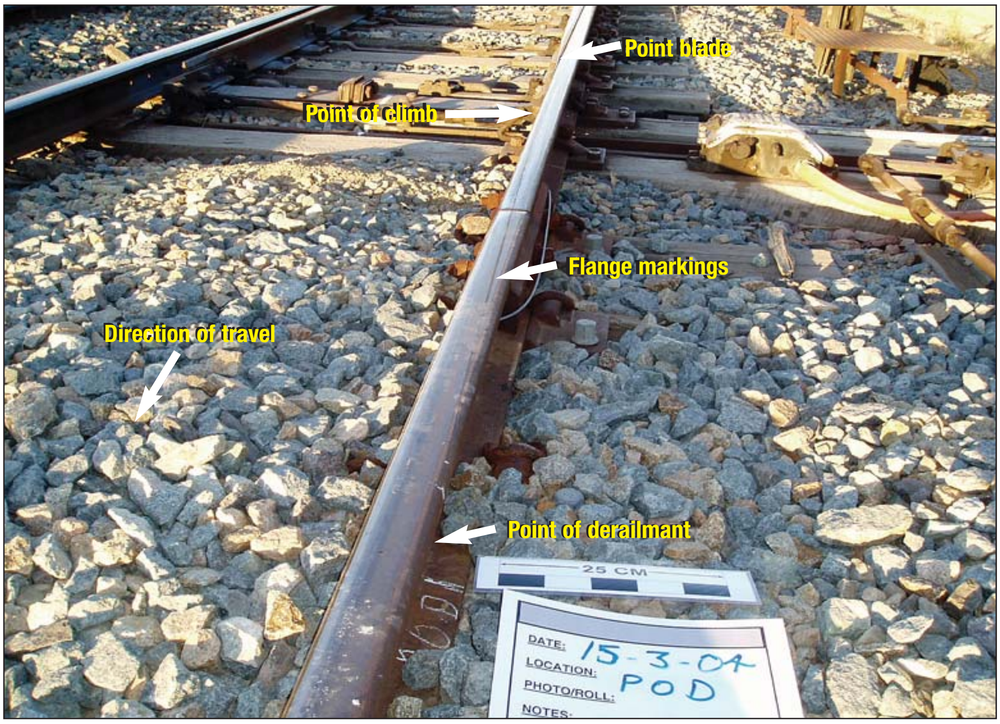
1.3 Sequence of events

1.3.1 Derailment at Alumatta crossing loop

Train 6SM9V departed the southern end of Alumatta crossing loop at 0333:47 on Monday 15 March 2004. The first 560 metres of this train (two locomotives and 25 wagons) traversed the turnout from the loop to the main line without incident. As the 26th wagon, (VQCY 850X) traversed this turnout, the left wheel of the third axle climbed the left (eastern) stock rail at or immediately after the toe of the point blade to the cripple siding. The flange of this wheel then ran along the head of the rail for 2.65 metres, tracking east, before derailing to the outer (east) side of the rail. The right wheel of the third axle of this wagon derailed to the inside of the right (western) rail 2.55 metres from the point of climb of the left wheel.

Both wheels of the fourth axle of VQCY 850X remained on the rails for 10.8 metres from the point of climb whereupon the left wheel derailed to the eastern side of the left rail. The right wheel of the fourth axle then travelled through the 'frog' of the crossing loop/main line points and derailed immediately after. At this time the trailing bogie of wagon VQCY 850X was completely derailed. The derailed wheels then struck the eastern point blade of the Alumatta crossing loop points and points machine causing damage to both components. A small metal object was propelled through the window of an adjacent residence as a result of the derailed wheels striking and deflecting track fasteners and other debris. No injuries resulted. The initial point of climb was at the 231.860 kilometre mark and the point of derailment was at the 231.85745 kilometre mark.

FIGURE 3: Point of derailment, Alumatta



1.3.2 Overview, point of derailment to kilometre 226.485

From the markings made in the ballast, track, sleepers and level crossings it is apparent that the angle of attack of the derailed bogie altered several times while travelling between the point of derailment and the Dellaro Road level crossing. These marks were also consistent with right side bogie side frame being displaced to an extent that the leading end was in contact with the track infrastructure.

1.3.3 Observations, point of derailment to kilometre 226.485

Once clear of the turnout at Alumatta the markings on the track indicated that all four wheels of this bogie remained derailed to the eastern side of their respective rails. An undamaged wagon bogie outer spring was found on the eastern side of the standard gauge line, 52.4 metres from the point of derailment. The track markings remained reasonably constant until the level crossing at Sandford Road (231.132 kilometre mark) was encountered. On the asphalt surface of the level crossing there were flange marks to the eastern side of the right rail and some scuff marks on the western side of the left rail. There were also flange markings on the eastern side of the left rail but these were only evident for the first three metres.

Between the Sandford Road level crossing and the Shanley Street level crossing, flange marks on the eastern side of the right and left rails were evident. Also, there were intermittent strikes on the timber sleepers from the bogie side frame and components.

FIGURE 4: Shanley Street level crossing, looking south

At the Shanley Street level crossing (230.352 kilometre mark) flange marks were again evident on the eastern side of both rails on the asphalt surface. There was also a significant indent consistent with the initial impact of the right bogie side frame as the level crossing was encountered. This indent was on the eastern side of the right rail. Then, about half way along this crossing, gouge marks of similar width and characteristics appeared on the crossing surface. Immediately beyond this level crossing, commencing at the fourth sleeper, there were marks on the western side of the right rail that were consistent with the heavy impact of the right bogie side frame 'bottoming out' after the level crossing had been traversed. It would seem that the right side bogie side frame crossed from the east to the west side of the right rail as it traversed this crossing (see figure 4).

Between the Shanley Street level crossing and the bridge over Fifteen Mile Creek (229.979 kilometre mark) the flange markings were consistent with the four wheels being derailed to the eastern side of both rails and the bogie side frame dragging along the western side of the right rail.

At the bridge over the Fifteen Mile Creek watercourse there were marks indicating heavy contact with the concrete bridge abutment and right side of the first timber transom. At the sixth transom the scuff markings on the western side of the right rail reappeared. On the eastern side of the right rail there were flange markings every six to 10 transoms. To the eastern side of the left rail flange marks were evident for the length of the bridge, with strike marks from the outer edge of the wheel marking the inside edge of the bolts of the transoms.

FIGURE 5: Damage to concrete abutment and transom

Between the bridge over the Fifteen Mile Creek watercourse and Gravel Pit Road at the 229.073 kilometre mark the scuff marks from the bogie side frame remained on the western side of the right rail. The flange markings continued intermittently along the eastern sides of the right and left rails until 16 metres from the Gravel Pit Road level crossing where they appear to reverse to the western side of the right and left rails. However, there were no climb marks visible on the rail head in this vicinity.

At Gravel Pit Road there was only one flange marking visible and this was on the western side of the left rail. About half way along the asphalt crossing this flange marking took a sudden deviation to the west but the scuff mark from the bogie frame maintained a constant line to the western side of the right rail.

FIGURE 6: Gravel Pit Road looking north

Between Gravel Pit Road and Dellaro Road (at the 227.380 kilometre mark) the sleeper scuff marks on the western side of the right rail continued. The pattern of the flange marks becomes less consistent between these two points though with intermittent markings on either side of the right and left rails. At the 229.055 kilometre mark a damaged brake hanger was lying on the western side of the standard gauge corridor and at the 228.887 kilometre mark a brake rod was lying on the eastern side of the standard gauge corridor. This brake rod had snapped at both ends.

The Dellaro Road level crossing is constructed of concrete aggregate. Severe damage was caused to this crossing when the derailed bogie struck it. In the aftermath, large portions of concrete aggregate were spread over the immediate vicinity of this level crossing.

FIGURE 7: Dellaro Road level crossing under repair

1.3.4 Derailment of wagon VQCY 952K

Wagon VQCY 952K was the trailing wagon on train 6SM9V. This wagon was carrying three containers, two loaded at each end and one empty in the middle for a gross weight of 67.30 tonnes.

FIGURE 8: Trailing wagon at the recovery site

Markings and the position of the bogies and wagon VQCY 952K at the recovery site indicate this wagon had derailed and separated from train 6SM9V due to the bogie of the adjacent wagon, VQCY 850X, becoming dislodged at the Dellaro Road level crossing. The trailing wagon, VQCY 952K, then travelled over the dislodged bogie, dislodging both of its bogies. Markings on the coupler knuckles between these two wagons also indicate that the deck of VQCY 850X dropped while the deck of the trailing wagon, VQCY 952K, lifted as the dislodged bogie fouled the trailing wagon.

1.3.5 Train crew account

The driver of 6SM9V said that he used dynamic brake to slow the train to 15 kph prior to entering the crossing loop at Alumatta at about 0330. This was followed by a low application of power to maintain entry speed at 15 kph. A minimum application of the train brakes was then used to bring train 6SM9V to a stop about four locomotive lengths from the home departure signal. A full service equalised application of the train brakes was then made prior to the train brakes being released.

Within minutes a northbound freight train proceeded through Alumatta via the main line and, upon receipt of a 'clear medium' indication (40 kph) in the home departure signal, the driver accelerated the train to about 35 kph. The driver stated that power was then reduced to maintain this speed until the whole of the train exited the crossing loop.

When the countdown meter on locomotive G533 indicated that the rear of the train was about 50 metres from exiting the Alumatta crossing loop, the driver applied full power, noting the gradual build up of engine revolutions and amperage output from the locomotive's main generators to the traction motors. Full power was then maintained until the speed of the train reached about 65 to 70 kph as indicated by the speedometer on G533.

At about the 227 kilometre mark the driver recalled that the flow meter[14] suddenly activated, indicating a loss of brake pipe air. The train was then brought to a stop by a combination of this loss of air and the driver's actions. The driver then broadcast a warning over the local radio channel to any broad gauge trains that may have been in the vicinity. This radio channel has a nominal range of between four and six kilometres.

Anticipating a ruptured air hose, the driver of 6SM9V delegated the task of contacting ARTC and Centrol control centres to the assistant driver. He then took the necessary equipment and proceeded towards the rear of the train. The assistant driver contacted ARTC control and told them that the train had come to a stop because of the loss of brake pipe air and that the driver had detrained and was investigating. The assistant driver then radioed the driver with advice from the ARTC controller that detection[15] of the loop points at the southern end of Alumatta had been lost. When the damage at the rear of the train was located the driver radioed the assistant driver and he in turn informed the ARTC train controller. The

14 Flow meter – provides an indication of the flow of air into and out of the train pipe at the locomotive.

15 Detection – electrically operated points machines provide an indication to the train controller of the position, either normal or reverse, of the points

assistant driver then joined the driver at the Dellaro Road level crossing. Both then remained at this level crossing for protection purposes until the arrival of the police at about 0440. Contact with ARTC and Centrol controllers was made several times from this location via mobile phone.

1.3.6 Witness account

In the early hours of the morning on 15 March 2004 a police officer, who was standing at the rear entrance to the Wangaratta police station, heard and observed a southbound train crossing Sisely Avenue as it was arriving at Alumatta. This vantage point was somewhere between 400 and 500 metres away. The witness advised that this train was visible as a silhouette and that he was unsure as to the time. He thought it was in the order of an hour before receiving the callout to attend the derailment at 0421:50. In addition, he was unsure if the train observed was actually the train in question.

The witness said he heard a loud noise (bang), citing a similarity to what is heard in a shunting yard. He thought the orientation of this noise was from the general direction of the Sisely Avenue level crossing.

This witness advised that several nights later, in the early hours of the morning, he was again standing at the rear entrance to the Wangaratta police station and heard and observed another train travelling in the same direction. He said that on this occasion he heard exactly the same noise (bang) as that on 15 March 2004.

1.4 Damage

1.4.1 Damage to infrastructure

The standard gauge infrastructure was damaged to a varying extent along the derailed route. There was no damage to the adjacent broad gauge infrastructure. Damage to the standard gauge infrastructure was confined to track fastenings, sleeper displacement and severing of track circuit cabling. There was no significant rail damage except at the turnout at Alumatta and in the immediate vicinity of Dellaro Road level crossing. Some transoms and rail fastenings on the bridge over Fifteen Mile Creek were damaged but no structural damage to the bridge itself was incurred.

Damage to the Sandford Road, Shanley Street and Gravel Pit Road level crossings was confined to flange marks, gouging and scuff marks in the asphalt road surfaces. This damage was relatively minor and none of these three level crossings were closed to vehicular traffic as a result. However, the damage at the Dellaro Road level crossing was significant. The concrete aggregate road surface was badly broken up rendering this crossing unusable to vehicular traffic.

1.4.2 Damage to train 6SM9V

The damage to train 6SM9V was confined to the rear two wagons, VQCY 850X and VQCY 952K.

Wagon VQCY 850X was carrying three 20ft containers, two loaded and one empty weighing, in order from the leading end, 22.9, 2.3 and 22.6 tonnes each. The damage to the wagon body of VQCY 850X was primarily confined to the trailing end. A number of severe gouge marks on the under-frame and under-side of the deck were evident, in one instance a groove from the flange of the right wheel number three axle had almost penetrated the wagon deck/floor. There was also some minor headstock deformation and brake rods and rigging missing. All three containers were correctly secured to this wagon by the wagon twistlocks when observed at the recovery site.

The damage to the trailing bogie of VQCY 850X was extensive. Both wheel sets were separated from the bogie and the bogie frame itself was in a dismantled state with the two side frames and associated components separated from the bolster.

VQCY 952K was the trailing wagon of train 6SM9V. This wagon was also carrying three 20 ft containers, two loaded and one empty weighing, in order from the southern end, 22.8, 2.3 and 22.6 tonnes respectively. The damage to VQCY 952K was located primarily on the underside of the wagon deck, the most significant of which was the distortion of the headstock and wagon framework on the leading end of this wagon. Numerous impact marks or gouges were also evident along the underside of this wagon. Truncated brake rigging, piping and so on were also evident. Of note was all three containers were still correctly secured to the wagon by the wagon twistlocks despite the derailment trauma.

The bogies of VQCY 952K were extensively damaged with three of the four wheel sets being torn from the bogie frames. The bogie framework was in a dismantled state with the bolsters separated from the side frame and associated components.

1.5 Injuries

There were no reported injuries to members of the public or the crew of train 6SM9V as a result of this derailment.

1.6 Toxicology

The driver and the assistant driver were breath tested by police officers from the Wangaratta Police Station at about 0445. Both recorded negative results. The ARTC train controller was not breath tested after the accident.

1.7 Environmental factors

At about 0330 on 15 March 2004 the weather conditions were dry and clear. The maximum temperature recorded was between 24 and 27 degrees Celsius. Sunrise occurred at Wangaratta at 0713.

1.8 Evidence of fire

There was no evidence of fire on board train 6SM9V, track infrastructure or adjacent countryside as a result of this derailment.

1.9 Dangerous goods

Train 6SM9V was not conveying freight defined as dangerous goods by the Dangerous Goods Act 1975 (as amended).

1.10 Overview of Freight Australia

Freight Australia Pty Ltd was formed in 1999 as a result of the sale by the Victorian State Government of V/Line Freight and the majority of the state's VicTrack freight rail network to RailAmerica.

Freight Australia operated trains on both the broad and standard gauge within the state of Victoria. Standard gauge trains were also operated to New South Wales and Western Australia. Freight Australia managed a mix of above rail and vertically integrated operations.Within Victoria it owned and maintained the majority of the broad gauge freight network on a 45 year lease but when operating over other standard gauge sectors it was essentially an above rail operator. Freight Australia had over 680 employees, approximately 107 locomotives, 2,660 freight wagons and hauled in the vicinity of eight million tonnes of freight per annum.

Several months after the derailment at Alumatta, Freight Australia was bought by Pacific National Pty Ltd.

1.11 Overview of the ARTC

The Australian Rail Track Corporation (ARTC) was created after the Commonwealth and State Governments agreed in 1997 to one organisation being responsible for the selling of access to railway operators, management of the network, management of infrastructure maintenance, capital investment in the corridors and the development of new business on the national interstate rail network.

The ARTC has responsibility for the management of the standard gauge interstate track, currently 4430 route kilometres, mainly in South Australia, Victoria and Western Australia. More recently, a lease agreement was made in respect to track in NSW. The standard gauge track between Melbourne and Albury is part of the defined interstate rail network (DIRN) managed by ARTC.

1.12 Train control

The ARTC train control and communication centre is located at the ARTC Complex, Mile End, Adelaide, South Australia.Within the state of Victoria, the ARTC train control centre coordinates all main line operations on the standard gauge track from Melbourne to Wolseley and Melbourne to Albury. The ARTC train control centre is divided into separate control boards that control specified sections of track and corridors. The 'Albury' control board controls the section of track from Albury to Tottenham (Melbourne).

Centrol train control centre is located at Collins Street,Melbourne. This control centre was operated by Freight Australia and was responsible for the coordination of all main line operations on the broad gauge track within the State of Victoria except for the electrified portion of the Melbourne suburban network, the Albion to Jacana and Frankston to Stony Point lines. The Centrol control centre was divided into separate control boards that control specified sections of track and corridors. The board known as 'room three' coordinated the section of track from Jacana to Albury.

1.13 Employee evidence

1.13.1 Driver 6SM9V

The driver of train 6SM9V was a 41 year old male. He began service in the rail industry as a trainee engine driver employed by the State Rail Authority in 1978. He then progressed to the position of locomotive driver before accepting a redundancy package in the early 1990s. After about 4.5 years he re-entered the rail industry as a casual employee and was progressively employed by Austrack, Pacific National, Lachlan Valley and Freight Australia. He was made a permanent employee of Freight Australia in June 2001. The driver of 6SM9V had extensive experience on freight trains and, apart from 15 months when he was based at Port Kembla, had worked trains in the Junee area (within the State of New South Wales) for over 21 years. In November 2001 he qualified in both the route and theory components of the standard gauge line south of Albury to Tottenham Loop. In March 2003 he was recertified as competent on this route.

At the age of 41 years, a driver employed by Freight Australia was required to be medically examined every two years. The driver of 6SM9V was last medically examined and passed fit for duty in May 2003.

1.13.2 Assistant driver 6SM9V

The assistant driver was a 26 year old male. This person began service in the rail industry as an assistant driver in October 2001. In this role he was employed by Freight Corp for eight months and then by Freight Australia for 18 months as a permanent employee. He qualified in the practical and theory components of the route between Albury and Tottenham Loop in November 2001.

At 26 years of age an assistant driver employed by Freight Australia was required to be medically examined every four years. He was last medically examined and passed as fit for duty in June 2003.

1.13.3 ARTC train controller

The ARTC train controller was a 38 year old male. This person has been a train controller since 1991 and had worked for V/Line Freight, VicTrack and ARTC. He had worked the north east control board since 1994 while still with VicTrack. When control of the north east corridor was transferred to ARTC Adelaide in July 1999 he transferred to the ARTC Adelaide. Relevant certificates of competency and all qualifications were current.

1.13.4 Shift and fatigue management, train crew 6SM9V

On 14 March 2004 the driver and assistant driver signed on duty at 2100 at Junee to work train 6SM9V from Junee to Somerton (Melbourne). At Melbourne they were rostered to book off duty prior to returning to Junee on train 2MS9 at around 1600 on 15 March 2004.

The shifts worked by the driver of 6SM9V over the 14 day period before 15 March 2004 have been examined. Fatigue is not considered to be a factor in this instance as this shift (2100, 14 March 2004) was his first shift after three clear days off duty. At the time of the incident he had been on duty for about six hours and 30 minutes.

The shifts worked by the assistant driver of 6SM9V over the 14 day period before 15 March 2004 have been examined. Again fatigue was not considered to be a factor as this shift (2100, 14 March 2004) was the first after two clear days off duty. At the time of the accident, he too had been on duty for about six hours and 30 minutes.

1.13.5 Shift and fatigue management, ARTC train controller

The active roster of the ARTC train controller on duty at the time of the derailment from Monday 1 March 2004 to Monday 15 March 2004 was examined. As the last four shifts, including the day of the derailment, were 2300 to 0715, this roster was analysed using the FAID Interdyne fatigue score index. A maximum score of 79 was recorded at the completion of the final shift of duty at 0700 on 15 March 2004. This score is towards the maximum rostered fatigue acceptable in the rail industry.

1.14 Communications

1.14.1 Communication overview

The radio network on the north eastern line used by ARTC is owned and maintained by VicTrack Communications. This network is a UHF system in the rail band with overlapping tower coverage. In this instance the nearest towers are at Wangaratta and Glenrowan.

The telemetry in this area is via a Teknis system which is in four sections. All four sections are backed up by Telstra lines should the rail bands develop problems. This function is tested by manually switching over to the Telstra lines on a regular basis.

All communications, both radio and telemetry, are connected to the Communications Room that is located at Collins Street, Melbourne. From here encoded control and indication data are passed to the ARTC control in Adelaide via a Telstra frame relay. The Communications Room is staffed 24 hours a day.

1.14.2 Communication, train control and train drivers

All trains operating on the standard gauge or broad gauge are required to have a train-to-base radio and a local radio. The train-to-base radio is to be manually tuned to the designated train control channel for the section of track being traversed. This gives the driver of a standard gauge train direct radio contact with the ARTC controller and vice-versa and the driver of a broad gauge train direct radio contact with the Centrol controller and vice-versa. Standard gauge trains have no direct means of contacting Centrol controllers in Melbourne by radio and likewise, broad gauge trains have no direct means of contacting ARTC control in Adelaide by radio. It is possible to manually tune the train-to-base radio to a Centrol or ARTC frequency but in doing so radio communication with the primary train control centre would be lost.

However, all Freight Australia locomotives (broad or standard gauge) were equipped with state mobile radio (SMR) equipment. This allowed a direct 'telephone' call to be dialled in by the driver to the ARTC or Centrol train control centre and vice-versa.

Also common to Freight Australia locomotives was a driver activated emergency call feature between the train and relevant train controller. When activated the train's unique identification number was automatically transmitted with this communication.

1.14.3 Communication between trains

All trains on either the standard or broad gauge must carry a local radio. The local radio must be manually tuned to the local train radio (LTR) channel except when operational requirements dictate otherwise. The 'LTR' channel allows open channel communication with any other trains, signal boxes or stations on the corridor that are within range. Nominally this range is between four and six kilometres.

1.14.4 Communication between ARTC control centre and Centrol control centre

Communication between the ARTC standard gauge control centre in Adelaide and the Centrol broad gauge control centre in Melbourne and vice-versa can be enacted via a dedicated phone link. Although the use of this link is not exclusively confined to emergency situations, should such a situation arise, a foot pedal located at the work station can be depressed by the train controller. The operation of this device has the effect of overriding any conversation taking place on this line and places the call on a loud speaker at the relevant work stations at Centrol and ARTC train control centres.

1.15 Standards and accreditation

1.15.1 Standards and accreditation, overview

The Australian railway system developed on a State basis involving metropolitan commuter services and intrastate freight and passenger services from country areas to the capital cities and ports. The standards, procedures and regulatory frame work were developed on a State by State basis for vertically integrated rail systems. Over recent years there has been a radical reorganisation of the Australian rail system, particularly on the DIRN, involving a significant increase in line haul rail traffic, interstate trade, privatisation and restructuring into infrastructure providers and train operators.

The six parts of Australian Standard AS 4292: Railway Safety Management provide the general principles to be followed in achieving safe operations.

The regulation of railways have trended away from prescriptive standards to a system referred to as 'co-regulation'. This is described as:

> a system in which some of the responsibilities for regulatory development, implementation and/or enforcement are shared between industry groupings and governments. Governments delegate certain responsibilities to industry by lending legislative backing to code or other instruments that are primarily industry developed.[16]

16 Glossary for National Code of Practice and Dictionary of Railway Terminology.

Under this system each organisation that manages infrastructure or operates trains must have documentation, approved by the applicable State regulatory body that details formally the standards and practices adopted by the organisation to meet the legislative requirements of that particular regulator. The system is based on organisations submitting a safety management plan which must:

- nominate the standard, consistent with the requirements of AS 4292, against which the organisation is to be assessed
- identify any significant risk that may be anticipated
- specify the controls that are to be employed to manage the risk and monitor safety in the rail operation
- comply with the requirements of the regulator.

Rail organisations are audited against these requirements by the regulators.

1.15.2 Standardising the standards

The Australian Rail industry, driven primarily by the reorganisation of the rail system in recent years, has developed a National Code of Practice (NCoP[17]) that is intended to provide:

- a uniform approach to the definition of operational standards
- safe operating environment where infrastructure, rollingstock and operating systems are in accord with the principles defined in these standards
- a uniform basis with which to comply with the mandatory requirements of AS 4292
- a basis for assisting the process of mutual recognition of rail safety accreditation
- a basis for developing investment decisions.

At March 2004 the development of the NCoP was being managed by the Australasian Railway Association Code Management Company on behalf of the industry. The NCoP consisted of the following four volumes:

- Volume one – General requirements and interface management
- Volume two – Glossary
- Volume three – Operations and safeworking
- Volume four – Track, civil and electrical infrastructure (draft).

The NCoP has been and is being developed primarily for use on the DIRN. However, in the longer term, the intent to expand this code for use on other corridors, such as those deemed to be of significance, is being considered. The ARTC has compiled an ARTC annotated version of volume four of the NCoP for application to much of the rail network that it manages. This version of volume four is an elaboration of volume four of the NCoP and, at the time of this derailment, was still in draft form.

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17 NCoP – now referred to as Australian Code of Practice (ACoP).

1.16 Previous derailments

1.16.1 Alumatta

On 26 November 2002 a derailment of a southbound freight train occurred while exiting the crossing loop points at Alumatta. Six loaded wagons of this train derailed to the east side of the standard gauge track, three overturning in the process. The broad gauge track was not fouled. This derailment occurred on the same turnout as the derailment of train 6SM9V on 15 March 2004, in comparison the point of derailment on 26 November 2002 was 1.65 metres to the north. The ARTC and the operator conducted a joint investigation into the earlier derailment.

The findings of this investigation were:

- The centre plate located on the A end of vehicle ROKX 2513 became detached from the vehicle when the rivets securing it sheared off, evidence found indicates that the centre plate had been loose before becoming detached from the body of the vehicle. The centre plate located on the B end of vehicle ROKX 2513 was firmly secured to the vehicle structure by swage type fastenings. Evidence was presented and post incident inspection indicated that vehicle ROKX 2513 had been subject to remedial works before the vehicle had been returned to service.
- There was no evidence that indicates that the loading was insecure prior to or contributed to the incident, after the rail vehicles derailed and fell on their sides, the restraint system did fail when subjected to a load that exceeded the maximum rated load of the system.
- No evidence was found to indicate that a pre existing track condition or defect caused or contributed to the derailment, measurements taken after the derailment indicate that all track components and geometry were within the condition requirements and tolerances necessary for safe reliable train operation. There is no evidence that heavy rainfall prior to the incident affected track stability or integrity. Maximum allowable reverse cant readings were recorded in the turnout, it has been established that the effect of reverse cant was not a factor in this incident.
- Train speed departing the loop at Alumatta at the time of the derailment was found to be below the maximum permitted.

Of note is that the measurements provided in the report reveal that the radius of the southern turnout was 154 metres at the time of this derailment.

1.16.2 Recent derailments, Freight Australia trains

Between May 2003 and March 2004 Freight Australia trains have been involved in eight derailments in Victoria. No injuries resulted and damage estimates ranged from within $10,000 to within $1 million. This investigation notes that the issue of derailments on the Victorian non-metropolitan rail network is now the subject of an independent inquiry as ordered by the Victorian Department of Infrastructure. As such, other than to note the number and severity of these derailments, no conclusion is reached.

A brief description of these derailments follows:

Date	***Location***	***Description***	***Track Gauge***
09/05/03	Newport	Crew of train 9741 reported rough riding between Champion and Maddox Roads. 1st wagon of train (VQOF 232U) derailed leading bogie all wheels.	Standard
27/05/03	Wodonga	Train 9691, wagon VQCY 548F derailed all wheels lead bogie, wagon VQCY 521S derailed all wheels trailing bogie, VQCY 909K derailed all wheels trailing bogie. Broad gauge line fouled.	Standard
18/08/03	Newport	Train 2MS9 derailed 15 wagons, track spread suspected.	Standard
16/01/04	St Arnaud	Train 9121 derailed on account of track buckle 45cm lateral shift, 60 metres length. One bogie derailed and dragged 10 kilometres.	Broad
25/02/04	Brooklyn	Train 4SM9 derailed VQCY 644W all wheels trailing bogie.	Standard
01/03/04	Morwell	Train 9461 after detaching the locomotive the wagons on the train ran away in the Up direction and derailed at the number two points at Morwell.	Broad
05/03/04	St James	Train 9392 derailed 14 grain wagons on account of track buckle.	Broad
07/03/04	Chrome Loop-Heywood	Train 9784 derailed seven grain wagons commencing at the 21st wagon of the train consist.	Standard

2 KEY ISSUES

2.1 Emergency response

2.1.1 Emergency response Freight Australia

On their network, Freight Australia, in the event of an emergency, was to act as the combat agency responsible for the management of the emergency. These arrangements were contained in the Freight Australia Emergency Management Plan, version three dated 1 March 2002.

When operating on the ARTC network though, Freight Australia was to act in accordance with the ARTC emergency management plan. In this instance this meant that the train crew of 6SM9V were required to take all necessary steps to protect the incident site and to immediately advise the ARTC train controller of the nature and location of the incident site.

An examination of the Hasler locomotive data logger has indicated that train 6SM9V came to a stop at 0339:58. The driver said that he immediately sent a ‘broadcast’ radio transmission over the ‘LTR’ local radio channel to warn any trains in the vicinity to stop as 6SM9V had lost brake pipe air and at that stage he did not know why. He then detrained and proceeded alongside the train. The voice tape transcript between the train crew (assistant driver) of 6SM9V and the ARTC train controller indicated that a call from train 6SM9V, advising of an unanticipated stop at about the 226 kilometre mark, was answered by the train controller at 0342:10.

During the ensuing conversation, the train controller requested the train crew to check for anything dragging from the train as point detection had been lost at the southern end of Alumatta. This conversation ceased at 0343:00. At 0353:10 the assistant driver of 6SM9V called ARTC control with advice that a derailment had occurred. Details as known at that time, along with an offer to contact Centrol broad gauge control, were then conveyed to the ARTC train controller. The driver of train 6SM9V remained at the badly damaged Dellaro Road level crossing to prevent road traffic access until the arrival of the police at about 0440.

2.1.2 Emergency response ARTC

The ARTC emergency management plan is contained in document TA 44, *Interface Procedure, Incident Management Plan*. This plan is supplemented by the Major Emergency Plan that is contained in document TA 09 - *ARTC Code of Practice*. The manual and code of practice detail the emergency actions and procedures to be followed including; the immediate action by train crews in the event of an accident or obstruction and the reporting of accidents to train control.

When an accident occurs on the ARTC network, the ARTC manage and coordinate the incident response. This includes protection of the incident site and notification of emergency services. The other party, usually an above rail operator, will act as a support agency.

In regard to corridors that have parallel tracks controlled by different train control centres, the emergency procedure requires that the train control centre of the parallel track be notified of any incident and that measures must be taken to warn any approaching train.

2.1.3 Record of communications

The transcripts of the communications between the driver of train 6SM9V and ARTC control, the Melbourne Signal Fault Centre and ARTC control, ARTC control and Centrol and ARTC to the emergency services have been examined. Pertinent information is as follows:

- At 0321:40 train 6SM9V, when approaching Alumatta, encountered an automatic signal displaying a restricted indication. The driver asked train control what they intended to do with his train. The controller replied that 6SM9V was to be admitted to the crossing loop to cross train PW4 and that the delay would be about 10 minutes.
- At 0341:20 ARTC control contacted the Melbourne Signal Fault Centre and advised that detection at number three points at Alumatta had been lost. Discussion between them was then broadly directed at when the next train was due and the need to have these points examined.
- At 0342:10 the assistant driver of 6SM9V contacted ARTC control and said that their train had come to a stop at about the 226 kilometre mark due to a loss of brake pipe air. He also said that the driver had detrained and was in the process of physically checking the train. ARTC control asked the assistant driver to request the driver to check if anything was dragging as detection of the points at Alumatta had been lost. This conversation ceased at 0343:00.
- Ten minutes later at 0353:10 the assistant driver of 6SM9V contacted ARTC control with advice that the bogie from the second last wagon was missing and that the driver was proceeding beyond this point in order to locate the bogie and the last wagon of the train. The assistant driver then made mention of contacting Centrol but the ARTC controller advised he would contact Centrol straight away. This conversation ceased at 0353:30.
- At 0353:40 the ARTC controller rang Centrol. This call was answered at 0354:00 whereupon the ARTC controller immediately told the Centrol controller to not let any trains operate in the Alumatta vicinity. The situation as known was then conveyed to the Centrol controller, including details of the location (about the 226 kilometre mark), missing bogie and wagon.
- Between 0356:40 and 0408:20 conversations took place between the ARTC controller and the track maintenance supervisor, the Melbourne Signal Fault Centre and RailCorp train control.
- At 0419:00 the driver of train 6SM9V contacted ARTC control and advised that the last wagon was on its side just clear of the main line, the road crossing was impassable and that three bogies and six sets of wheels had been found in the vicinity of the road crossing. The name of the road crossing was not known. This conversation ceased at 0421:10.

- At 0421:50 the ARTC controller contacted the police and details were exchanged. The police officer undertook to send resources to investigate. This conversation ceased at 0425:30.

2.1.4 Train control and train crew response

Emergency procedures to be followed by train controllers and train crew in the event of an accident on railways in Victoria are an integral component of the accreditation system. The procedures in place meet the accreditation requirements. The first indication that there may have been a problem occurred eight minutes and three seconds after the southbound home departure signal cleared at Alumatta. At 0341:20, the technician at the Melbourne Signal Fault Centre received a phone call from the ARTC train controller that advised of a loss of detection at number three points, Alumatta. These are the points that train 6SM9V traversed as it departed Alumatta. The conversation lasted 30 seconds and focused primarily on the next train movements on the standard gauge. Twenty seconds later at 0342:10, the initial notification was received from the train crew of 6SM9V that they had come to an unanticipated stop at about the 227 kilometre mark. As a result of the signal engineer's call the train controller asked the train crew to check for anything from the train that may have been dragging along the ground. This conversation finished at 343:00.

Ten minutes and 10 seconds later at 0353:10 the assistant driver of 6SM9V called the ARTC train controller. The assistant driver said that the driver had found the second last wagon was missing the trailing bogie and that the last wagon was not in sight. This conversation finished at 0353:30. The ARTC train controller then called the Centrol controller on the direct telephone link at 0353:40. This call was answered at 0354:00. The broad gauge track was then blocked to all traffic by the Centrol controller.

The delay between the first indication of a possible hazard and passing a message to Centrol was about 11 minutes. It is self evident that with the broad and standard gauge tracks being in close proximity, an accident on one line may affect the safety of the other. The investigation established that ARTC procedures clearly detail what actions must be taken when an accident occurs that may impinge on the track of another owner.

The investigation also examined the reciprocal procedures in the event of an accident on the broad gauge. The Freight Australia Emergency Management Plan did not give any specific instruction on the contact to be made, or that any such contact should be immediate.

In essence there is no transparency between the two rail systems and the ARTC controller could not know whether or not there was any traffic on the broad gauge line. It would seem reasonable for a controller who had been given indication of a possible problem on his/her track to alert the other control centre of a potential problem. It may be argued that the loss of detection of a single set of points is not sufficiently significant to trigger an alert. However, when this is followed within a short space of time by an unexplained stopping of the train that has just passed over the points, it would be reasonable to set some contingency action in motion.

There was a lack of understanding of the possible consequences in delaying 11 minutes between being advised of 6SM9V stopping and alerting Centrol.

In regard to the notification of the emergency services personnel by the ARTC controller, it is contended that the loss of point's detection at Alumatta and the unanticipated stoppage of train 6SM9V did not require the train controller to contact the emergency services at that stage. However, the receipt of advice in regard to missing bogies and the trailing wagon at 0353:10 (concluding at 0353:30) broadened the possibilities of collateral damage significantly, particularly in relation to the five level crossings traversed between Alumatta and the 226 kilometre mark. Notification of the emergency services at this juncture (0353:10) would have been desirable. The police from Wangaratta were called at 0421:50 and arrived at about 0440.

2.2 Rollingstock factors

2.2.1 Wagon and bogie maintenance VQCY 850X

Freight Australia's wagon department maintained the wagon fleet in accordance with the standards that were set out in the *Freight Australia Ltd Maintenance Manual*. The development of this manual was based on the recommended practices and data from the *Railways of Australia Manual of Engineering* and the *Engineering Code of Practice* for the DIRN.

Pre departure examinations (coded as FX1 examinations) were carried out on all Freight Australia trains at the originating freight depot. In addition, Pacific Rail Engineering were contracted to carry out regular wagon inspections on the CRT train consist at the Yennora container terminal in Sydney. These inspections were conducted every time this wagon consist entered Yennora. The purpose of these inspections was to monitor wagon condition and included inspection of the bogies and associated springs.

Defects that do not prevent the wagon from remaining in service that are unable to be rectified at these inspections, were referred to either the Freight Australia Running Maintenance Area at Dynon or dedicated workshops at Newport or North Geelong.

Wagon VQCY 850X, the first wagon of train 6SM9V to derail, was manufactured by the Ballarat North Workshops circa 1975 – 1978. The bogies fitted to VQCY 850X were three piece Ride Control A3 50 tonne standard gauge (often referred to as high speed stuki bogies) and the derailed bogie was allotted the identification code of VXSC 15611.

In August 2003 bogie VXSC 15611 had its bearings inspected and wheels turned to ANZR2 profile at the Evans Deakin Industry (EDI) workshops at Newport.

Maintenance carried out to wagon VQCY 850X by Freight Australia's wagon department at Dynon since April 2002 was:

- 20/04/2002 – Wheels greased, grease added to axle box and axle box faces painted
- 20/04/2002 – Refitted container twist locks, repair one anchor bracket
- 18/05/2002 – Replace knuckle coupler
- 05/05/2003 – Repair diaphragm type brake control valve and test
- 22/05/2003 – Replace one side mounted hand brake handle.

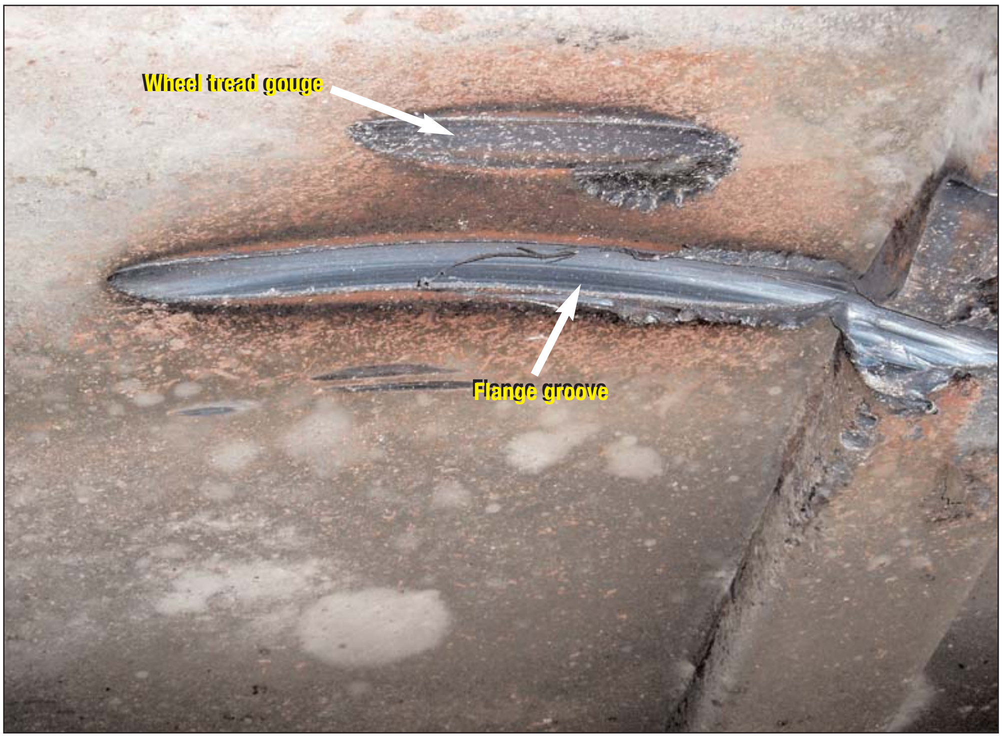
The last wagon inspection conducted by Pacific Rail Engineering was carried out on VQCY 850X on 12 March 2004 at Yennora. All categories were examined and all were recorded as being in a satisfactory condition.

2.2.2 Post incident wagon examination

An examination of wagon VQCY 850X took place at Dynon in the presence of ARTC and Freight Australia representatives. This wagon was lifted off the replacement bogie in order to allow for a closer inspection of damage and wheel markings on the underside of the wagon deck.

The wagon deck had been damaged by wheel contact at four locations above where bogie VXSC 15611 had been situated. On one side the damage was predominantly to the underside of the deck and on the other side the wheel flanges had indented the deck thereby deforming the deck. Humps were formed in the wagon deck floor as a result. The location of this damage was almost directly above and slightly inwards from the normal operating position of the wheels.

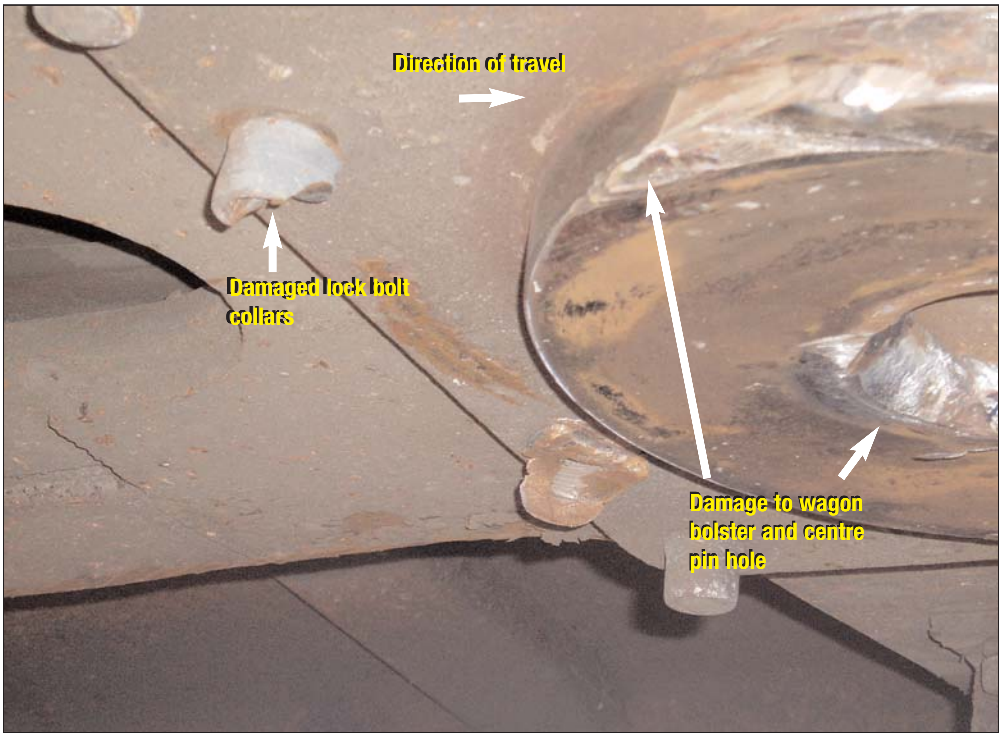
FIGURE 9: Indent marks underside of VQCY from wheel flange



There was also evidence of impact damage to the underside of the wagon side sills. This damage was consistent with contact between the side sill and the axle boxes in their normal operating location.

The wagon showed damage to the two rear bolster plate swage lock bolt collars and localised deformation at the sides of the wagon bolster matching the deformation evident on the bogie centre plate. The damage to the swage lock bolt collars and the localised deformation to the wagon bolster indicated that the bolster had experienced angular and linear displacement during operation.

FIGURE 10: Damage to lock bolt collars and wagon bolster



The bent centre pin and damage caused to the wagon bolster bowl and swage lock bolt led to some conjecture that the wagon and bogie may have been disengaged prior to the derailment at Alumatta. During testing the wagon body was lifted from the replacement bogie to see if sufficient displacement could be attained to allow contact between these components with the centre pin engaged and the bogie bolster horizontal. Contact could not be made. The only way in which such contact could occur would be by angular displacement of the bogie bolster combined with a bent centre pin. Extreme forces would be necessary for this to occur, such as a bogie being dragged beneath the wagon at speed.

The wheel flange and tread grooves under the right side of the wagon body could have only been made as a result of either the dislodgement of bogie spring nests and/or the disengagement of the bogie side frame from the axle box keeps.While the investigation has not been able to detail conclusively the exact sequence in this regard, the right wheels of the derailed bogie had assumed a raised position under the wagon to allow these grooves to be made. Because the wheel flange and tread groove were almost directly above and slightly inwards from the normal projected position of the wheels of this bogie, it is considered that this contact occurred prior to the rearward and angular displacement of the bogie bolster that caused contact between the bolster and swage lock bolts. This contention is supported by the location of an outer spring on the east side of the standard gauge track 52.4 metres from the point of derailment and the later location of the right side bogie side frame scuff marks along the west side of the track between Sandford and Shanley Street level crossings. To further support the contention that this displacement was the result of the derailment and subsequent dynamic trauma, metallurgical testing indicated that the metal hardness of the swage lock bolt collars was less than the bogie material. This indicated the wear observed to the swage lock bolt collars was sacrificial to that of the bogie bolster material. This leads to an indication that the swage lock bolt collars could have worn through if the bogie had been disengaged over an extended period of time.

Examination of the wagon bogie of VQCY 850X revealed no evidence to suggest structural faults or worn components could have contributed to this derailment.

Damage to this wagon was primarily confined to the underside of the deck in the vicinity of where bogie VXSC 15611 was situated prior to disengagement. This damage consisted of gouges and abrasions consistent with vigorous contact being made by the components of bogie VXSC 15611 as it became detached from the bogie bolster shortly after the train derailed as it exited the Alumatta crossing loop.

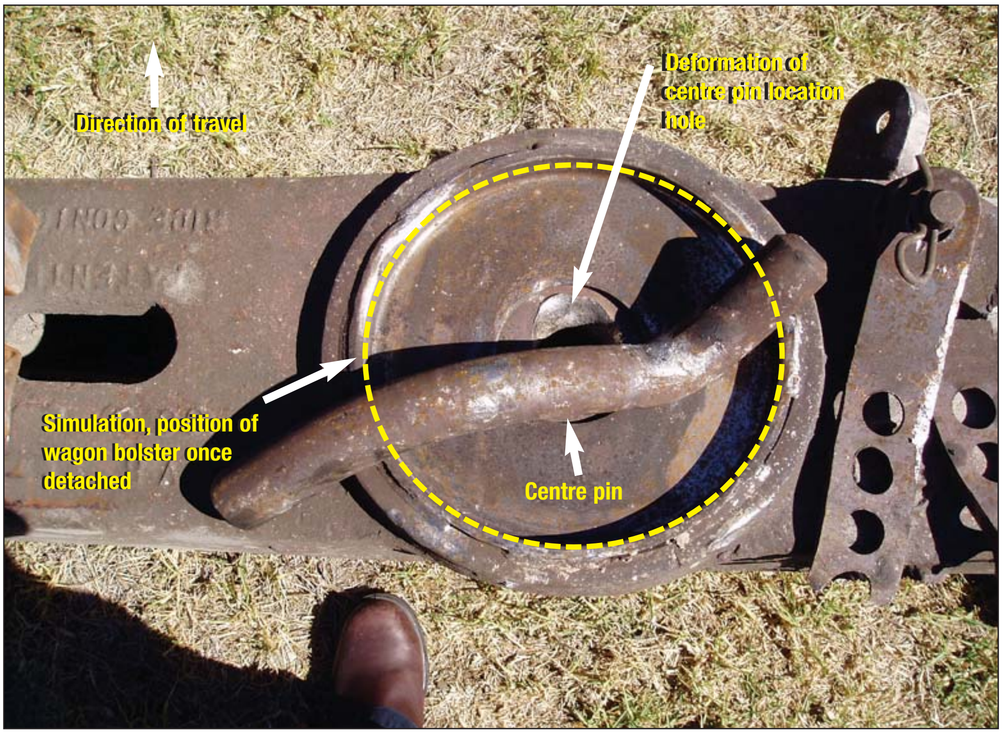
2.2.3 Post incident bogie examination

Bogie VXSC 15611 was in a dismantled state when delivered to the Non Destructive Testing (NDT) premises at Newport, Victoria. One bogie side frame, the wheel sets, brake beams and most of the springs were dislodged. There were gouge marks on the inside leading end of the left side frames and notable wear and deformation of the leading end of the right side frame pedestal leg. This deformation and wear was consistent in dimension with the scuff marks found along the western side of the derailed route.

FIGURE 11: Recovered components of bogie VXSC 15611 showing deformation of leading pedestal leg and gouge marks from wheel 3L

The independent examination commissioned by the ATSB identified damage to the pedestal frame. The examination concluded that some of the damage had occurred as a result of contact with the ballast/track work. The report determined that the damage to the pedestal was caused by instantaneous overload as a result of the derailment.

FIGURE 12: View of bogie bolster centre plate bowl area and centre pin deformation



Similarly, deformation of the bolster in the gib clearance region and the absence of excessive wear make it probable that the dislodgement of the right side frame from the bogie resulted from the initial derailment and subsequently being dragged in a derailed state. There was no sign of pre existing cracking that would suggest failure of the side frame.

The two bogies from the trailing wagon of train 6SM9V, VQCY 952K, were also examined at the NDT premises at Newport. The condition of these bogies was found to be within specifications with the exception of the centre plate liner and centre plate bowl of the leading bogie. This centre plate liner measured 314 mm in the longitudinal direction and 311 mm in the transverse direction.While there were no signs of crushing of this liner, it had been worn out of round and was close to condemning size. The nominal diameter for centre plate wear liners is 305 mm. Also, there were cracks in the weld that attached the centre plate around 75 per cent of the periphery of the bogie centre plate bowl. This cracking exceeded the maximum allowable. Despite the deterioration in the centre plate liner there was no evidence that the condition of the plate was a factor in this derailment.

Springs from the bogies of wagon VQCY 952K and bogie VXSC 15611 were recovered for examination. In all, 30 springs should have been recovered. Sixteen springs were recovered from the derailment site, one spring nest was retained in bogie VXSC 15611 and the other two bogies contained eight and four springs respectively. One spring was not accounted for. It was not possible to determine from which position the recovered springs originated.

Three of the recovered springs were found to be broken. Metallurgic examination revealed that one spring was probably broken before the derailment. The other two springs probably broke at the time of, or after the initial derailment. Although the examination found some evidence of fatigue at the break, it was estimated that 90 per cent of both fractures were due to instantaneous overload.

In addition, an inspection of the leading bogie of wagon VQCY 850X was conducted at Dynon. This inspection was conducted visually and the wagon body was not lifted from the bogie. One broken spring from the centre nest on the right side of the wagon (in the direction of travel) was found.

FIGURE 13: Typical bogie spring nest showing inner and outer springs

If both the previously broken springs were present in the bogies of wagon VQCY 850X, one would have been in the lead bogie (as found) and one in the trailing bogie. The ability of the bogies of wagon VQCY 850X to steer though the turnout at Alumatta may have been inhibited. In addition, if the springs that were not recovered were missing from the trailing bogie of this wagon, then further impediments to bogie steering could have emerged. However, it is considered more probable that the missing springs were simply not recovered or misplaced during the recovery operations.

Apart from the damage caused by the derailment, bogie VXSC 15611 itself was in good condition. The evidence is that all component fractures were the result of instantaneous overload and that the damage to the bogie occurred as a result of the derailment and was not a cause.

2.3 Train handling

2.3.1 Hasler locomotive data logger G533

Locomotive G533 was fitted with a Hasler type data recorder. The parameters monitored are traced on a wax paper chart by a stylus.

The Hasler data recorder fitted to locomotive G533 recorded:

- distance travelled
- time
- speed
- vigilance cycle system acknowledgment by crew.

Traces one and six record distance by the spaces between the dots.When stationary, each dot represents 30 minutes and when moving, each dot represents 500 metres travelled.

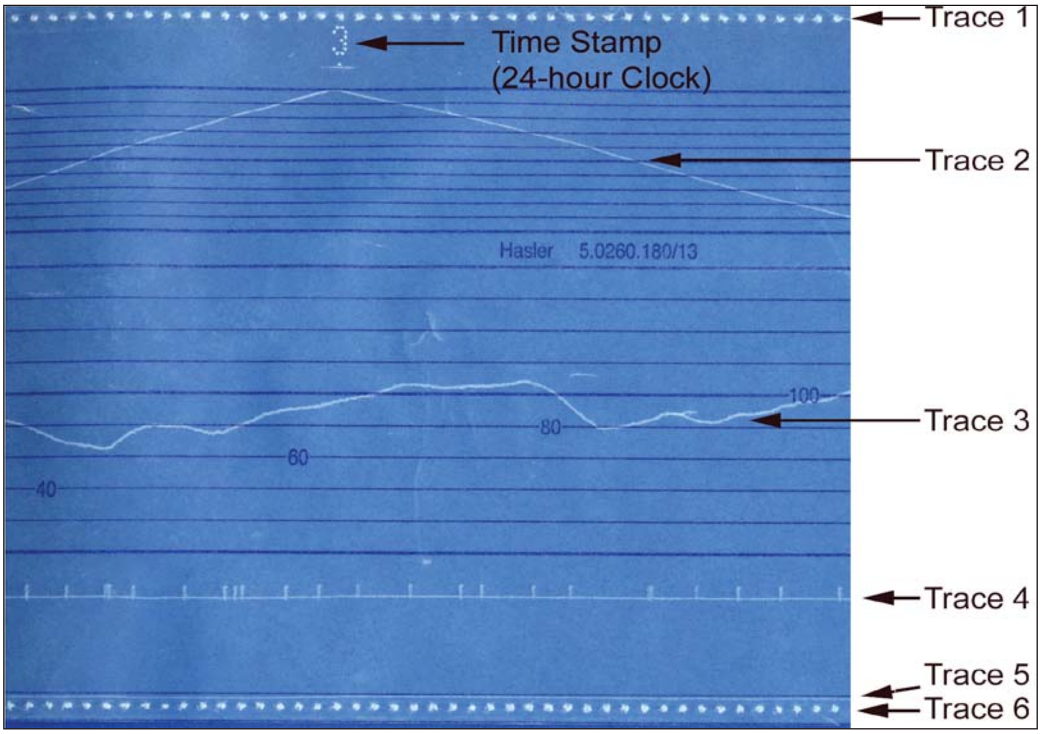
Trace two records time elapsed and each line represents one minute. The time trace crosses the horizontal line at one minute increments and the actual time is recorded at hourly intervals at the top of the chart in 24 hour clock format.

Trace three records speed from zero to 180 kph. In this instance the trace crosses the horizontal line at 10 kph intervals.

Trace four records vigilance system acknowledgment by the crew as short 'spikes' in the trace. If the locomotive brakes are fully applied, for instance when the train is stationary, the locomotive vigilance system is overridden and therefore not recorded.

Trace five not used.

FIGURE 14: Hasler recorder graphic



2.3.2 Hasler locomotive data logger X51

Locomotive X51 was also fitted with a Hasler type data recorder. The parameters monitored are recorded on a wax paper chart by a stylus in the same manner as the Hasler recorder on G533. The parameters monitored are different because vigilance system acknowledgment is not recorded but throttle and locomotive brake cylinder pressure are.

The Hasler data recorder fitted to locomotive X51 recorded:

- distance travelled
- time
- speed
- throttle
- locomotive brake cylinder pressure.

In the same manner as the Hasler recorder fitted to G533 trace one, two and six record distance travelled and time. Trace three records speed from 0 to 150 kph (in lieu of 180 kph).

Trace four records locomotive power settings in a broad sense.When the locomotive throttle is in either idle or notch one (the lowest power setting), the trace will be in a raised position.When the locomotive throttle is in any notch setting from two to eight (eight being the maximum power setting) the trace will be in the lower position.

Trace five records the percentage of locomotive brake cylinder pressure from zero to 100 per cent. This equates to between 0 kpa and 375 kpa. This is shown by the trace rising from the base line.

2.3.3 Data logger readings, train 6SM9V

The data logger readings from locomotives G533 and X51 were examined in order to evaluate their accuracy and the method of train handling used by the train crew of 6SM9V from arrival at Alumatta to the 226.485 kilometre mark.

It was found that the Hasler data logger installed in X51 was not recording time. Also, there were variances in the speed and distance recorded between G533 and X51 in that G533 recorded a maximum speed of 71 kph and a distance of 5788 metres and X51 recorded a maximum speed of 69 kph and a distance of 5570 metres. A probable cause is the difference in wheel diameters, G533's wheels being near the minimum diameter allowable at 933 mm and X51's wheels being almost new with a diameter of 1015 mm. Speed and distance recorded by a Hasler data logger are directly linked and therefore, proportionate to one another.

In order to minimise variances Hasler data loggers are calibrated to a mid size diameter wheel, in this case 965 mm. In this way tolerance of about plus or minus five per cent variation between actual and indicated speed should not be exceeded.

FIGURE 15: G533 Hasler data reproduction as recorded

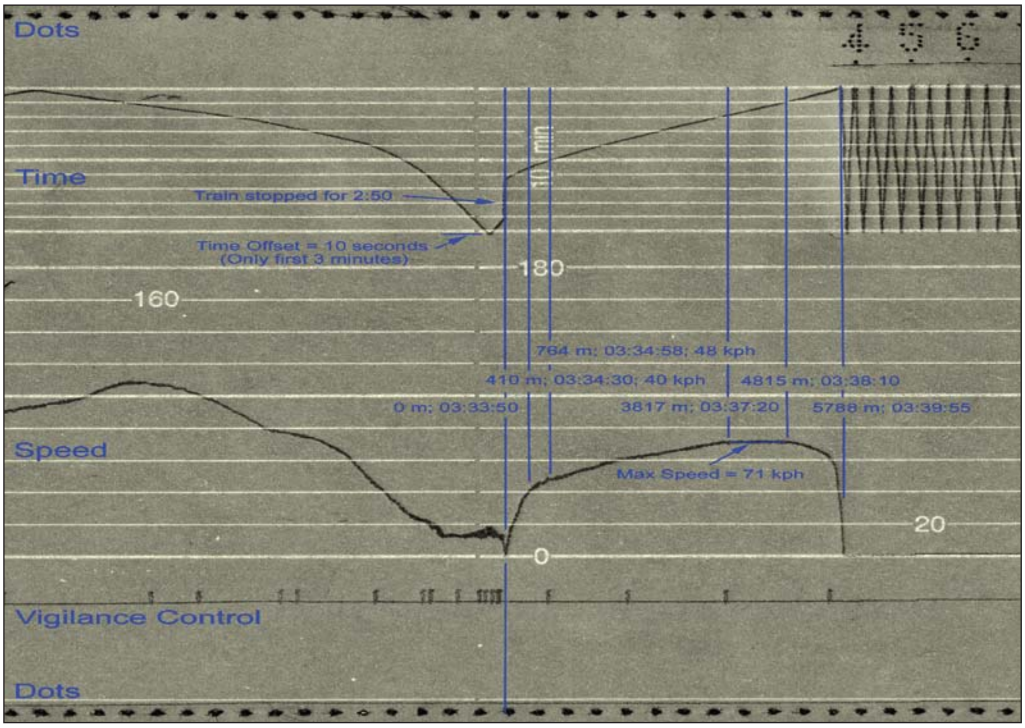
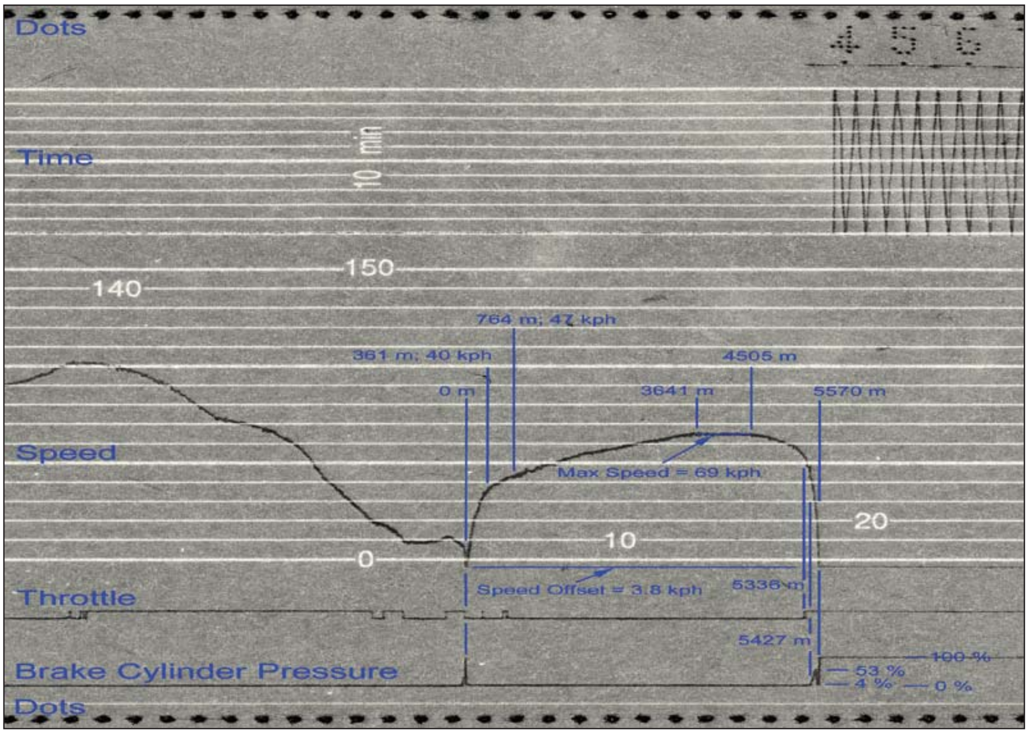


FIGURE 16: X51 Hasler data reproduction as recorded

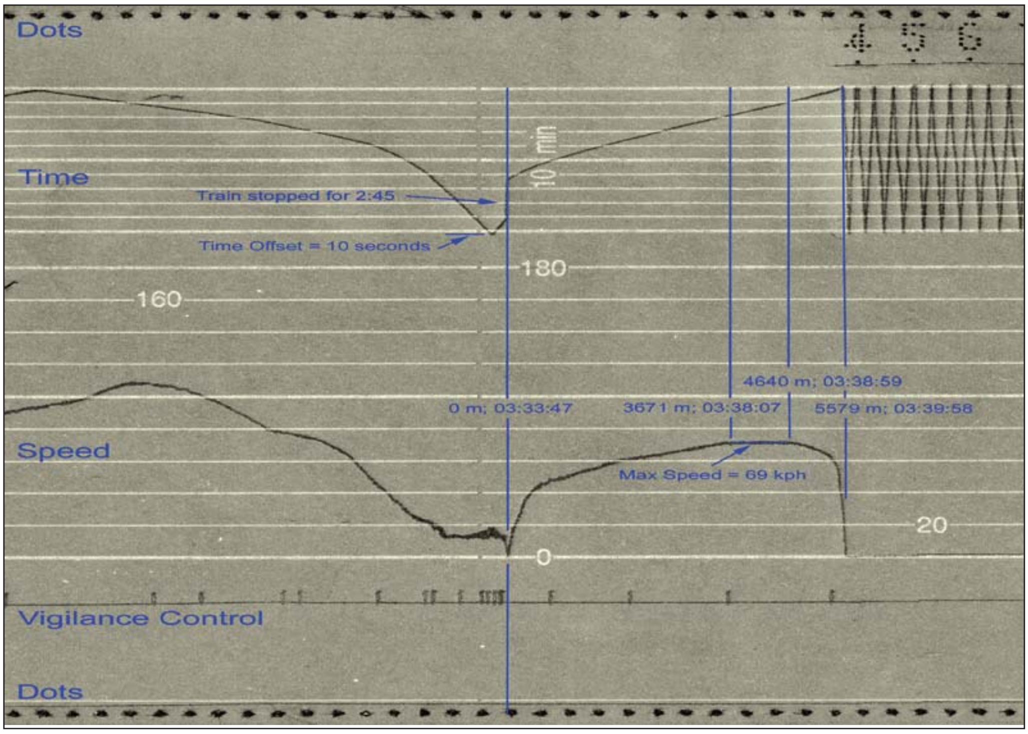


Locomotive G533 with the smaller worn wheels should have travelled a true (actual) speed and distance less than that recorded by the Hasler data logger (Figure 15). Similarly, X51 with near new full size wheels should have travelled a true (actual) speed and distance greater than that recorded by the Hasler data logger (Figure 16).

The driver of train 6SM9V said he stopped the train about four locomotive lengths from the home departure signal at Alumatta. The distance from this point to the 226.485 kilometre (where the lead end of locomotive G533 stopped) is about 5532 metres. In order to confirm the accuracy of both Hasler data loggers, speed and distance has been recalculated as if the wheel diameter was 965 mm, the actual size to which the data logger was calibrated. The distance recorded by this recalculation is then compared to the actual distance of 5532 metres.

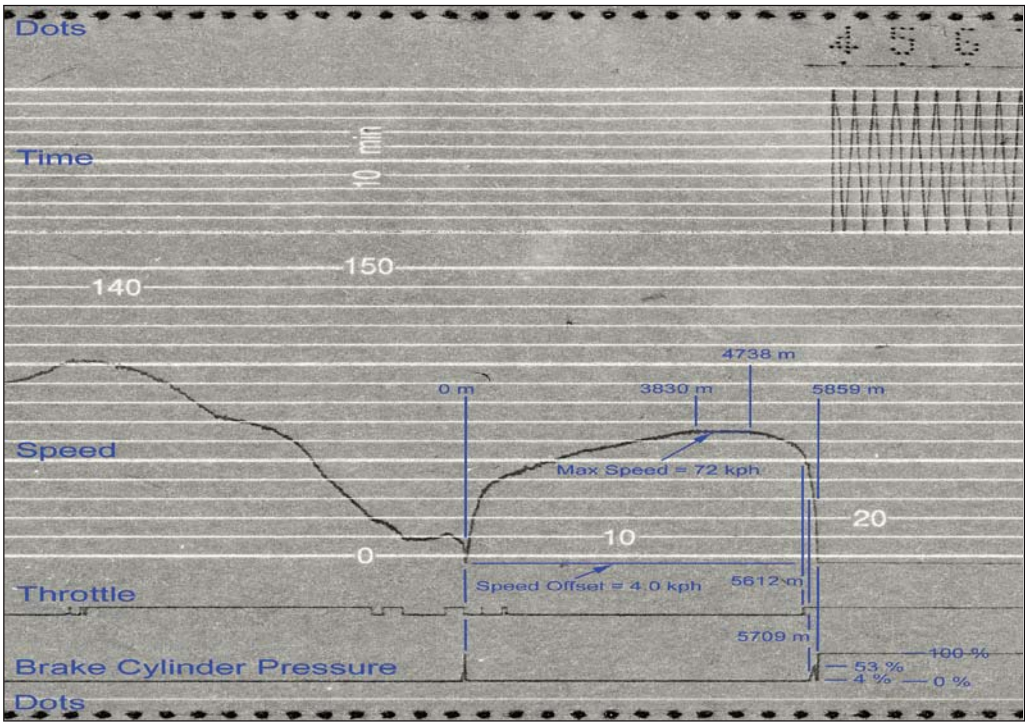
With the data logger from G533 this is a factor of 0.964. Therefore the actual distance travelled if the wheels were 965mm diameter was calculated to be 5579 metres. This is 47 metres (or about 2.5 locomotive lengths) further than the distance travelled if the locomotive was stopped four locomotive lengths from the home departure signal at Alumatta.

FIGURE 17: G533 Hasler data normalised at wheel size 965 mm



With the data logger from X51 this recalibration is a factor of 1.05. Therefore the actual distance travelled if the wheels were 965 mm diameter was calculated to be 5859 metres. This is 327 metres further than the distance travelled if the locomotive was stopped four locomotive lengths from the home departure signal at Alumatta.

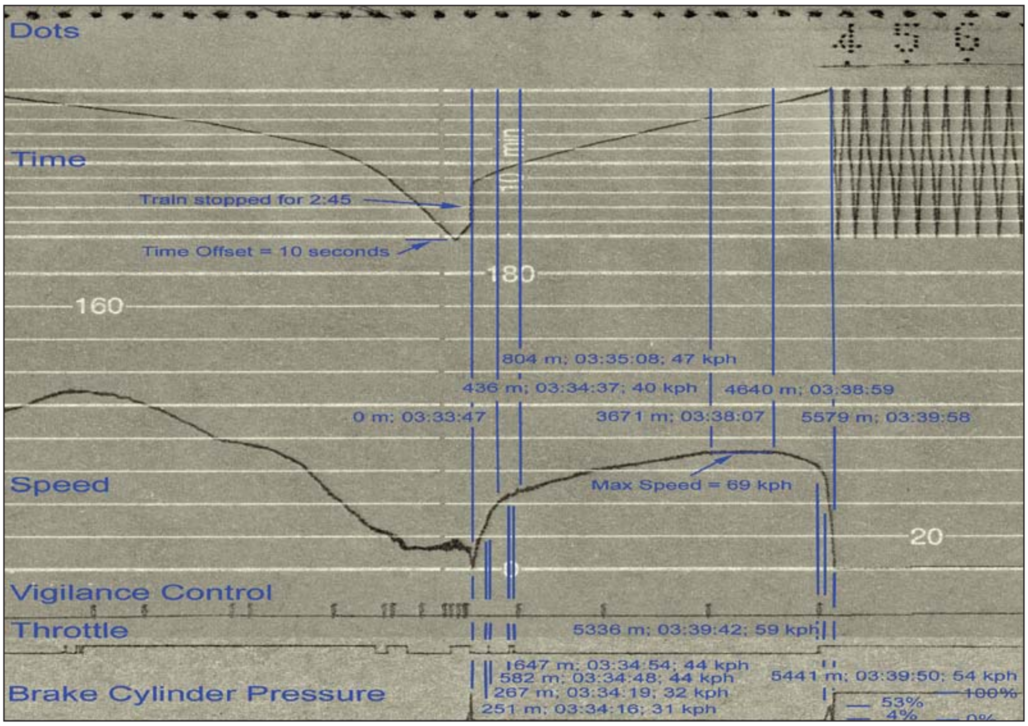
FIGURE 18: X51 Hasler data normalised at wheel size 965 mm



The minimum distance able to be travelled (lead locomotive stopped at the home departure signal at Alumatta) would have been 5456 metres. The maximum distance able to be travelled (rear of train just in clear of the loop at Alumatta) would have been 5747 metres. Therefore the distance recorded by the Hasler data logger in X51 at wheel diameter 965 mm (5859 metres) would not have allowed 6SM9V to stop with the rear of the train clear of the mainline at Alumatta.

It is concluded that the Hasler data logger from G533 is more accurate than the Hasler data logger from X51 in terms of distance. Because speed and distance are linked, the Hasler data logger from G533 should also be more accurate in terms of speed. The normalised data at wheel diameter 965 mm from G533 will be used for the analysis of train 6SM9V. Throttle settings and brake cylinder pressure readings have been derived from the Hasler data logger on X51.

FIGURE 19: G533 Hasler combined distance, speed, time, brake cylinder pressure and vigilance acknowledgement data normalised at wheel diameter 965 mm



Of particular importance is the speed at which the rear of the 600 metre long train exited the turnout at the southern end of Alumatta. In this instance, because the train is accelerating, the exit speed of the rear wagons is directly related to the distance it had to travel to the points.

Using the recalculated data logger reading of 5579 metres and working back from the 226.485 kilometre point, the leading end of G533 was about 123.5 metres from the home departure signal at Alumatta. This distance is about 40 metres greater than the driver's best recollection of about four locomotive lengths or 80 metres. To the recalculated distance of 123.5 metres the 81 metres from this signal to the turnout must then be added to the 600 metre train length in order to calculate the recorded speed at which the rear exited the turnout. This combined distance equals 804 metres from the turnout to the rear of the last wagon.

Although the absolute accuracy of the Hasler data logger from G533 is still not confirmed, somewhere between four and six and a half locomotive lengths from the home departure signal at Alumatta would seem the most reasonable conclusion as to the departure point of train 6SM9V from the Alumatta crossing loop. Therefore, calculations will be based on the departure point from which 804 metres has to be travelled before the rear of the train exits the crossing loop.

The following table illustrates the timeline of key events that took place during the departure of train 6SM9V from Alumatta crossing loop, the data in this table being taken from the normalised Hasler data logger calculations of G533. Referring to this table, it is evident that the departure speed of 40 kph was reached 436 metres after departure and that, except for a six second reduction, an amount of power greater than notch two was retained until the rear of the train exited the loop at a calculated speed of 47 kph.

Time	*Distance (Metres)*	*Event*
0331:00	0	Locomotive stops at Alumatta crossing loop
0333:47	0	Locomotive commences to move
0334:16	251	Speed is 31kph, throttle decreased below notch two
0334:19	267	Speed 32kph, throttle notch two or higher
0334:37	436	Exit speed of 40kph reached
0334:48	582	Speed 44kph, throttle decreased below notch two
0334:54	647	Speed 44kph, throttle notch two or higher
0335:08	804	Speed 47kph, rear of train exits crossing loop
0338:07	3671	Speed 69kph (constant)
0338:59	4640	Speed 69kph, commences to decrease
0339:42	5336	Speed 59kph, throttle decreased below notch two
0339:50	5441	Speed 54kph, loco brake cylinder pressure commences to fluctuate from zero to 53%, to 4% thence to 100%
0339:58	5579	Locomotive stops, brake cylinder pressure 100%

Of note is that if train 6SM9V had stopped with the rear of the train as far back in the loop as possible (just in clear of the Down home departure signal), the rear of this train would have exited the turnout at 50 kph. If train 6SM9V had stopped with the leading locomotive at the Up home departure signal the rear of this train would have exited the turnout at 45 kph. These calculations were obtained by adjusting the wheel diameter to alter the placement of the lead locomotive. The speed recorded was altered by the same factor as the distance travelled (to the 226.485 kilometre point). In this manner the acceleration curve remains relative to the distance travelled.

2.3.4 Summary

This investigation has gained insight as to how train 6SM9V was handled as it entered and exited the crossing loop at Alumatta by undertaking a detailed analysis of the Hasler locomotive data recorders from both locomotives and interviewing both train crew.

Hasler data recorders are amongst the earliest types of data recorders fitted to locomotives, indeed their inception goes back many years to the days of steam locomotives.While various improvements have been made over the years, they have been incremental in nature and in essence the same principle of recording data derived from speedometer cables and electrical pulses remains.While the Hasler data recorders are proven devices that have given valuable service over many years, they are nevertheless prone to inconsistencies in regard to accuracy and, on occasions, failures due to speedometer cable or mechanism malfunctions.

However, in this instance, it is concluded that the normalised data logger readout from locomotive G533 is reasonably accurate. Therefore it is probable that the lead locomotive was stopped between four locomotive lengths (as stated by the driver) and six and a half locomotive lengths (as calculated by the normalised G533 data logger) from the Up home departure signal at Alumatta Loop.

At interview, the driver said he set the countdown meter on G533 as it exited the turnout at the Alumatta crossing loop. Speed was then said to have been maintained at about 35 kph until the countdown meter indicated there was about 50 metres of the train to clear the loop. At this point power was increased to eight notches (full throttle). This account of events was similar to that of the assistant driver. In general discussion after the interview, the driver also said that he had recently booked the speedometer of G533 as reading a speed in excess of that being travelled. No record of this booking has been found in the current locomotive log book and the previous log book is missing.

Given that the countdown meter on G533 derived input from the same axle as the Hasler data recorder, several tests were conducted to ascertain the accuracy of this device. In each instance, the countdown meter recorded a distance greater than that actually travelled. Over shorter distances the results varied considerably but over 5,000 metres a fairly consistent discrepancy of about 200 metres was recorded. This equates to an error of about four per cent. If this four percent was consistent, 600 metres would be registered on the countdown meter at an actual distance of 576 metres. However, given the varied results of these tests, no conclusion can be reached other than the countdown meter was probably about four percent in error.

Trains regularly operate on the Victorian DIRN network at lengths of up to 1,500 metres. There are many instances where train crew, even when travelling during daylight hours, are unable to sight the rear of their train. During the hours of darkness, the rear of the train is never sighted. This, coupled with the high power to weight ratio of some modern trains, can lead to a situation where the speed of a restricted section of track can be unintentionally exceeded by the rear of a train. It is therefore imperative that locomotives operating such trains have accurate speedometers and countdown/distance measuring meters or sufficient safety margins built into operating procedures.

Train 6SM9V had a (horsepower) kilowatt to tonne ratio of (3.66) 2.74. Although at 600 metres it was not a long train by contemporary standards, this power to weight ratio was quite high and trains regularly operate with less than half of this figure. The driver and driver's assistant said at interview that no indication of the derailment was felt via train dynamics, the first indication being the loss of brake pipe air pressure. Given the power to weight ratio factor and the stated application of full power by the driver as the train was clearing the crossing loop at Alumatta, it is reasonable that the draft (drag) forces exerted by the derailed bogie would be difficult, if not impossible, to detect from the locomotive.

It is concluded that it is likely that a power setting excess to the requirements of maintaining the exit speed of 40 kph was applied and retained as train 6SM9V exited the crossing loop at Alumatta. Notwithstanding the calculated inaccuracies of the count down meter, given that the exit speed was attained 436 metres after departure and that the train was 600 metres in length, it is evident that greater judgement in regard to the application of power should have been exercised.

An analysis of train handling as train 6SM9V entered the crossing loop at Alumatta was also conducted. Train handling in this instance was not outside set parameters.

2.4 Rail/wheel interface

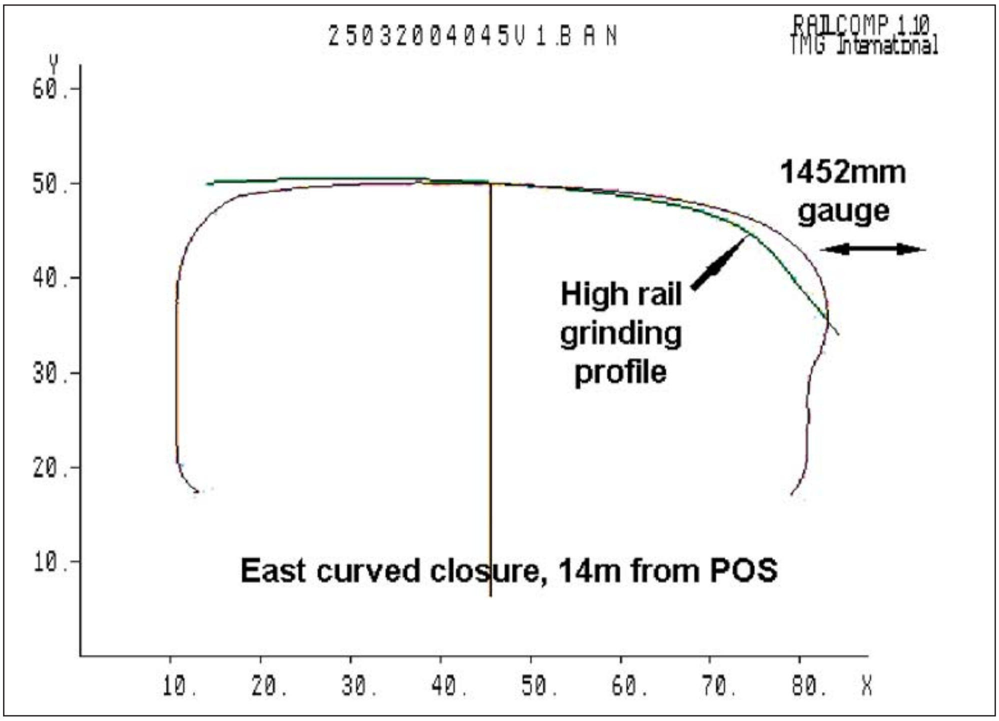
2.4.1 Rail and wheel profile

In order to establish the probable wheel and rail interface at the point of derailment at Alumatta, accurate measurements and profiles of the rail and wheels were taken. These measurements were taken using a Miniprof Wheel instrument. The Miniprof Wheel is a very precise instrument that utilises a series of displacement transducers to create a two dimensional plot of rail and wheel profiles.When used to measure wheel profiles, a profile is generated referenced to the back of the wheel flange and a nominal location on the wheel tread 70 mm offset from the back of the flange.

The measurements taken by the Miniprof Wheel instrument revealed that the rail profiles of the east point blade were heavily worn and had not been ground in many years. Figure 20 shows the actual profile of the east curved closure rail as measured compared with a theoretical profile had the rail been ground in recent times. The red trace shows the rail as measured, the green trace as if it had been ground.

All eight wheels of wagon RCQY 850X were found to match the Railways of Australia ANZR2 profile. Most wheels in Australia are now manufactured and maintained to match new National Code of Practice profiles known as WPR2000. This profile has been progressively implemented in recent years.When new, the WPR2000 wheel profile is different in shape from the ANZR2.When worn, this difference in shape is less noticeable except for the outer part of the wheel tread which remains materially different.

FIGURE 20: Typical curve closure rail profile



When new, the probability is that a wheel of the WPR2000 profile would experience less complications with steering as they are deliberately shaped to lift the outer part of the wheel tread away from the rail. Consequently, when negotiating track configured in a similar manner to the turnout at Alumatta the outer part of the tread is less likely to contact the stock rail, thereby removing an impediment to steering cleanly.

According to the wheel numbers, both wheel sets fitted to bogie VXSC 15611 were manufactured in 1998. At inspection, the diameter of these wheels was about 20 mm below that of a new diameter wheel, well within specification. The wear, however, indicates that a significant amount of service had occurred since manufacture. The tread profile though was near new, as all four wheels were turned and profiled to the ANZR2 profile in August 2003.

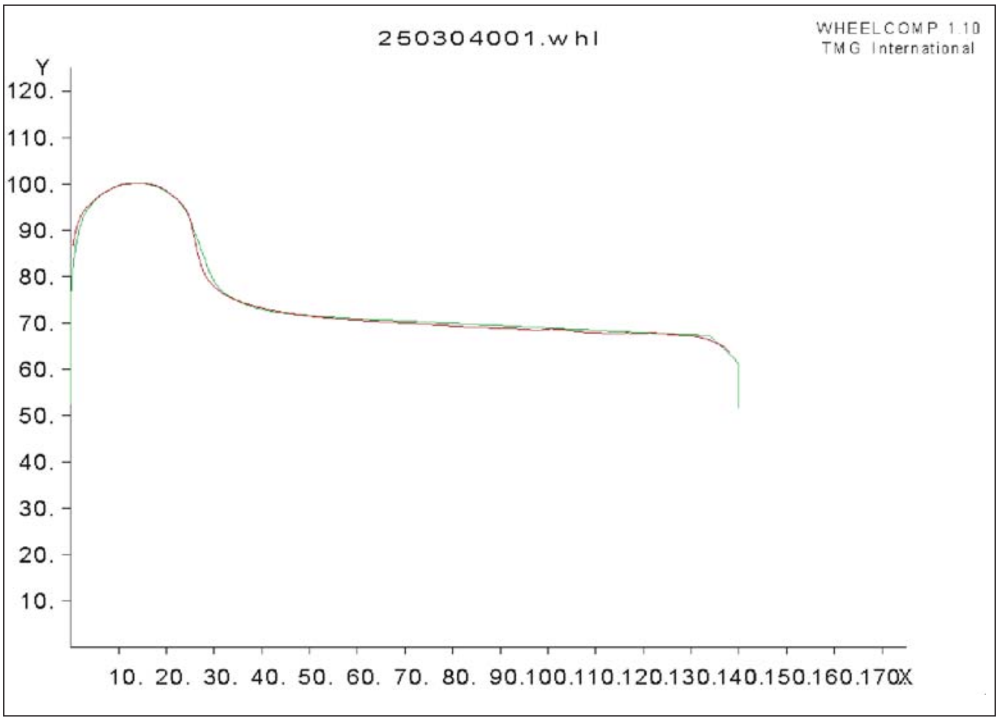
All four wheels of bogie VXSC 15611 were in good condition apart from some derailment damage.Wheel 3L was ground on the rim face and bevel, consistent with the gouge marks on the inside of the left side bearer. This wheel also had damage around the bevel and edge of the tread.Wheel 3R was damaged about the wheel face.Wheel 4R was 'bruised' on the rim face and bevel and wheel 4L had a dent in the flange which was about 15 mm wide, 50 mm long and 8 mm deep. This dent was about 45 degrees to the wheel flange. In general terms, the damage to these four wheels was 'impact' in nature, resulting from wheels running over track and bogie componentry while in a derailed state.

The following data is from measurements taken from the first wheel to derail, the left wheel of number three axle (3L), trailing bogie of wagon VQCY 850X. This wheel was coded CSC 98 S7384:

- Flange height limit: (max 35 mm) 30.203 mm
- Hollowing limit: (max 3 mm) 0.485 mm
- Flange width limit: (min 19 mm) 34.446 mm
- Flange lip: 0.054 mm
- Gauge face angle: 12.052 degrees.

Notwithstanding the impediments caused by the damaged condition of the wheel when measured, it can be seen that the wear data is quite benign and therefore not considered a factor in this derailment. Figure 21 below is a comparison of this wheel with a theoretical new wheel of an ANZR2 profile. The green trace represents the new wheel.

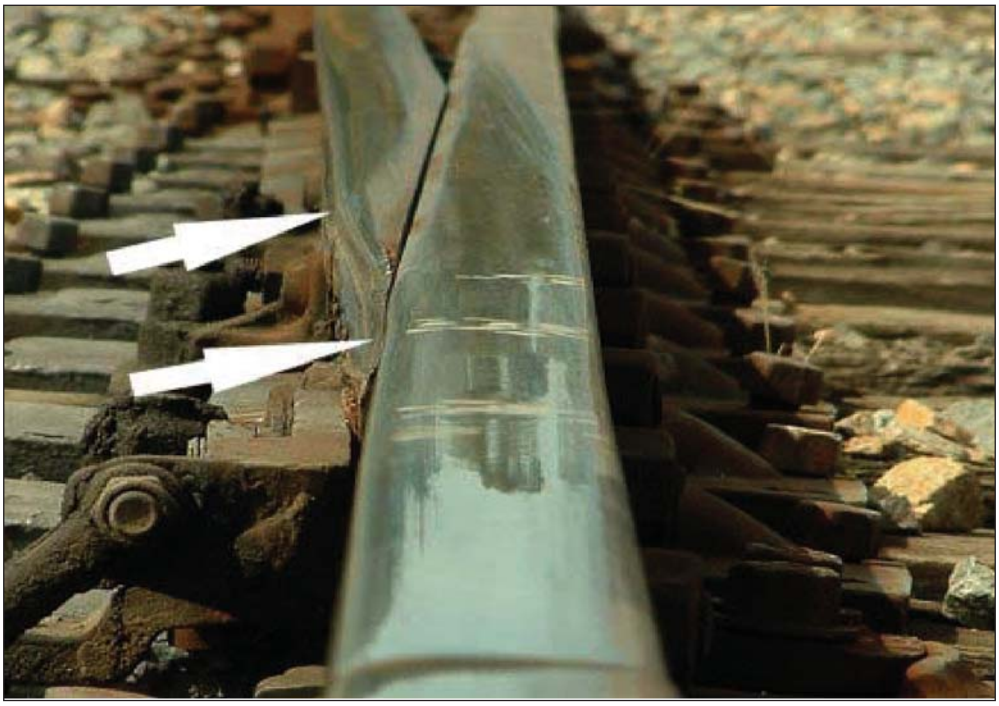
FIGURE 21: Profile comparison, the first wheel to derail



2.4.2 Probable path of wheels

At figure 22 a photo of the east point blade can be seen. The last 500 mm of the east point blade was hollowed out. Indications are that some wheels followed a projected line of this point blade (not contacting the hollowed portion) and some followed the actual point blade profile.

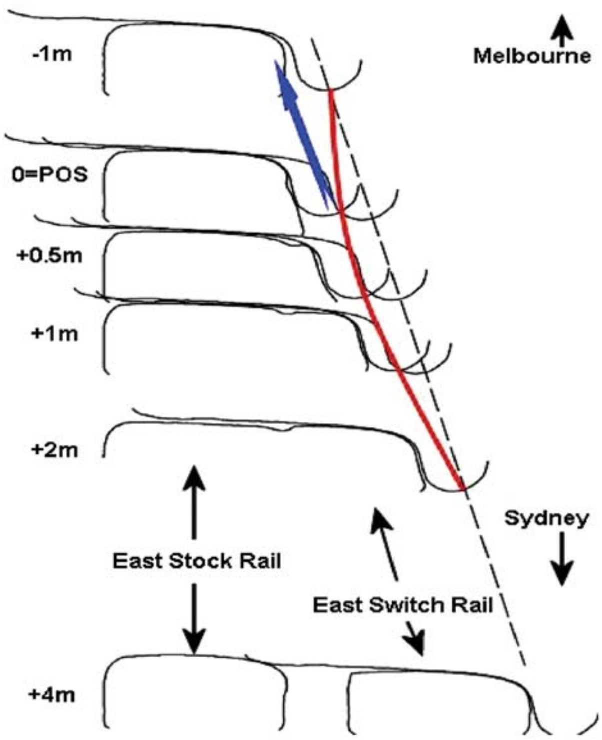
FIGURE 22: Alignment and flared nature of last 500mm of east point blade



Should the latter path be taken, the stock rail is impacted immediately beyond the toe of the point blade. If this were not so, the gauge corner would not be crushed down at the tip of the switch point. Figure 23 shows these two paths, the black dotted line is the path that the majority of wheels take. The red solid line indicates the approximate path of the wheels that follow the point blade alignment. The evidence indicates that the wheel that derailed did not curve back onto the straight stock rail but carried on across the stock rail head in the direction indicated by the blue arrow.

Observation of southbound trains travelling via the crossing loop at Alumatta showed that most wheels followed the projection of the point blade rather than closely conforming to the actual alignment. This meant that the wheel flange met the stock rail somewhere along the stock rail beyond the toe of the point blade. In observing the point of climb at the very end of the point blade point though, it is apparent that the first wheel to derail followed a path closely conforming to the actual alignment of the last portion of the point blade. If such an alignment is followed, the wheel tread is well over the head of the stock rail and the flange would be very close to, or in contact with, the point blade gauge face. There are two issues to be considered. Firstly, the wheel will contact the stock rail immediately beyond the toe of the point at an acute angle and secondly, this tracking will lead the outer side of the wheel tread into contact with the outer or field side of the closure and stock rails.

FIGURE 23: Wheel paths over east point blade

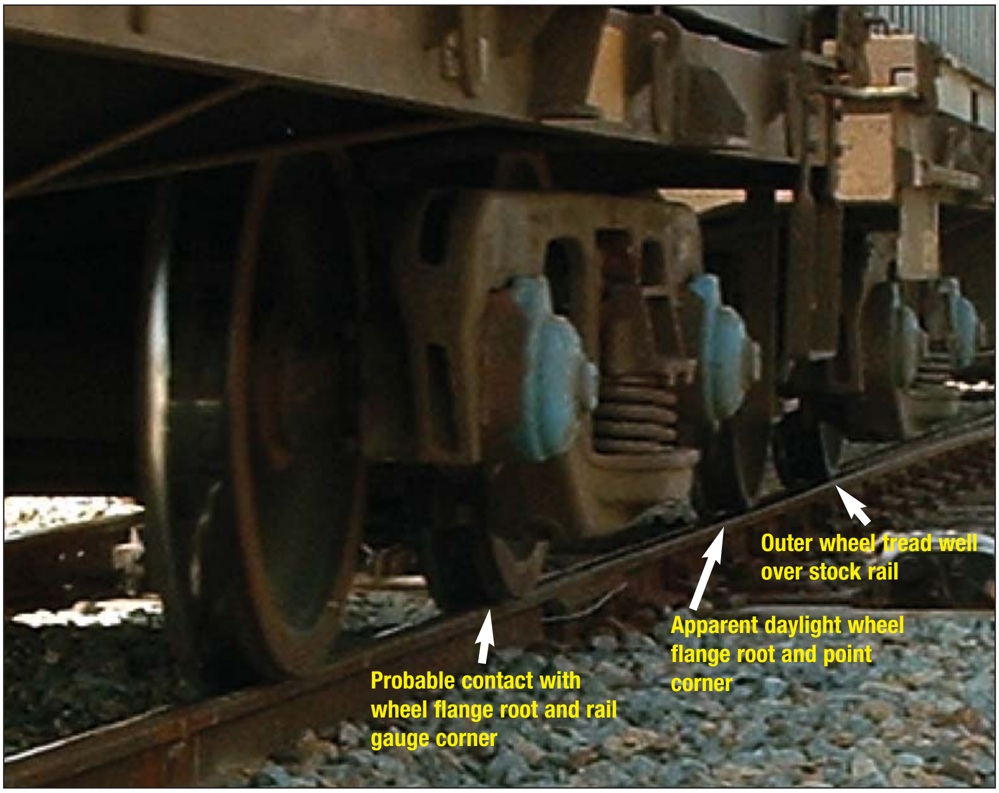


There are two factors that may have contributed to the derailed wheel taking this path. Firstly, as the wheel tread has a conical cross-section, for any given rotation of the wheel, the outer part of the wheel tread has a rim speed less than the inner part. This is known as the 'rolling radius differential'. The result is often creep induced wear (scrubbing) on the outer side of the stock rail. The net effect of such contact can be a tendency to steer the wheelset towards the field side of the closure and stock rails.

In this instance, evidence of scrubbing was found on both the curved closure and stock rails.

The photo in figure 24 was taken on site at the point of derailment and illustrates this point. The left arrow shows the wheels well over towards the rail, with probable full contact between the wheel flange root and the rail gauge corner. The right arrow shows the side of the wheels well over the head of the stock rail, meaning the flange would be very close to, or in contact with, the point blade gauge face while, near the point of the switch, there is daylight visible between the wheel flange root and the point blade corner.

FIGURE 24: Wheels passing over the point of derailment, cripple siding Alumatta



Secondly, with three piece bogies the bolster and side frames are held approximately square by roller bearing adaptors, friction snubbers and bolster gibs. Should wheel creep occur, this can have the tendency to cause the inner side frame to move slightly ahead of the outer side frame which results in the bogie yawing (a warped angle). This yawing is known as 'parallelogram' and can lead to an increase in the angle of attack and therefore the lateral force of the bogies lead outer wheel.

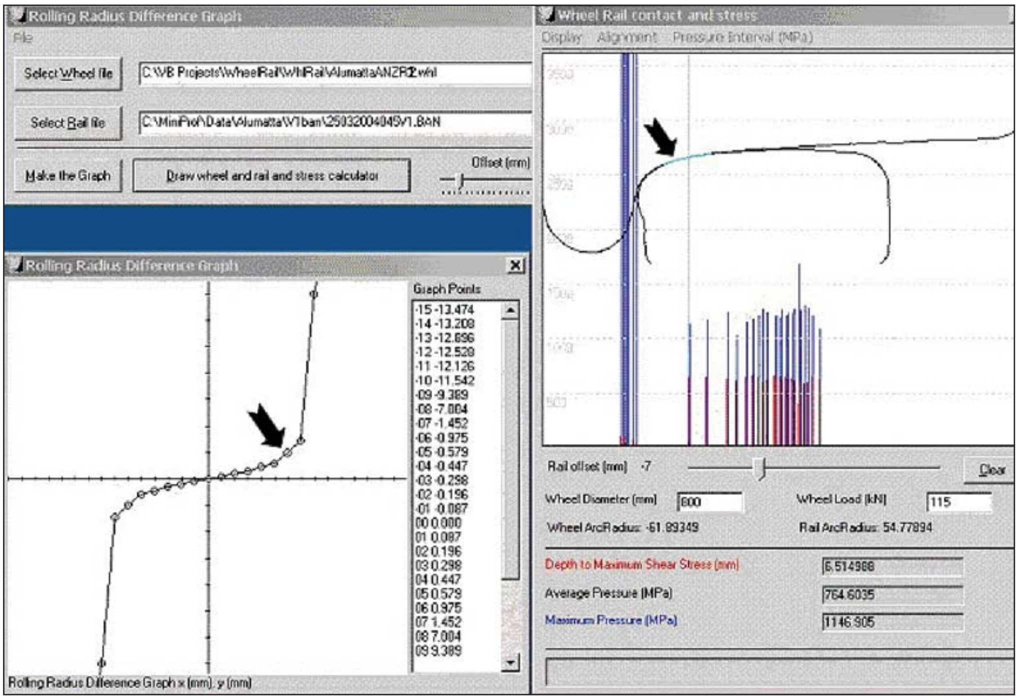
2.4.3 Derailment mechanics

A common assessment for the potential for wheel climbing is undertaken using the 'Nadal' formula. This takes into account the vertical and horizontal wheel loads, the coefficient of friction and the tangent of the angle of contact between the wheel and the rail. This formula, however, does not take into account any turning forces that may apply to wheelset action.

The nominal flange face angle for the first wheel to derail was 12 degrees to the vertical. Applying that angle to a high friction coefficient of 0.6 (due to dry rail) would suggest that a lateral force slightly greater (1.1) than the vertical wheel load would be required before the wheel would climb the rail at this point.

The right graph in figure 25 shows the wheel very close to making contact with the flange at the toe of the point blade. The left graph shows the change in the rolling radius as the wheel moved across the rail. Importantly, immediately before flange contact (shown in both graphs by the black arrows) the effective conicity[18] is high and the angle of contact is low. High conicity can have beneficial and negative effects as the wheel steering can be improved but stability can lessen. A degradation of stability means that a relatively low lateral force would result in wheel climb according to the 'Nadal' formula.

FIGURE 25: Conicity at east point blade

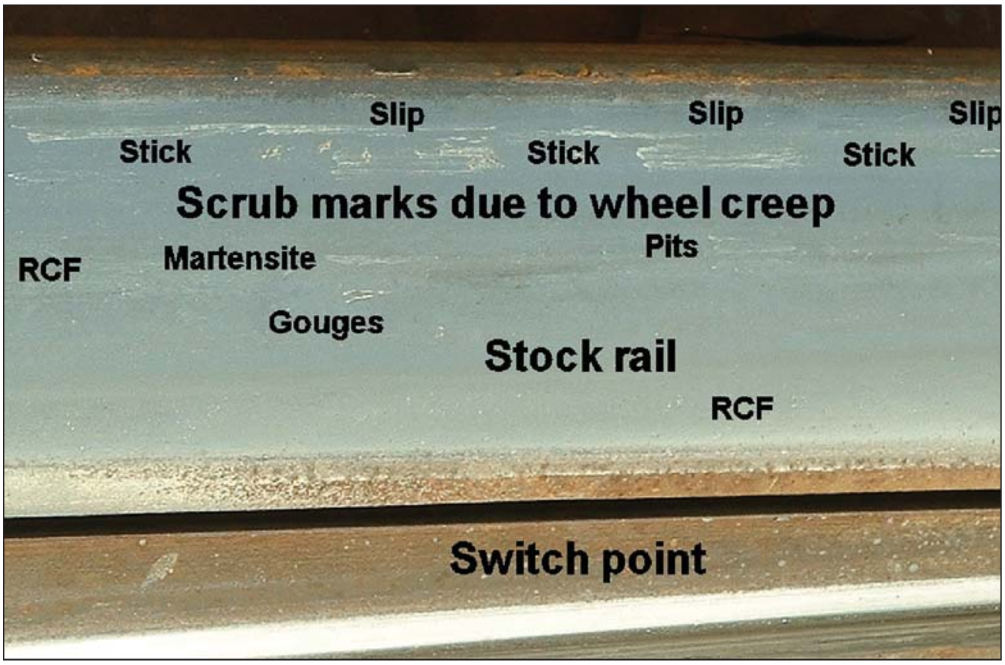


In submission the ARTC contended that an application of a friction coefficient of 0.4 would be more appropriate than 0.6. The friction coefficient of 0.6 was chosen because of the dry track condition at site inspection and the wear patterns found on the rail. These markings indicated martensite formation and shallow pits where

18 Effective conicity – conicity is an expression of the cone angle of the tread of a wheel. Effective conicity is a mix of the cone angle of the wheel tread and interaction with the rail.

martensite had cracked off the rail surfaces and minor rolling contact fatigue. Such markings are a consequence of high friction coefficient. At the time of the derailment dew could have been present; however no records of the condition or appearance of the rail were taken.

FIGURE 26: Rail wear pattern



However, the fact remains that in order for the wheel to climb there must be a lateral force that is significant enough to overcome the vertical wheel load. In addition, draft or buff forces[19] should not have been excessive given that by the time this portion of the train exited the turnout power had been applied for about 126 metres.

At about 13 metres before the toe of the point blade the radius of the turnout measured in March 2004 was 129 metres. The speed of the rear of the train was 47 kph. Calculations reveal that the actual wagon speed through the turnout exceeded the calculated design speed[20] for a 129 metre radius turnout by about 54 per cent (refer to section 2.3.4). The result of such acceleration is the right or inner wheel unloading by 28 per cent. The rail is almost straight from this point, leading to a likely rolling of the vehicle outwards at about 13 metres before the toe of the point blade then inwards somewhere in the vicinity of the toe of the points. The speed and likely roll frequency of the wagon give rise to the possibility of wheel unloading near the point of climb. Note that the calculations in figure 27 do not take into account the condition of the track, hence wheel loading variances are very likely to have been more than these figures suggest.

19 Draft or buff – a commonly used term in the rail industry. Draft forces are those exerted when a train is being pulled or stretched, buff forces are those exerted when a train is being compressed or bunched.

20 Calculated design speed – based on the draft *Code of Practice for the Defined Interstate Rail Network, Volume four Track*, *Civil and Electrical Infrastructure, Part three Infrastructure Guidelines*.

FIGURE 27: Calculated wheel loading variances

Basic Input													
Speed			V =	47	kph, or	13.1	m/s						
Curve radius			R =	129	m								
Gravitational accel'n			g =	9.81	m/s^2								
Actual cant			a =	10	mm								
Rail contact point distance			s =	1500	mm								
Height to C of G			h =	1700	mm								
Basic Results:													
Equilibrium cant for speed V, e =			202	mm									
Calculated cant deficiency, d =			192	mm - excess if negative									
Balance speed for cant a, Ve =			10	kph, or	2.9	m/s							
Total lateral accel'n due to V =			1.3	m/s^2									
Vertical-to-datum unit load multiplier for equilibrium cant						1.01							
Lateral accel'n due to cant excess or deficiency						1.26	m/s^2						
			Which should not be more than 0.52m/s^2 normally, or 0.65m/s^2 exceptionally for track up to 125kph, (Ref Esveld, p.27)										
Vertical acceleration on rail due to cant deficiency, +ve for HR, -ve for LR							1.42	m/s^2					
For example, for nom. axle load			19.0	t, load diff. on high rail is			27.0	kN, and diff. on load rail is			-27.0	kN	
Hence the vertical load on the high rail for selected axle load is						12.3	t or	121	kN and on the low rail		6.8	t or	67
Offset from track CL to resultant, inc. 50mm vehicle slack						268	mm				28%	unloading	
					Which should not be more than 250mm on SG track or 180mm on NG track (Ref Hay, p.603)								

Although the first wheel to derail was the loaded left or outer wheel, considerable vehicle dynamics would have been evident at this time. The vertical profile was such that wagon suspension activity would be significant. Figure 29 illustrates this profile as it appears to the eye at rail level. It will be seen that there are two dips in the curved closure rail and a third at the toe of the point blade to the cripple siding. This was the point of climb of the first wheel to derail. The dynamics of such a situation can manifest themselves in the form of transient forces that will act laterally and vertically respectively (a 'bouncing and rolling' effect). Thus the derailed wheel, in this instance, could have experienced rapid alternate excessive loading and unloading. Sudden increase of curvature can also impact on lateral loading, exacerbating the dynamics of the situation.

2.4.4 Maintenance standards used in Victoria

Railway Safety Management, as defined in Australian Standard 4292, requires that an organisation shall establish and maintain formal frequency schedules for the regular inspection and testing of safety related engineering and operational systems. Organisations shall determine the frequency of inspection and testing of each system. The *National Codes of Practice* have been developed by the rail industry in this country over several years and represent, in general terms, an agreed industry position.When the system of co-regulation and accreditation was introduced in 1998 the Volume four of the draft ARTC annotated *NCoP DIRN Track, Civil and Electrical Infrastructure* (referred to as 'the NCoP' in sections 2.4.4, 2.4.5, 2.4.6 and 2.4.7 of this report) had not been developed.

It is important to note that where the NCoP is referred to in sections 2.4.4, 2.4.5, 2.4.6 and 2.4.7 of this report it is for comparative and analytical purposes in regard to current maintenance standards and practices.

The standard gauge track between Melbourne and Albury is leased by the ARTC. The maintenance standards applicable to this track under the accreditation agreement are said to be the *Civil Engineering Circulars* (CECs) of the former Victorian Government Public Transport Commission. The CECs mandate the track geometry standards and defect response requirements while the track maintenance contractor standards set out the monitoring requirements.

Under the CECs monitoring of the track condition is by direct physical inspection, augmented by a specialised track vehicle which measures the geometry of the track. Before the autumn of 2002 the specialised track vehicle was an 'EM' Car, the readings from which gave a track quality index calibrated to provide readings relevant to the CEC standards. In about May 2002, the EM Car was superseded by a new car monitoring system, the 'AK' Car. When the AK Car, owned and operated by the Rail Infrastructure Corporation (RIC), commenced operations in Victoria, the requirements for remedial action on identified exceedences were altered from those set out in CECs 7/86 and 8/86 to a defect and response table specific to the AK Car. This table was a result of the need for intervention standards that ensured all faults recorded were consistent with previously collected data from the EM Car. Therefore, taking account of the different way in which the AK and EM Cars measured vertical alignment (inertial system) and the differing dynamics (weight and speed), certain track defect parameters were altered.

The risk assessment associated with the introduction of the AK Car examined:

- changes to intervention standards
- defect deterioration
- risk of misinterpreting results
- different measuring system before correlation
- inadequate correlation
- AK Car performance
- AK Car producing 'false readings'
- loss of data continuity.

The risk assessment did not address track fault response requirements.

Response codes of the CECs are coded as 'A', 'B' or 'C' with 'A' being the highest priority. These codes place broad time frames on inspection and remedial action in lieu of specific time frames. Response codes of the NCoP are coded 'E1', 'E2', 'P1' and 'P2' with 'E1' (emergency class one) being the highest priority. These response codes do place specific time frames on inspection and remedial actions. A copy of '*Table 5.5 Geometry Defects – Response Codes*' is at 7.2 Appendix Two.

The ARTC have submitted a material change application to the Victorian regulator, The Department of Infrastructure, for the introduction of Volume four of the ARTC annotated NCoP DIRN, *Track, Civil and Electrical Infrastructure.* A number of outstanding issues are still being addressed therefore this application has yet to be approved.

2.4.5 Turnout geometry

2.4.5.1 Assessment overview

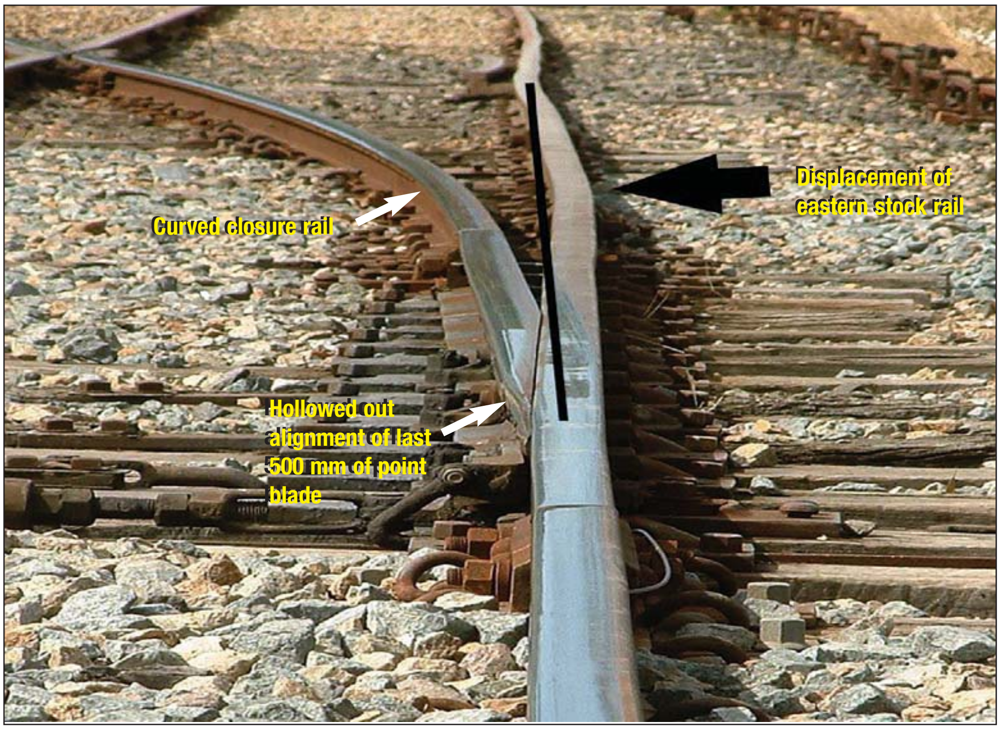
After the derailment of train 6SM9V an examination of the southern turnout and cripple siding at Alumatta was carried out by the ARTC, an ARTC contractor, the ATSB and an independent expert engaged by the ATSB. The purpose of these inspections was to ascertain the geometry of the turnout in regard to gauge, rail profile, radius, alignment and vertical profile. Also, a similar examination of the turnout and cripple siding at the northern end of Alumatta and southern end of Glenrowan was carried out for comparative purposes. The examination of the southern turnout at Alumatta focused on the area either side of the toe of the eastern point blade - the point of climb.

2.4.5.2 Visual assessment

Visual examination of the point blade revealed that where the point blade from the cripple siding closed with the stock rail there was wear and the alignment did not follow a smooth transition.

The eastern stock rail[21] at the cripple siding was displaced before closure with the point blade. This displacement increases to a maximum immediately behind the heel block, and is technically a misalignment of the track. As this rail is attached to the same bearers as the curved closure rail there is the likelihood of similar misalignment of the eastern curved closure rail occuring.

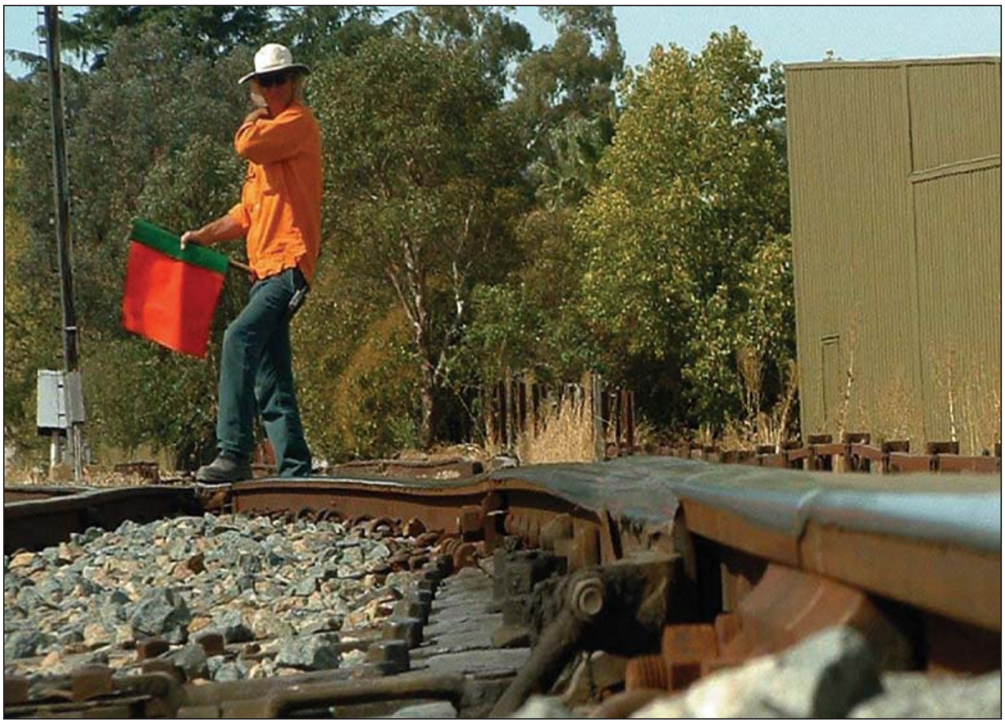
FIGURE 28: Alignment of eastern stock rail



The horizontal alignment and vertical profile of the turnout was observed to be such that considerable wagon body and suspension activity would be experienced by passing rail traffic. This movement was seen by ATSB investigators when observing a train negotiating the turnout. At a reduced speed of 20 kph wagons were observed to change direction with noticeable lateral movement

21 Stock rail – The rail to which a point blade fits up against when in the closed position.

FIGURE 29: Vertical profile, illustrating the undulations of the curved closure rail and the flared rail at the point blade



2.4.5.3 Twist, cross level, gauge and longitudinal measurements

Twist, cross level, gauge and longitudinal level measurements were taken (on the day of the derailment) by the contactor engaged by the ARTC. These measurements were taken using a track gauge with level and tape measure and by field level with a survey staff at two metre intervals.

These measurements revealed the presence of a twist in the vicinity of the point of climb. This twist correlated to a rate of change of 1:91 using a track gauge and 1:118 using a field level. Depending on the measurement referred to, this is either just outside or just within bogie acceptance tests that require the ability to negotiate a twist of 1:100. This twist could result in localised loading and unloading of downward wheel forces due to torsion.

CEC 8/86 stipulates the increments in which track measurements are to be taken and, for certain parameters, they are different to those prescribed by the NCoP. For example, the measurement of short twist is to be taken over 3.5 metre intervals, long twist over 10 metre intervals.

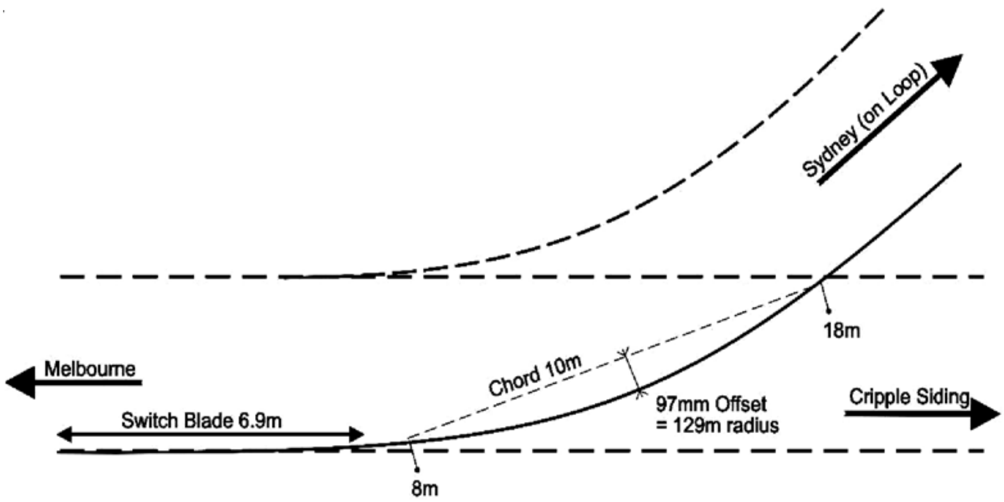
In this regard, the twist measurements taken by the ARTC and their contractor were not in accordance with the requirements of CEC 8/86. Rather, they were taken in two metre intervals which are in accordance with contemporary practices more aligned to the NCoP. As such, determination as to whether or not the turnout was compliant with the geometry standards of CEC 8/86 that pertain to short twist is not possible because these measurements cannot be accurately correlated to measurements taken at 3.5 metre intervals.

However, the AK Car recorded through the loop at Alumatta on 11 December 2003, about four months prior to this derailment. Because theses readings are measured in .5 metre increments, a calculation was able to be made in regard to 3.5 metre short twist. This calculation indicated a twist of -31.38 in the vicinity of the point of climb. This would have constituted a CEC 'A' exceedence as at 11 December 2003 requiring 'swift attention'[22].

2.4.5.4 Radius and cant deficiency

Chord and offset measurements of the curved closure rail were taken 12 days after the derailment by an independent expert who was engaged by the ATSB. These measurements were taken at two metre intervals using a 10 metre stringline. A maximum offset of 97 mm was measured over a chord extending between eight and 18 metres from the toe of the point blade. This offset equates to a curve radius of 129 metres. Figure 30 illustrates the method used and measurements obtained.

FIGURE 30: Curve radius, Alumatta cripple siding southern end



The design radius of this turnout as defined by plan number 426.61 was 219 metres. After a derailment at almost the exact same location in November 2002, the radius of this turnout was measured at 154 metres. These measurements represent a steady deterioration of the design radius. The comparative examinations undertaken of the turnouts at the northern end of Alumatta and southern end of Glenrowan also revealed non compliance in terms of design radius. The design radius of the Glenrowan turnout is 227 metres but was measured as 169 metres. The design radius of the Alumatta turnout (northern end) is 219 metres but was measured as 185 metres.

Radius of curves and the speed of trains are directly linked to the degree of cant deficiency[23] experienced when negotiating curvature track. Limits on cross level variation (or cant) are set by the CECs and the NCoP. In addition, the NCoP places limits in tabular form (table 5.2) on rail vehicle cant deficiency.

The NCoP parameters in terms of cant deficiency are used (in part) to calculate and recommend an appropriate speed limit applicable to a specific curve. Relevant to tangential turnouts, a typical design cant deficiency of 75 mm is recommended. However, with the infrastructure owner's approval, this may extend out to a

22 Swift attention – Category A exceedences 'Is the priority exceedence sub-level. All faults of this level must receive swift attention'.

23 Cant deficiency – is the difference between ideal cant (that can apply to only one speed) and actual cant. Track is designed for differing train speeds; cant deficiency is calculated to determine tolerance levels.

maximum of 85 mm. To adopt a less conservative design parameter (more) than 85 mm cant deficiency, the NCoP recommends a full site specific risk assessment. The southern turnout at Alumatta has a design radius of 219 metres. This equates to a calculated recommended speed of 37.3 kph at 75 mm cant deficiency and 39.7 kph at 85 mm cant deficiency. The posted speed limit for this turnout is 40 kph, which approximates the NCoP design standard.

The reduction in radius of the turnout from 219 metres to 129 metres meant that the posted speed limit of 40 kph was excessive for the altered conditions. Based on the NCoP calculations for a track radius of 129 metres, not taking cant into account, is 30.5 kph, about 31 per cent slower than the posted speed.While exceeding a speed limit based on the NCoP recommended design parameters does not mean that a derailment will occur, it would result in unusually high lateral forces.

2.4.5.5 AK Car measurements

The computer file '0.5 raw parameter data set' from the AK Car run of 11 December 2003 identified a horizontal alignment defect of -70.25 mm at the 231.870[24] kilometre point. As calculated, this is about seven metres prior to the point of climb and within about six metres of where the 97 mm offset was measured 12 days after this derailment. The maintenance contractor, however, worked on data from the corridor exceedence Maximo[25] report that generated a lesser horizontal alignment defect of -48 mm at the same point (231.870 km). The data in the Maximo report was generated from the same AK Car run. This is an inaccuracy of concern.

It is acknowledged that, from time to time, track recording data is amended where spurious readings are recorded. This can easily happen at road crossings and in parts of turnouts as a consequence of multiple rail and road surfaces. However, where this occurs, it is the responsibility of those concerned to ensure no defects are omitted. The investigation has found no apparent reason as to why the maintenance contractors would receive a record that indicates a lesser exceedence than that recorded by the AK Car in this instance.

AK Car outputs correlate with a Geometric Defects table (Appendix 7.1). A defect of greater than 45 mm horizontal alignment on 40 kph maximum speed track is coded as a P2 response priority and requires inspection within seven days and repair within 28 days. It is noted that this same defect (> 45 mm) would be afforded a P1 response code priority at table 5.5 of the NCoP (Appendix 7.2).

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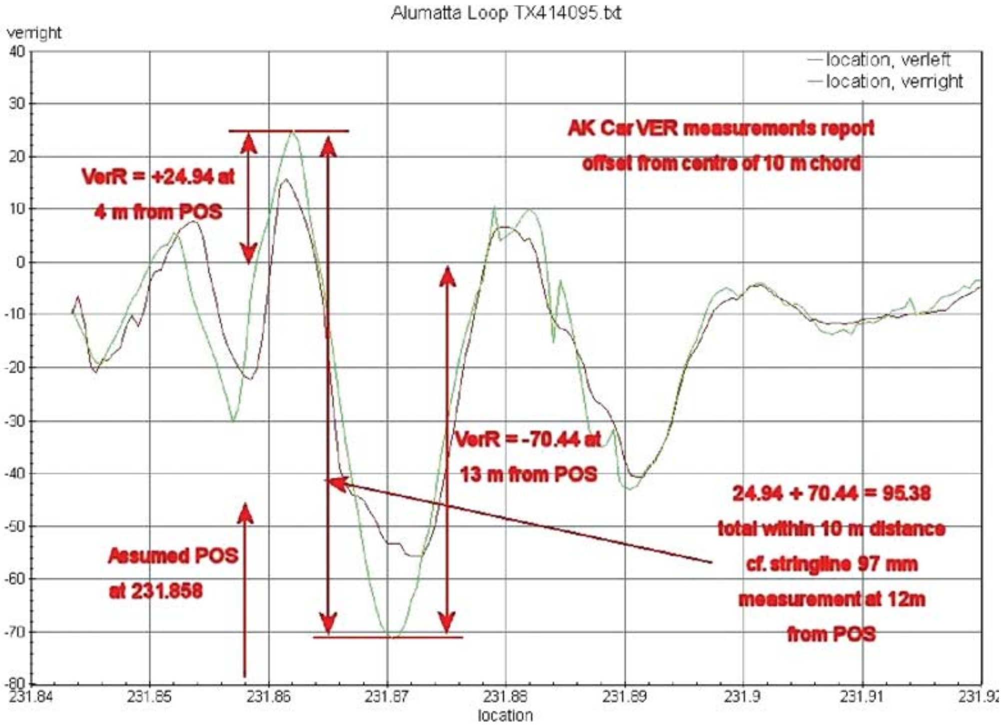
24 231.870 – location calculated from comparison and alignment of data sets. Not necessarily the true location, but rather the location as recorded on the dataset.

25 Maximo – the registered name of the corridor exceedence program/reports used by the ARTC track maintenance contractor.

FIGURE 31: AK Car horizontal alignment through cripple siding turnout, 16 December 2003



2.4.6 Turnout monitoring and maintenance

Track maintenance standards and maintenance records for the period March 2003 to March 2004 were examined. The track maintenance contractor's standard sets out six categories of inspections ranging from basic track patrols to track recorder car runs. Maintenance records examined for the period March 2003 to March 2004 applicable to the southern turnout at Alumatta indicate that the inspection category of 'track patrols' were conducted in accordance with the criteria set out in the track maintenance contractor's standard. However, no other evidence was sighted in regard to other inspection categories with the exception of the AK recording car.

In regard to measurements taken and inspections conducted in the field (manually, as opposed to AK Car recordings) track faults are prioritised using the fault category table that is contained in document POP 6.2 of the track maintenance contractor's safety management system. This table reads as follows:

Fault Category	*Remedial Action*
One	Fault is to be listed for swift repair. Impose a temporary speed restriction if required. Fault is to be listed for re-inspection on the Work Order for every subsequent patrol until the fault is removed.
Two	Fault is to be listed for re-inspection every four weeks (plus or minus one week) until removed. The fault may be listed on the Work Order for: • a routine track patrol that covers the location or • a specific fault(s) re-inspection task.
Three	Fault is to be re-inspected every 26 weeks (plus or minus six weeks) until removed. The fault may be listed on the Work Order for: • a routine track patrol that covers the location or • a specific fault(s) re-inspection task.
Four	No repair priority or re-inspection interval is assigned.

These faults are entered into the track maintenance contractor's Maximo data base by the track inspector. The determination of which category a fault constitutes is made by the track inspector/supervisor based on their individual knowledge and experience. There appears to be no correlation of track exceedences with these fault categories.

Whether other categories of inspection were carried out or not (evidence was not provided during the course of this investigation), it needs to be emphasised that the AK Car was never meant to replace the 'hands on' oversight of track by competent personnel. Rather, the AK Car is a management tool that, in addition to identifying exceedences, identifies overall track degradation from one run to another. Also, because all parameters are measured independently the assessment of different fault categories as required by identical notes applying to the AK Car defect and response table (note 5) and the NCoP (note 12) can only be undertaken separately by competent track personnel. These notes read in part:

> Normally occurring multiple defects are provided for in the limits set, for example top and twist defects would commonly be expected to occur together. In such cases the most stringent response criterion of the two should be selected. Unusual combinations of defects that are considered to act together, for example horizontal alignment with twist should be subject to special consideration. A more stringent response than that specified for rectifying the defects should be considered.

In this instance, the turnout at the southern end of Alumatta had the 'unusual combination' of horizontal alignment and twist defects.

When the AK Car commenced service in Victoria in about May 2002 a risk assessment, aimed at ensuring all faults recorded were consistent with previously collected data from the superseded EM Car, was conducted (see 2.4.4 of this report). A copy of this risk management plan and risk assessment was sent to the ARTC track maintenance contractor attached to a covering letter that read in part:

> The AK Car commences its run in Victoria in early May 2002. It will then continue to run quarterly in Victoria. Please be advised that the attached intervention levels (appendix B of the attached risk assessment) are to be used in place of the exceedence table on page two of appendix A in CEC 7/86. The revised intervention levels have been designed for use with the AK Car. Please advise all affected W.I. employees of this change. The attached table will be provided to W.I. employees on the car with the car results.

The text above the two tables that set out the response definitions and requirements of the new intervention standards read:

> The tables below show the AK Car's current defect thresholds for processing track geometry exceedences. They set out the defect limit sizes, corresponding allowable train speeds and the minimum response requirements in terms of inspection and repair. The upper table is in accordance with the current ARA Code of Practice, while the values in the lower table are generally in accordance with the draft Code of Practice, except that those in the SURFACE and SHORT TWIST columns have been altered. The changed SURFACE values have resulted from the fact that vertical alignment is now measured using data from the inertial system (20 metre wavelength) instead of from a chord based measuring technique. The changes to the SHORT TWIST thresholds result from the different dynamics of the AK Car when compared to the EM80 Track Recording Car.

In respect to the operation of the AK Car in Victoria, this documentation clearly indicates that the exceedence table at page two of appendix A of CEC 7/86 is to be replaced by intervention levels of the AK Car.

However, evidence obtained during this investigation indicates that the intervention levels specified for use with the AK Car are not being applied. Instead, the faults are being correlated to the Victorian CEC response codes. It appears that U1 and U2 response codes are being dealt with in accordance with the CEC 'A' response code, P1 response codes are being dealt with in accordance with the CEC 'B' response code and P2 and 'M' faults are being dealt with in accordance with the CEC 'C' response code. The CEC 'C' response code is classed as a 'base level exceedence' and places no time frame on remedial action. The evidence is that, in this instance, the CEC 'C' response code has been applied to the P2 fault identified by the AK Car at Alumatta on 11 December 2003.

In this instance a comparison with generally accepted 'industry agreed practice' is critical. As detailed at 2.4.5.5 of this report, the ARTC annotated NCoP would have classified this exceedence as a P1 fault priority requiring inspection within 24 hours and remedial action within seven days. The P2 fault categorisation of the AK Car defect and response table referred to would have required inspection within seven days and remedial action within 28 days. Yet, in this instance, a CEC 'C' fault categorisation has been determined and applied meaning that the horizontal alignment exceedence identified by the AK Car in December 2003 required no defined response in terms of inspection or remedial action.

No evidence of remedial action has been sighted during this investigation between the time the horizontal exceedence was identified by the AK Car on the 11 December 2003 and the derailment of train 6SM9V on 15 March 2004. Moreover, no evidence has been sighted that validates the practice of applying CEC fault response codes to the fault response requirements that are contained in the defect and response table that has application to the AK Car in Victoria. This is in terms of the use of the codes themselves or how the correlation was arrived at. For example, on what basis was a P2 fault considered a CEC 'C' base exceedence fault?

2.4.7 Summary

Throughout this investigation the contention that the Victorian CEC's have application in regard to track maintenance standards has been made. However, little evidence has been found that corroborates this contention. Interviews and conversations with ARTC and track contractor personnel have revealed that considerable confusion exists as to whether CEC, NCoP or some hybrid standards are to be applied. One person indicated that, in his view, there were two different standards applying necessitating his having to make the best judgement he could. Also, within the CEC's themselves, confusion existed in terms of track classification, one person regarded the turnout at Alumatta, as class one track[26], another as class five track[27].

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26 Class one track – defined in CEC 8/86 as that where passenger trains are authorised to 100 kph or over and goods trains at 80 kph or over.

27 Class five track – defined in circular CEC 8/86 as that where no passenger trains are authorised and where goods train can travel at up to 50 kph.

In addition, the manner in which the track is measured, either by AK Car or manually, lends itself more to practices more aligned with the NCoP than the CEC's. In fact, no examples of track measurements being taken in accordance with the increments in CEC 8/86 were sighted during this investigation.

The Victorian CECs response codes do not set out specific response times in the manner that the NCoP does. These CECs date from a time when track personnel were 'on hand' to rectify faults in accordance with the broad fault response categorisation of these standards. Significant modernisation and mechanisation since that time has changed working and maintenance practices and reduced the pool of track personnel.

In developing an application for accreditation an infrastructure provider must be qualified to safely manage the rail infrastructure, provide documentary evidence that a safety management system is in place and provide a risk management strategy that provides a clear identification, analysis assessment and monitoring of all risks associated with the activities[28]. In terms of track maintenance involving the risk of derailment at the Alumatta turnout the standards applicable to the ARTC leased track in Victoria are not clearly defined or properly documented. In this instance there have been a number of exceedences in existence for some time, some identified, some not, that have not been rectified. It is considered that the lack of clear definition and documentation is a contributing factor to the confusion that exists and therefore, this derailment.

28 Transport (Rail Safety) Regulations 1998, Victoria.

3 CONCLUSIONS

3.1 Findings

1. Train 6SM9V was crewed by a driver and driver's assistant both of whom were qualified in all relevant aspects of operating this train. Fatigue should not have been a factor as train 6SM9V was the first turn of duty for the crew after rostered days off.

2. On the evidence provided, train 6SM9V was examined by qualified train examiners at the departure terminal depot of Yennora in accordance with Freight Australia train examination procedures and no faults were found.

3. On the evidence provided, the required modified examinations were carried out on train 6SM9V by the train crew at locations where attaches and detaches of wagons took place on the journey from Yennora to Albury.

4. The speedometer of lead locomotive G533 was recording a speed greater than the actual speed and a distance greater than the actual distance.

5. An examination of the Hasler locomotive data recorder indicated that the maximum speed (as recorded) of train 6SM9V had not been exceeded from Junee to Alumatta.

6. Train 6SM9V had been diverted to the crossing loop at Alumatta to cross an opposing freight train in accordance with normal operating practices. Train 6SM9V entered this loop at Alumatta without incident.

7. The wagon body of VQCY 850X contained no evidence of structural or component failures or faults that could have contributed to this derailment. The damage to this wagon was a result of and not causal to the derailment.

8. The derailed bogie of wagon VQCY 850X (VXSC 15611) contained no evidence of structural or component failures or faults that could have contributed to this derailment. The damage to this bogie was the result of and not causal to the derailment.

9. The investigation was unable to conclusively determine that the missing or broken springs were from bogie VXSC 15611. It was concluded that the lead bogie of VQCY 850X did contain a previously broken outer spring. The steering of wagon VQCY 850X could have been impeded if the broken or missing springs were in fact from bogie VXSC 15611.

10. The investigation was unable to conclusively determine if bogie VXSC 15611 was yawing to an extent that may have influenced the steering of the number three wheel immediately prior to the point of derailment.

11. All four wheels of the two wheel sets from bogie VXSC 15611 were profiled to the ANZR2 profile and uniformly worn to about 20 mm below new diameter. The tread profile was near new and the wheels themselves in good condition apart from off road damage. The potential for wheels of the ANZR2 profile to experience creep induced wear (scrubbing) was considered but no conclusions reached.

12. The detachment of the bogie bolster from the wagon bolster occurred after the initial derailment at Alumatta.

13. Extensive damage was caused to rail infrastructure and level crossings encountered en route.

14. The train crew carried out procedures correctly by firstly, sending a 'broadcast' message for broad gauge trains in the vicinity to stop (following the indication of brake pipe pressure loss in 6SM9V) and secondly, by calling and informing the ARTC train controller of the circumstances as then known.

15. At 0353:10 advice that the second last wagon was missing the trailing bogie and that the last wagon had not been located was radioed to ARTC control in Adelaide. At 0353:40 the ARTC train controller contacted the Centrol train controller in Melbourne with advice of the derailment.

16. Police from Wangaratta arrived on site at about 0440. Both train crew were breath tested with negative results.

17. The ARTC train controller was appropriately qualified in all aspects in regard to the operation of the north east corridor.

3.2 Contributing factors

1. The derailment of the number three wheel of bogie VXSC 15611 was caused by excessive lateral acceleration combined with rapid loading and unloading due to wagon body and bogie dynamics that resulted in transient forces at the wheel/rail interface that acted laterally and vertically respectively.

2. The excessive lateral acceleration and wagon body and bogie dynamics were caused by a combination of the alignment, radius, vertical profile, rail profile and track formation of the turnout and the estimated speed exceedence of the rear of train 6SM9V.

3. Based on the commencement position of train 6SM9V and the normalised reading obtained from the Hasler data logger of G533, the rear of train 6SM9V travelled through the southern turnout at 47 kph. This was an exceedence of 17.5 per cent of the permitted speed of 40 kph.

4. The countdown meter of the lead locomotive was recording a distance slightly greater than that travelled. This would lead to the driver receiving a slightly premature indication that the rear of the train was clear of the southern turnout at Alumatta.

5. The power to weight ratio of train 6SM9V was relatively high at 3.66 horsepower to tonne. The drag forces exerted by the derailed bogie at the rear of the train would therefore have been difficult to detect.

6. A correlation of data from the AK Car run in December 2003 revealed that the southern turnout at Alumatta was not in compliance with the minimum standards contained in CEC 8/86 in terms of 3.5 metre twist. This twist was recorded in the vicinity of the point of climb and constituted an 'A' exceedence.

7. This twist equated to a rate of change of track cross level that was marginal in terms of the calculated capabilities of the wagon bogies.

8. The design radius of the southern turnout at Alumatta was 219 metres. This had steadily deteriorated to 129 metres at the time of the derailment. Based on radius alone, the posted speed of 40 kph was about 31 per cent in excess of the calculated recommended design speed as calculated at table 5.2 of the draft ARTC annotated *NCoP DIRN Track, Civil and Electrical Infrastructure*.

9. Based on the radius of 129 metres alone, at 47 kph the rear of train 6SM9V exceeded the calculated recommended design speed as formulated at table 5.5 of the draft ARTC annotated *NCoP DIRN Track, Civil and Electrical Infrastructure* by about 54 per cent.

10. No remedial works were undertaken in response to the horizontal alignment exceedences identified by the track recording car inspection 11 December 2003. The faults were coded as priority two (P2) which, in accordance with the table that correlates the AK Car outputs with the former EM Car and the Victorian CECs, required an inspection within seven days and remedial action within 28 days.

11. The horizontal alignment exceedences recorded by the AK Car in December 2003 in accordance with the table that correlates AK Car data outputs with the former EM Car and the Victorian CECs require a P2 priority response. For comparative purposes, the draft ARTC annotated *NCoP DIRN Track, Civil and Electrical Infrastructure* calculates the same exceedence as a P1 priority fault code thereby requiring inspection within 24 hours and remedial action within seven days.

12. There was an unvalidated correlation between the fault priority response codes contained in the AK Car defect and response table and the fault priority codes of the CECs. This led to the horizontal alignment exceedence at the southern turnout at Alumatta being categorised as a CEC 'C' fault in lieu of a P2 fault. A CEC 'C' fault is termed a 'base level exceedence' and places no time limit for inspection or rectification.

13. The exceedence (Maximo) report generated as a result of the AK Car run on 11 December 2003 for the information of the track maintenance contractor contained a lesser horizontal alignment exceedence (-48 mm) than the actual data output of the AK Car (-70.25 mm).

14. No evidence of 'front of train rides', 'on condition inspections', 'walking inspections' or 'special inspections' during the period March 2003 to March 2004 was sighted during this investigation. The categories of 'track patrols' and 'track recorder car runs' were conducted in accordance with the track maintenance contractor's safety management system.

15. In general terms the standards applicable to the ARTC leased standard gauge track between Albury and Melbourne are not clearly defined, properly documented or understood.

16. There was a contention that the Victorian CECs are the standards used for maintenance and monitoring of the ARTC leased standard gauge track between Albury and Melbourne, but little evidence was found who support this.

17. The time taken after initial notification for the ARTC controller to inform the Centrol controller was not in accordance with the section 4.6 of the ARTC Incident Management Manual, 'Parallel Rail Lines' in that it was not 'immediate'.

4 PREVIOUSLY RECOMMENDED SAFETY ACTIONS

4.1 Australian Rail Track Corporation

Following an on site inspection of the southern turnout at Alumatta and the southern turnout at Glenrowan 12 days after the derailment of train 6SM9V, in the company of the independent track expert engaged by the ATSB to assist with this investigation, the ATSB issued the following interim recommendation:

That the Australian Rail Track Corporation review the speed at which trains are permitted to traverse the southern turnout at Alumatta while the turnout remains in its present condition. In addition, an audit of turnouts across the ARTC network be commenced to ensure that the existing radii are within acceptable limits of the design radius.

5 RECOMMENDED SAFETY ACTIONS

5.1 Australian Rail Track Corporation

RR20050012

The ATSB recommends that the ARTC review their risk analysis for track standards to ensure that suitable track maintenance and monitoring standards, aligned with contemporary practices and workforce resources, are implemented on ARTC leased track in Victoria.

RR20050013

The ATSB recommends that the ARTC conduct an audit of crossing loops, turnouts and cripple sidings on their leased standard gauge track in Victoria with a view to ensuring this track is fit for intended purpose.

RR20050014

The ATSB recommends that the ARTC ensures compliance to section 4.6 of the *ARTC Incident Management Plan TA44*, specifically the requirements for immediate communication with other train control centres.

RR20050015

The ATSB recommends that the ARTC, in conjunction with other track owners and operators, examine ways of improving operational transparency between standard and broad gauge parallel corridors within Victoria.

5.2 Pacific National

RR20050016

The ATSB recommends that the *Freight Australia Emergency Management Plan* or the current equivalent (if updated or replaced by Pacific National), ensures that in the event of an incident or suspected incident on the broad gauge track that immediate contact is made with the ARTC train controller. This recommendation applies to rail corridors in Victoria where Pacific National leased tracks and ARTC leased tracks parallel each other.

RR20050017

The ATSB recommends that Pacific National reinforces the need for locomotive drivers not to increase the speed of their trains above the maximum permitted until the whole of the train is clear of a curve, turnout or temporary speed restriction.

RR20050018

The ATSB recommends that Pacific National ensure that locomotive speedometers and countdown/distance measuring devices (where fitted) are checked for accuracy in accordance with existing requirements.

5.3 Victorian Department of Infrastructure

RR20050019

The ATSB recommends that the Victorian Department of Infrastructure review their requirements for accreditation to ensure that suitable track maintenance and monitoring standards, aligned with contemporary practices and workforce resources, are implemented on ARTC leased track within Victoria.

RR20050020

The ATSB recommends that the Victorian Department of Infrastructure monitors the recommended ARTC audit of crossing loops, turnouts and cripple sidings.

RR20050021

The ATSB recommends that the Victorian Department of Infrastructure monitors the recommended examination of improvements to operational transparency between standard and broad gauge parallel rail corridors within Victoria.

6 SUBMISSIONS

Section 26, Division two of part four of the Transport Safety Investigation Act 2003, requires that the Executive Director may provide a draft report, on a confidential basis, to any person whom the Executive Director considers appropriate, for the purposes of:

(a) allowing the person to make submissions to the Executive Director about the draft; or

(b) giving the person advance notice of the likely form of the published report.

6.1 The Australian Rail Track Corporation

The Australian Rail Track Corporation made a number of comments and observations on the draft report issued to directly involved parties. Some of these comments and observations have been incorporated into this report.

6.2 Freight Australia Pty Ltd

Freight Australia made a number of comments and observations on the draft report issued to directly involved parties. Some of these comments and observations have been incorporated into this report.

6.3 Victorian Department of Infrastructure

The Victorian Department of Infrastructure made a number of comments and observations on the draft report issued to directly involved parties. Some of these comments and observations have been incorporated into this report.

7 APPENDICES

7.1 Appendix One – New intervention standards, AK Car

AK-Car Track Condition Monitoring System

Geometric Defects

RAILINFRASTRUCTURE CORPORATION

The tables below show the AK-Car's current defect thresholds for processing track geometry exceedences. They set out the defect limit sizes, corresponding allowable train speeds and the minimum response requirements in terms of inspection and repair.

The upper table is in accordance with the current ARA Code of Practice, while the values in the lower table are generally in accordance with the draft Code of Practice, except that those in the SURFACE and SHORT TWIST columns have been altered. The changed SURFACE values have resulted from the fact that vertical alignment is now measured using data from the inertial system (20-metre wavelength) instead of from a chord-based measuring technique. The changes to the SHORT TWIST thresholds result from the different dynamics of the AK-Car when compared to the EM80 Track Recording Car.

August 2003 Timber only

Response Requirement Definitions for Track Geometry Conditions

RESPONSE CATEGORY	INSPECTION	REPAIR	OTHER REQUIREMENTS
U1 Urgent Class 1	Immediate	Immediate	Where the response category cannot be reduced below U1 by a reduction in operating speed, trains may only pass the site under the control of a pilot. The site must first be assessed by a qualified worker to determine if trains can be piloted.
U2 Urgent Class 2	Within 2 hours or before the next train	Within 24 hours	If the defect site cannot be inspected or repaired within the times shown and the response category cannot be reduced below U2 by a reduction in operating speed, trains may only pass the site at 20 km/h if authorised by a qualified worker
P1 Priority Class 1	Within 24 hours	Within 7 days	
P2 Priority Class 2	Within 7 days	Within 28 days	
M Monitor			Monitor during routine track inspection and consider for planned maintenance

Minimum Response Requirements for Track Geometry Conditions and Allowable Train Speeds

MEASURED PARAMETERS IN MM UNDER LOADED CONDITIONS (round to nearest mm)								MAXIMUM SPEED (freight/passenger)						DEFECT BAND
GAUGE		H-ALIGN	SURFACE	TWIST			XLEVEL							
WIDE (note 8)	TIGHT	10m chord	20m inertial (note 9)	LONG, 14m Non-Trans	LONG, 14m Transition	SHORT, 2m	(note 2)	20/20	40/40	60/65	80/90	100/115	115/-	
>35	>20	>156 note 1	>40	>70	>74	>25	>75	U1	U1	U1	U1	U1	U1	A
32-35	19-20	>125 note 1	38-40	61-70	65-74	24-25	69-75	U2	U2	U2	U1	U1	U1	B
29-31	17-18	>45	35-37	53-60	56-64	23-23	61-68	M	P2	P1	U2	U1	U1	C
27-28	15-16	35-45	32-34	47-52	50-55	22-22	51-60	Nil	M	P2	P1	U2	U1	D
25-26		25-34	29-31	41-46	43-49	21-21	43-50	Nil	Nil	M	P2	P1	U2	U
23-24		19-24	27-28	36-40	38-42	18-20	38-42	Nil	Nil	Nil	M	P2	P1	F
21-22		15-18	24-26	31-35	33-37	15-17	33-37	Nil	Nil	Nil	Nil	M	P2	G

Notes:

1. These are absolute versine measurements (not variation from design) for simple and compound curves. Where curves are reversing, the actual versine should not exceed 156mm.
2. For trains to run, the absolute maximum limit for the difference in rail levels is 150mm.
3. For operational track where train speeds are above 40kph the absolute maximum negative superelevation limit is 10mm. For operational track where train speeds are 40kph and less the absolute maximum negative superelevation limit is 50mm.
4. All geometry parameters used are based on the loaded conditions. Where static or unloaded measurements are taken, due allowance should be made for the additional impact of loading and dynamics.
5. The measured parameter limits set in the above table are derived from commonly occurring defects in actual conditions. Normally occurring multiple defects are provided for in the limits set, for example top and twist defects would commonly be expected to occur together. In such cases the most stringent response criterion of the two should be selected. Unusual combinations of defects which are considered to act together, for example with horizontal alignment and twist, require special consideration. A more stringent response than that specified for rectifying the defects individually should be considered.
6. Defect parameters selected represent only one range of defects historically specified by railway systems. Defect types including cyclic, excess cant deficiency and other types giving rise to rough track should not be ignored. Assessments should be made by observation and experience, which should include on-train ride. Each defect located in this manner is to be classified by an accredited worker using the same response categories specified in the lower table. Acceleration based measuring devices may also be used to identify defects of this type.
7. Wide gauge on curves due to curve wear may be permitted up to a maximum of 30mm without action, provided that the track is secure against further widening due to lateral movement of the rail and the rail side wear limits are not exceeded.
8. The table applies to track well tied with timber sleepers only. For tracks with concrete and steel sleepers, where a higher than expected deterioration in gauge has been detected between inspections, the track should be subjected to an unscheduled detailed inspection and appropriate actions taken.
9. Vertical surface on the AK-Car is measured using a 20-metre wavelength inertial system. Long Top (20m chord) defect limits have also been defined in the ARA Code to assist track inspectors making manual measurements.

C:\...\AK-Car Defect & Response Tables, Std & Vic Aug03.doc Pg2 (Values last revised: November 2002)

7.2 Appendix Two – Table 5.5, draft ARTC annotated NCoP, track, civil and electrical infrastructure

TABLE 5.5 GEOMETRY DEFECTS—RESPONSE CODES (See Table 5.6)

Measured parameters in mm under loaded track									Max. speed (f/p), see Note 1						Defect band
Gauge		Horiz. align.	Top, see Note 2			Twist									
						Long 14m		Short							
Wide	Tight	10 m chord	Short 10 m chord (1.8 m offset)	Short 5 m chord (2 m offset)	Long 20 m chord see Note 3	Transition	Non Transition	2 m	20/20	40/40	60/65	80/90	100/115	115/ -	
>38	>20	>156, see Note 4	>37	>36	>90	>74	>70	>25	E1	E1	E1	E1	E1	E1	A
35-38	19-20	125-156, see Note 4	32-37	30-36	72-90	65-74	61-70	23-25	E2	E2	E2	E1	E1	E1	B
29-34	17-18	>45	28-31	26-29	67-71	56-64	53-60	21-22	P2	P1	P1	E2	E1	E1	C
27-28	15-16	35-45	25-27	22-25	57-66	50-55	47-52	19-20	N	N	P2	P1	E2	E1	D
25-26		25-34	22-24	19-21	52-56	43-49	41-46	17- 18	N	N	N	P2	P1	E2	E
23-24		19-24	19-21	16-18	47-51	38-42	36-40	15-16	N	N	N	N	P2	P1	F
21-22	10-14	15-18	15-18	13-15	38-46	33-37	31-35	12-14	N	N	N	N	N	P2	G

	Cross level Variation, see Note 5	Tangent track (Tangent & Radii ≥ 2000m)	Curved track including transitions (Radii <2000m)		
			Insufficient cant based on maximum design speed	Excess cant based on maximum design speed	
	Absolute superelevation >170 mm requires E1 response, see Note 6				
	>60	E2	E2, see Note 7	E2, see Note 9	A
	50-60	P1	P1, see Note 8	P1, see Note 9	B

7.3 Appendix Three - Page two of appendix A, CEC 7/86

Class 5

Sub-Level	C	B	A
Top	25.0	30.0	40.0
Line	30.0	35.0	40.0
Wide Gauge	16.0	20.0	25.0
Canc	35.0	45.0	55.0
Twist 3.5m	20.0	23.0	30.0
Twist 10.0m	45.0	50.0	60.0

SUB-LEVELS

As indicated above each class of track is divided into 3 sub-levels.

SUB-LEVEL A Is the Priority Exceedence Sub-Level. All faults of this level must receive swift attention.

SUB-LEVEL B General Maintenance Exceedence. These Exceedences should be used to program general track maintenance and should be repaired after the priority 'A' Exceedences.

These are the levels adopted as standards for inspection by Patrolmen, Gangers and Road Foremen as detailed in Circular C.E.C.8/86.

SUB-LEVEL C Base level Exceedence.

7.3Timeline diagram

Derailment of Freight Train 6SM9V
Alumatta, Victoria, 15 March 2004

ISBN 1 921092 05 X

1800 621 372

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