Derailment of Pacific National Train 2PW4-N – 28 November 2003

Australian Government
Australian Transport Safety Bureau

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Australian Transport Safety Bureau
PO Box 967,
Civic Square ACT 2608
Australia
1800 621 372
www.atsb.gov.au

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The format of an ATSB rail safety report usually follows 'AS 5022-2001 guidelines for rail safety investigation'. However, this report has been presented in a different format to aid readability of key points. The ATSB welcomes feedback regarding this format.

Derailment of Pacific National Freight Train 2PW4-N

On 28 November 2003, Pacific National freight train 2PW4-N travelling between Perth and Wollongong via Melbourne derailed two wagons after traversing a buckled rail at Ararat in Western Victoria. No injuries resulted from the derailment.

Ararat is located on the main railway corridor between Melbourne and Adelaide, approximately 265 kilometres from Spencer Street Station in Melbourne.

The derailment

On 28 November 2003, train 2PW4-N was travelling between Adelaide and Melbourne. At Dimboola, about half way between Adelaide and Melbourne, the train crew was changed and the train resumed its journey at 1206 (Eastern Summer Time). As the train approached the Western Highway level crossing north of Ararat, travelling at about 66 kph, the driver noticed two track maintenance workers about 90 m ahead standing adjacent to the track. He acknowledged them by train whistle at 1408:27[1] and received an 'okay' hand signal from one of the maintenance workers.

FIGURE 1:
The buckled rail at Ararat looking towards Adelaide

As the train approached the two workers the locomotive was seen to sway, although the train crew stated that they did not notice any track misalignment. The train straightened and seemed to continue normally towards the two workers.

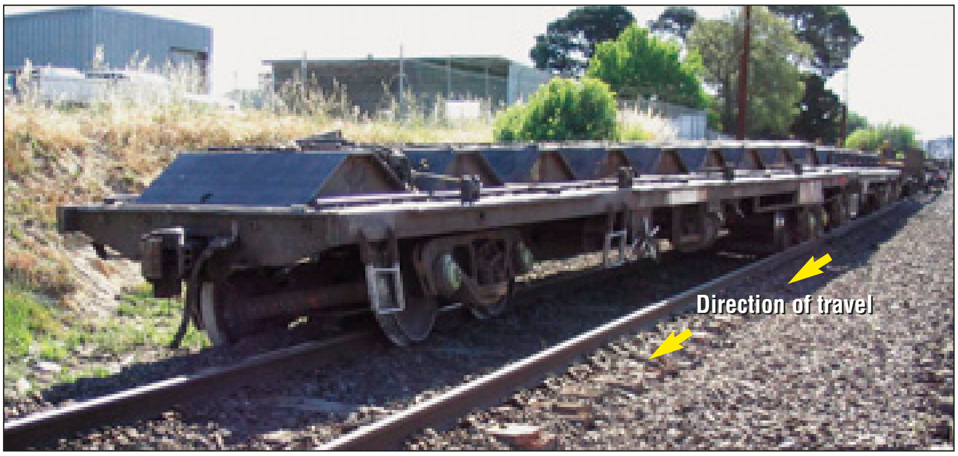
The maintenance workers saw a slight kink[2] in the line just before the locomotive passed over it. They then noticed the wagons swaying as the train passed over the kink in the line and ballast being churned up by a derailed bogie as the rear of the train continued past them. The maintenance workers immediately rang the Australian Rail Track Corporation (ARTC) train control centre in Adelaide to tell them to stop the train.

The locomotive was a short distance over the Western Highway level crossing at 1408:59 when the driver of the train noticed that the brake pipe air was rapidly decreasing causing the train brakes to apply. The train came to a stand at 1409:41 blocking the highway. The train controller meanwhile, contacted the driver but the train had already stopped by the time the call was received.

Two wagons had derailed at 265.745 km (Point of Derailment). The first derailed wagon was RQKY2716J located in the 45th position in the train. The following wagon (46th position) RCRX23141U was also derailed. Wagon RQCXO902X at the 44th position received minimal damage and remained on track. Empty containers RVO01 and RVO17 dislodged from wagon RQKY2716J (45th) during the course of the derailment and were substantially damaged.

The derailed wagons on train 2PW4-N travelled about 1053 metres past the point of derailment before the brake pipe air hoses between them came apart causing the train brakes to apply with the wagons travelling a further 424 metres before coming to a stand.

FIGURE 2:
Derailed Wagon RCRX23141U (46th position)



Pacific National Train 2PW4-N

Pacific National is a railway operator carrying interstate and intrastate freight in all mainline states of Australia. The company also provides locomotives and train crew for several rail operators of long distance trains.

Pacific National train 2PW4-N was a scheduled freight train service between Perth and Wollongong via Melbourne. Train 2PW4-N consisted of three 'NR' class diesel electric locomotives (NR85, NR102, and NR86) hauling 48 wagons consisting of containers, empty wagons and steel products. The total train weight was 1710.83 tonnes with a length of 899.59 metres. The maximum permissible line speed of train 2PW4N was limited to 80 km/h, due to the type of rollingstock in the consist.

Following the derailment, the train and rolling stock were examined.

The crew working train 2PW4-N each had over ten years experience driving trains on this particular route. Information from the locomotive data loggers indicated that the train did not exceed the track speed.

The track

The ARTC manages the standard gauge track at Ararat and had contracted track maintenance to Works Infrastructure[3].

The standard gauge track at this location consists of 60 kg/metre continuous welded rail (CWR) which is fastened to timber sleepers by Pandrol clips and lock spikes on Pandrol Plates with sleeper spacings of 685 mm. The ballast profile is 300 mm of under-sleeper ballast and 405 mm of shoulder ballast with additional requirements for the high rail of curves. The section of track where the derailment occurred was limited to a track speed of 70 kilometres per hour.

The curvature of the track is recorded at 362/402 metres. Track with a curvature of less than 800 metres is subjected to higher levels of monitoring and maintenance. The track was laid and maintained to the *Public Transport Corporation Infrastructure Design CEC 3/87* standard.

Continuous welded rail

The formation of continuous welded rail involves a process of welding shorter lengths of rail together. This means that the rail can be very long with no mechanical joins and is measured in kilometres rather than metres.

At the time of installation or repair, CWR should be stressed at a neutral temperature[4]. This prevents either excessive thermal expansion forces (which can cause buckled rail) or excessive thermal contraction forces (which can cause cracked or broken rail). Calculations of the pre-stress parameters must be accurate or the track will eventually buckle during hot weather or crack during cold weather.

If the stress level in CWR is altered due to track work, subsidence of track base or any other reason, good engineering practice dictates that the track should be stress tested to see that the rail is still within the correct stress free temperature. If it is not, the rail should be restressed and adjusted.

The *Public Transport Corporation Infrastructure Design CEC 3/87* standard includes the following instructions to minimise buckled rail:

- The track is laid and subsequent repairs made so that it is in a stress free state at 38° C (rail temperature).
- Creep is closely monitored and controlled.
- Ballast profile is maintained.
- Special precautions are taken to avoid disturbance during or immediately prior to the summer season.
- The track is adequately anchored, sleepered and the rail joints are properly maintained.
- Expansion gaps are frequently checked and adjusted.
- It must also be emphasised that any surfacing, sledding, slewing, lifting or lining of the track may have an effect on the neutral stress temperature of the track so processed.

Environmental factors

The derailment occurred on a fine, dry day. Temperature readings taken at the derailment site two hours after the 28 November derailment indicated an ambient air temperature of 33° C and a track temperature of 42° C.

The maximum indicative ambient air temperatures obtained from the Bureau of Meteorology for the Ararat area from 20 November until 28 November were as follows.

Date	*Maximum temperature*
20 November	22.9
21 November	19.4
22 November	11.7
23 November	16.9
24 November	18.2
25 November	21.2
26 November	23.1
27 November	28
28 November	30.6

Contribution of temperature to buckled rails

ARTC track in Victoria is normally maintained to be in a stress free state at 38° C (rail temperature). If the geometry of the track changes during maintenance or other work then the track may have a different stress free state induced and should be tested. If restressing is necessary but is not carried out, the track has the potential to buckle because the fasteners and ballast profile may not be adequate to hold the track in place once thermal expansion occurs.

In times of high temperatures, to prevent rails buckling with the passage of trains, a speed restriction known as a 'WOLO'[5] forms part of ARTC procedures. For this section of track, the 'WOLO' applies once the ambient air temperature has reached 36° C between 1200 and 2000. Freight trains are restricted to 65 kph. While 'WOLO' did not apply, train 2PW4-N was travelling at 66 kph over the derailment area.

Inspection and maintenance history

Track inspection records from the previous twelve months, reviewed by the investigation team, indicated 57 track inspections covering the section of track where the derailment occurred. There was also one rail creep[6] inspection in April 2003.

The standards used for track maintenance by the ARTC state:

> ...that tamping operations are to be programmed to a minimum between November and March and after such work, the track should be kept under close observation and a speed restriction applied if considered necessary.

The track was tamped[7] on 20 November 2003 to remove a line fault (minor cant/twist[8]) on the curve in the area where the rail buckled. The ambient air temperature on this day was 22.9° C. A temporary speed restriction was placed on the track for the following seven days. The speed reduction was gradually lifted over the seven day period to full line speed.

Track and Rail Condition Monitoring carried out on the 24 November, four days after addressing the line fault, indicated rough riding[9].

On the morning of the derailment, track inspectors carried out a routine inspection of the track by a walking inspection at 0800 and by riding in the locomotive cab of a train. There was no evidence of track misalignment during the walking inspection or cab ride. However, one sleeper had fallen away from the rail and needed to be re-fastened at 265.650 km, 95 metres east of the point of derailment.

There were no temporary speed restrictions in place at the time of the derailment.

Rail creep

Rail creep is the longitudinal movement of rails in track caused by the action of traffic on the line. Rail creep is most likely to take place on grades, at places where trains brake, and in the direction of traffic on double lines or the direction of predominant traffic tonnage on single lines.

The standard used to maintain the track, *Public Transport Corporation Infrastructure Design CEC 3/87*, states that:

> As any rail movement subsequent to welding will upset the rail stress conditions, it is imperative that strict measures be taken to control rail movement. To do this it is necessary to recognise when the rail moves, measure the movement and organise to correct it...
>
> All welded rail track is to be closely monitored for creep. Close monitoring and corrective action of creep on all curves below 800m radius is essential...
>
> Particular attention must be paid to the approaches to level crossings and crossing work as rail is likely to 'bunch up' at these locations if creep is present causing an even more hazardous situation.
>
> To facilitate the accurate measurement of creep, monuments are to be utilised. Where necessary new monuments of a permanent nature are to be placed at 1 km intervals. To permit closer monitoring on curves of radius 800m and under, additional monuments are to be placed at each end of the curve and around it so that there is no more than 500m between them...
>
> Track is to be checked against the creep markers at six monthly intervals or more regularly as required. One set of measurements is to be taken in the September–October period, the other set in the March–April period.

Evidence provided to the investigation indicated that rail creep had been monitored by ARTC. Monitoring occurred regularly in April and October of each year. No rail creep had been recorded in the rail creep register in the vicinity of the buckled rail but the October 2003 inspection had not been completed. While there is no evidence available to suggest that rail creep was a causal factor in the track buckle, no regular creep monuments had been erected to monitor rail creep on the curve where the track buckled which had a radius less than 800 metres.

Post derailment repairs

FIGURE 3:
Recovery operation at derailment site

Both rails were restressed in the week after the derailment with the following results:

Table 3:
Restressing of rail details

265.764 km UP Rail	
Module length	302 m
Rail temperature	22° C
Gap required	57 mm
Movement when rail cut	10 mm Open*
Rail cut out	47 mm
265.764 km DOWN Rail	
Module length	302 m
Rail temperature	31° C
Gap required	25 mm
Movement when rail cut	Nil Closed*
Rail cut out	25 mm

* When the rail is cut it will either move apart or come together depending on whether it is under expansion or compression forces at the time.

Following the derailment, the rail was cut out to restore it to a stress free state at its neutral temperature.

Analysis

Examination of the data logger and interviews with the train crew strongly supports the proposition that the train was driven within the prescribed operating limits. Train driving, or dynamics, is not considered to be a factor in the derailment.

Representatives from the ARTC, Pacific National and the Victorian Department of Infrastructure inspected the train and rolling stock. No defects or deficiencies were found that were considered relevant to the derailment. The length, weight and wagon loading of train 2PW4-N did not contribute to this derailment.

In the absence of any evidence that train driving or the condition of the rolling stock contributed to the derailment, the investigation centred on the condition of the track.

The track was restressed in the week after the accident and found to have excess rail[10]. The stresses induced due to the excess rail condition would tend to raise the rail with sleepers and fasteners from the ballast due to the increased expansion of the rail. This would then weaken the ability of the ballast to hold the track in place.

Given that the track had been tamped one week prior, and that seven days of speed restrictions were on cooler days, it is probable that the action of tamping the track reduced the resistance of the ballast on the track. The tamping 'broke the seal' between the track and ballast holding it in place.

On curved tracks, the lateral (sideways) and vertical (downward) forces of the train exert heavy forces on the outside rail of the curve. These forces are compensated for in the track design by elevating the outside rail to maintain the rail vehicles' equilibrium and prevent the outside wheels from riding up over the rail and derailing at normal speeds.

When a buckled rail occurs, there is no compensation for lateral and vertical forces on the outside rail at normal speeds. If the lateral forces become greater than the vertical forces, the outside wheel will most likely ride up over the rail causing the wheel set to drop off the rail and derail.

The passage of train 2PW4-N exacerbated the condition of the buckle, which became progressively worse as the train passed over it.

Submissions

Submissions from ARTC and Victorian DOI were received. A number of comments and observations were made and have been incorporated into the report.

Conclusion

Some external factor, probably the tamping operation of 20 November, altered the geometry of the track lowering the stress free temperature to below 38° C. The tamping would have also reduced the ability of the ballast to hold the track in place.

The passage of train 2PW4-N exacerbated the condition of the buckle, which became progressively worse as the train passed over it.

There was no evidence available to suggest that rail creep had contributed to the track buckle. However, rail creep monuments had not been erected in accordance with the Public Transport Corporation Infrastructure Design CEC 3/87 standard for curves less than 800 metre radii. The absence of monuments makes effective rail creep monitoring problematic.

Significant Factors

1. The track was not stress tested after the tamping operation on 20 November 2003 up to the time of the accident and it is likely that the stress free temperature of the rail had changed from that before tamping.

2. Excess rail cut out after the derailment indicated that the stress free temperature of the rail at the time of the derailment would have been lower than the Public Transport Corporation Infrustructure design standard used by ARTC.

3. A lower stress free temperature would mean that the track was more susceptible to rail buckle during higher ambient temperatures.

4. No action was taken after Track and Rail Conditioning Monitoring found rough riding on the tamped piece of track on 24 November.

Recommendations

RR20050001

The ATSB recommends that the ARTC review track maintenance procedures to ensure that track geometry and stress free temperature are within the specified standards.

RR20050002

The ATSB recommends that the ARTC review the use of rail creep monuments to better monitor, record, and control rail creep.

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1 Times obtained from locomotive data logger.

2 Slight buckle in the rail that a train would be expected to traverse without problems occurring.

3 A division of Downer EDI Ltd.

4 The rail temperature at which the track has no longitudinal thermal stresses (Australian Standard 4292.2-1997). The design neutral temperature should be between 35 and 40 degrees Celsius (Australasian Railway Association Code of Practice for the DIRN – Infrastructure Guidelines Section 6).

5 'WOLO' is short for Welded track restrictions on speed of Operation of LOcomotives.

6 Rail Creep is the longitudinal movement of rail due to thermal forces as well as train movement.

7 Process of lifting, lining and ballasting track using specially designed track machines.

8 Variation in the correct levels between the two rails.

9 Rough riding is indicated by track and rail condition monitoring showing measurements varying from normal but not serious enough to require immediate attention.

10 Excess rail is when the rail is under longitudinal compression at the design neutral temperature.