



Office of Transport Safety Investigations

RAIL SAFETY INVESTIGATION REPORT

DERAILMENT OF CITYRAIL SERVICE 312A

THIRROUL

11 SEPTEMBER 2006



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- The RAIB (UK) for permission to use the diagram at *Appendix 4*.
- Geoscience Australia for the permission to use the map in *Figure 1*.
- Monash University for assistance in relation to friction matters pertaining to rail conditions.

GLOSSARY OF TERMS

Catch-points	A single switch assembly and throw-off rail. The catch-point switch is normally set in the open position, thus breaking the continuity of the track causing unauthorised train movements to derail at a point clear of the main line.
Dog Spike	A round spike that is driven into a pre-drilled hole in a sleeper to fasten the rail to the sleeper to restrain vertical and lateral movement.
Fair Type Anchor	A track anchor that minimises track creep in the longitudinal plane.
Foul	In a position to obstruct rail traffic on an adjacent line.
Points	The mechanical arrangement by which one railway track can be made to converge or diverge with another thereby allowing trains to be directed from one track to another.
SPAD	A signal passed at danger. When a train passes a signal at stop without authority.
Train Stop	A trackside mechanical device linked to a signal that provides a level of protection for trains travelling past a signal that is at stop. When the signal is not clear to pass, the trip is raised which activates a passing train's brakes through contact with the air valve at the front of the train
'Up Main' line	A railway line that is for rail services travelling in the direction towards Sydney Central Station.

EXECUTIVE SUMMARY

At 5:32am on 11 September 2006, the leading car on CityRail's passenger service 312A, operated by RailCorp, derailed at catch-points in the vicinity of No. 3 Platform at Thirroul after failing to stop at Signal WG 568D. On approach to the signal the train did not respond to normal braking techniques forcing the driver to apply his emergency brakes approximately 20 metres prior to the signal.

The train consisted of an eight-car Tangara set and was carrying approximately 30 passengers who were safely disembarked under the direction of the guard. There were no injuries and only minor damage to the train and track. The prevailing weather conditions were wet and blustery.

Based on the preliminary investigation on site, the Chief Investigator determined that the accident warranted formal investigation in accordance with Section 67 of the Rail Safety Act 2002.

Speed, signalling anomalies, driver fatigue and wheel and rail defects were able to be readily excluded as contributory factors. Importantly, brake failure was eliminated at the beginning of the investigation as a result of on-site testing undertaken by RailCorp engineers. The investigation then focussed on track conditions and the braking process.

Severe weather conditions prevailing at the time were found to be responsible for the formation of an emulsion consisting of rust, moisture and salt building up on the rail which had not been used for some 58 hours. This resulted in a particularly slippery rail surface and consequent reduced braking effectiveness. Historically, there have been a number of similar situations of Tangaras encountering stopping difficulties in wet and inclement conditions at Thirroul and in the wider South Coast region. Further, having disc brakes, the Tangara contributes less to rail head conditioning during normal operation than do trains with brake shoes that help to remove contamination from the wheel tread.

In this instance, braking effectiveness was reduced to such a degree that significantly greater stopping distances were needed than was usual. This should have been apparent to the driver from an experience of minor wheel slip under similar conditions earlier in the trip. However, insufficient allowance was made for the obvious reduction in braking effectiveness.

Despite a memo issued by RailCorp to all its CityRail drivers in 2003, there still appears to be some lack of understanding of the operation of the Wheel Slip Protection (WSP) system fitted to Tangara trains. Lengthy periods of dry weather deny drivers the opportunity of maintaining their skills in handling adverse weather conditions. Additionally, this also reduces opportunities during initial training and periodic re-assessment to practice and be tested in the essential skills. However, there is no evidence that a better understanding of the WSP system would, of itself, prevented this particular derailment

Consequently, the key recommendations seek to have RailCorp review the adequacy of current training, assessment and instructions to ensure drivers have a thorough understanding of the effect of adverse environmental conditions on braking efficiency, and the need to adjust train handling accordingly. It is also recommended that RailCorp investigate better use of simulation so that weather does not remain the sole determinant of the extent of training and currency of experience of its drivers.

PART 1 FACTUAL INFORMATION

Incident Synopsis

- 1.1 At 5:32am on 11 September 2006, the leading car on CityRail's passenger service 312A, operated by RailCorp, derailed at catch-points in the vicinity of No. 3 Platform at Thirroul after failing to stop at Signal WG 568D.¹ The Driver indicated that he had approached the signal, which was at 'Stop', with caution, and had applied his emergency brakes approximately 20 metres prior to the signal when he realised that his train was not responding to normal braking techniques.
- 1.2 The incident occurred on the Sydney, or Northern end, of Thirroul Station's No. 3 (Back) Platform (see *Photo 1*). Service 312A had travelled from Coniston and was scheduled to dwell at the platform for 28 minutes before proceeding to Bondi Junction as Service 312B. There were approximately 30 passengers on board at the time of the derailment. The prevailing weather conditions were wet and blustery.

Derailment Location

- 1.3 Thirroul is located in the Illawarra region of NSW, 70km South of Sydney and 13km North of Wollongong (see *Figure 1*). It is bounded by the Tasman Sea to the East and the Illawarra escarpment, which is approximately 300 metres above sea level, to the West (see *Photo 2*).

¹ Passing a signal that is displaying a 'Stop' indication is referred to as a 'SPAD' (Signal Passed at Danger). The danger associated with such an occurrence is that of a collision with another train that does have an authority to be moving. Catch-points are intended to mitigate such a risk by derailing the train that has passed the signal at danger away from any converging lines.

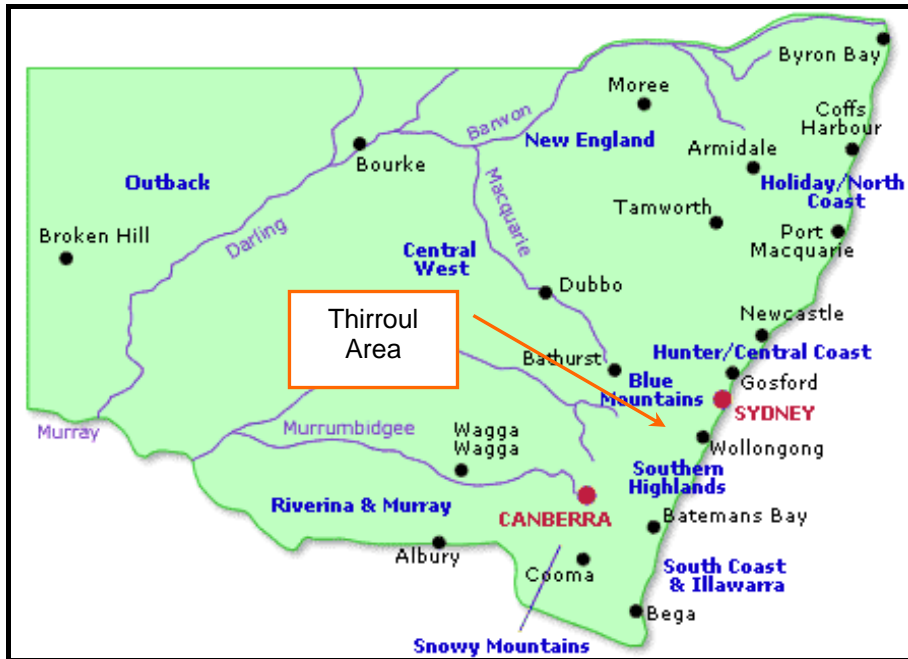


Figure 1: Map of NSW depicting the location of Thirroul.

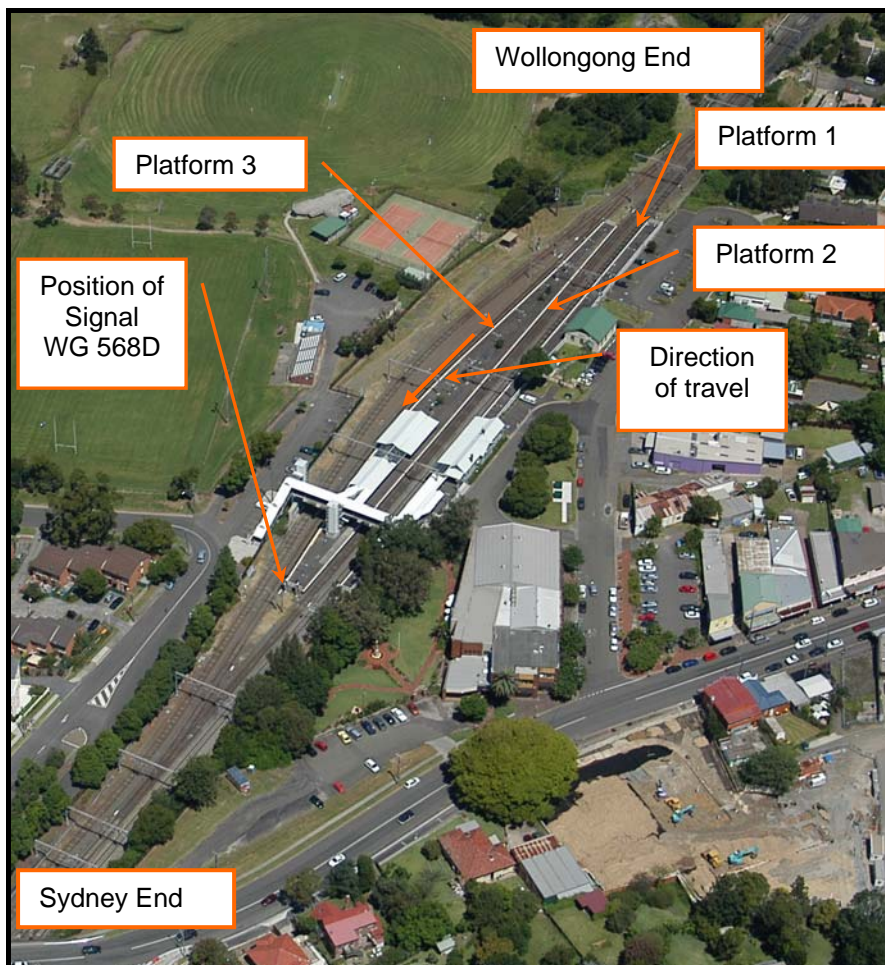


Photo 1: Aerial view of track configuration at Thirroul.

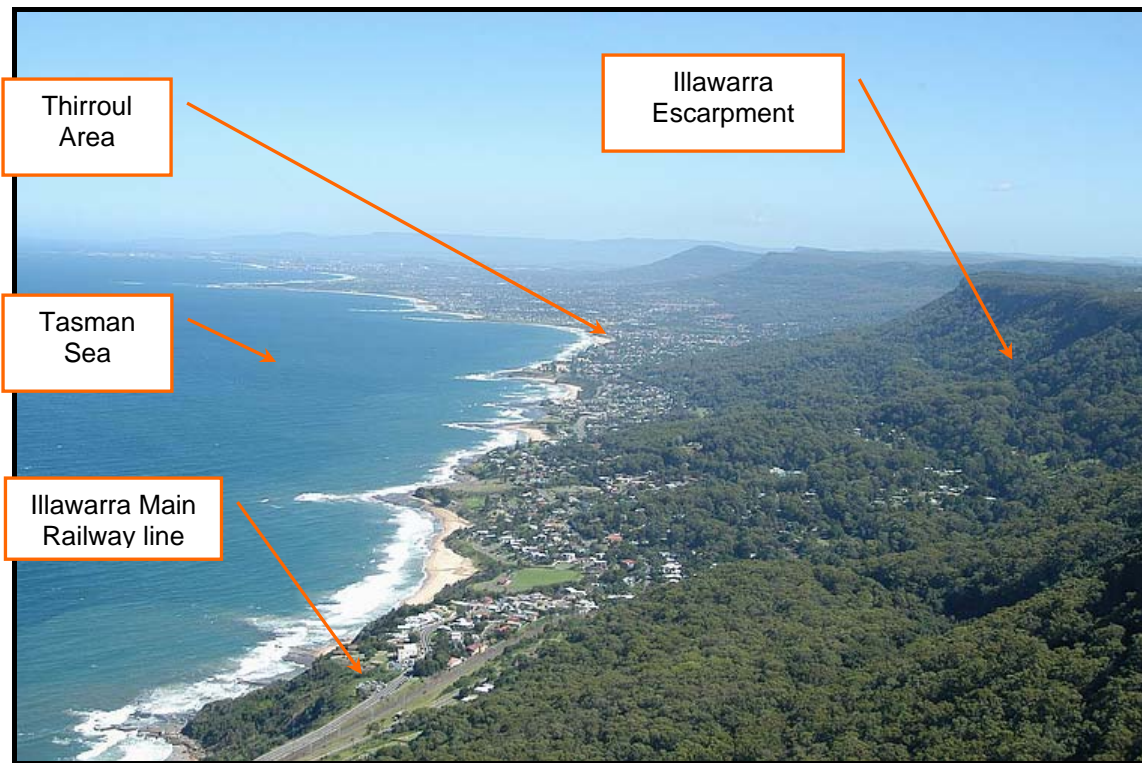


Photo 2: Aerial Photo of Illawarra region.

Injuries and Damage

- 1.4 There were no injuries arising from the derailment and only minor damage to the track and the leading car of the train.

Train Information

- 1.5 312A consisted of an eight car Tangara set made up of two four car sets (T29 and T19). Tangaras were introduced into service in NSW in 1987.

Track

- 1.6 The derailment occurred on a level track consisting of 50kg/m rail secured to timber sleepers by dog spikes and 'fair type' anchors.

Employee Information

- 1.7 The Driver obtained his driving qualification in August 1990 and had been employed by RailCorp, as an intercity driver, since February 2003. He underwent a periodic reassessment on 22 December 2005 and achieved a satisfactory result (see *Appendix 1*). However, the record shows that train handling in the wet was not assessed as the prevailing conditions were dry.

- 1.8 The Driver had undergone a medical assessment on 14 February 2006 and was classified “fit for duty unconditionally”.

Incident Narrative

Before the Derailment

- 1.9 The Driver commenced his duties at Wollongong station at 3:30am on 11 September 2006. After completing sign-on formalities and safeworking requirements the Driver made his way to the yard where the train was stored. He undertook the required ‘train preparation’ procedures which included checking brake cylinder pressures, the brake controller and the electro-pneumatic braking system of both power cars. Then, with the assistance of the Guard, he conducted a brake continuity test.²
- 1.10 The train departed Wollongong yard as passenger service 311A, and arrived at Coniston Station at 4:35am. The Driver then relocated from the Southern to the Northern end of the train after which it departed Coniston for Bondi Junction at 5:08am designated as passenger service 312A.
- 1.11 At interview, the Driver indicated that he was mindful of the prevailing wet and blustery conditions as he operated 312A, and that he exercised additional caution because such conditions often resulted in reduced traction when braking, especially so with Tangaras. His concerns were heightened when, at 5:15am, 312A stopped three metres past the platform at Fairy Meadow³ because of reduced traction. The Guard noted “jerking movements” when the brakes were applied at this station and stated that he could hear noise from the Wheel Slip Protection (WSP) module at the same time. Examination of the train’s event recorder (‘data logger’) indicated that wheel slip was detected when the driver increased braking from notch three to notch seven and that, unnoticed by the driver, there had been a similar occurrence when stopping at the previous station, North Wollongong.
- 1.12 Approximately 1,300 metres from Thirroul Station, the Driver sighted Signal WG 553U displaying a ‘caution’ indication. He reduced speed because he

² A brake continuity test ensures that there is no interruption to the air supply that supports the operation of the brakes over the length of the train and that no other brake controllers are cut in.

³ Fairy Meadow is the 3rd station after Coniston.

was aware that he could either be required to traverse from the 'Up Main' line to the 'Down Main' line, or onto the No. 3 Platform line (see *Figure 2*).

- 1.13 After rounding a curve approximately 1,000 metres beyond this signal, and while on a straight section of track, the Driver sighted the next signal, WG 558U, which was displaying a 'turnout' indication. This required the Driver to negotiate a turnout⁴ and restrict his speed to not more than 25km/h. Data obtained from 312A's event recorder indicates that the Driver slowed the train to 25km/h as he negotiated the turnout and entered the No. 3 Platform line.

The Derailment

- 1.14 The Driver saw Signal WG 568D displaying a 'Stop' indication at a distance of approximately 100 metres, approximately halfway down the No. 3 Platform track (see *Figure 2 and Photos 3 and 4*).

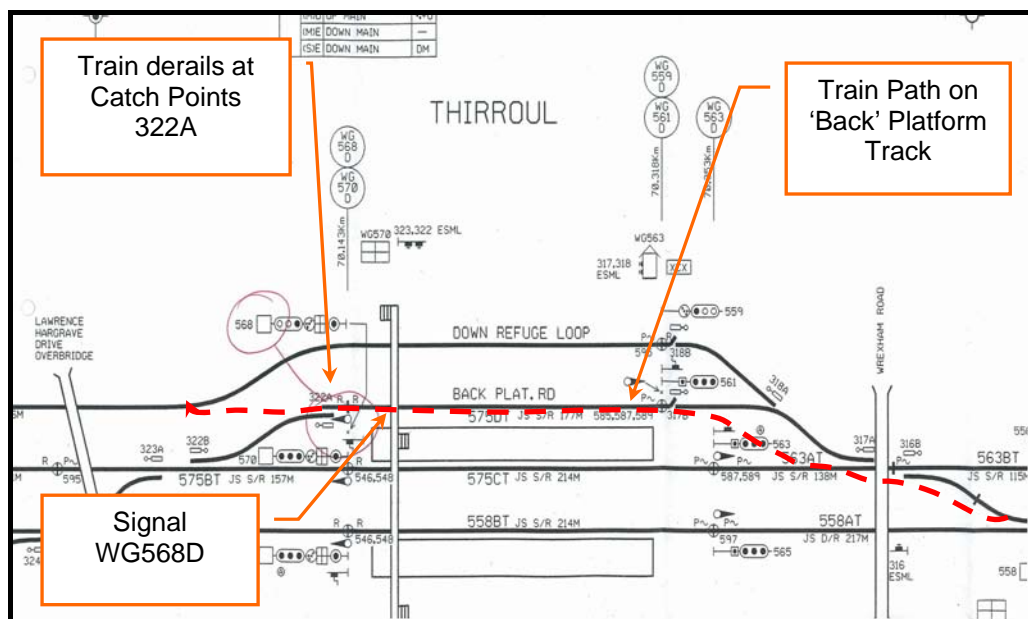


Figure 2: Map of track layout.

- 1.15 At this point, 312A was travelling at approximately 19km/h and the Driver manipulated the driver's brake valve⁵ from the 'Off' position in sequence through to positions 1, 3, 1, 2, 3, 6 and 7. As he was approaching Signal WG 568D, the Driver realised that his train was not decelerating and that it was

⁴ A turnout is the area of track which allows a train to cross from one line onto another. The turnout just prior to Thirroul effectively takes the train from the 'Up Main' line onto the No.3 Platform track.

⁵ The drivers' brake valve controls the operation of the train's pneumatic/electro pneumatic brakes. There are seven brake settings and an emergency setting.

not going to stop prior to the Signal WG 568D, and he therefore engaged the emergency brake.



Photo 3: Signal WG 568D viewed from 100 metres.

- 1.16 The train subsequently skidded past Signal WG 568D and then encountered the 322A catch-points positioned 33 metres beyond. This caused the four leading wheels of the leading car to derail, after which the train continued for a further 13 metres in the track's substructure (see *Photo 5*).

After the Derailment

- 1.17 Once the train stopped and the Driver realised that it had derailed, he applied the park-brake; lowered the pantograph on the leading carriage to isolate it from the 1,500v overhead wires; and then pressed the 'CS' (call signaller) button on the train's Metronet radio to report that 312A had derailed.



Photo 4: Direction of travel on number three platform track, in dry conditions.



Photo 5: Signal WG 568D and catch-points.

- 1.18 Once the train stopped, the Guard opened the crew door on his carriage and found that several of the passenger doors on the train were not adjacent to the platform. He immediately made an announcement instructing passengers to alight only from the fourth carriage, which was adjacent to the platform, and subsequently supervised their movement onto the platform. The Driver and the Guard then established that their train was obstructing the 'Down Refuge Loop' (see *Photo 6*), advised the Signaller accordingly, and awaited the arrival of RailCorp's incident management and maintenance staff.

Emergency Response

- 1.19 An emergency response as such was not required. No passengers or crew were injured and the passengers were able to alight onto the platform without difficulty. RailCorp's Emergency Train Re-railing Unit (RETRU) arrived at the site at 8:30am and T29 was re-railed at 10:10am.

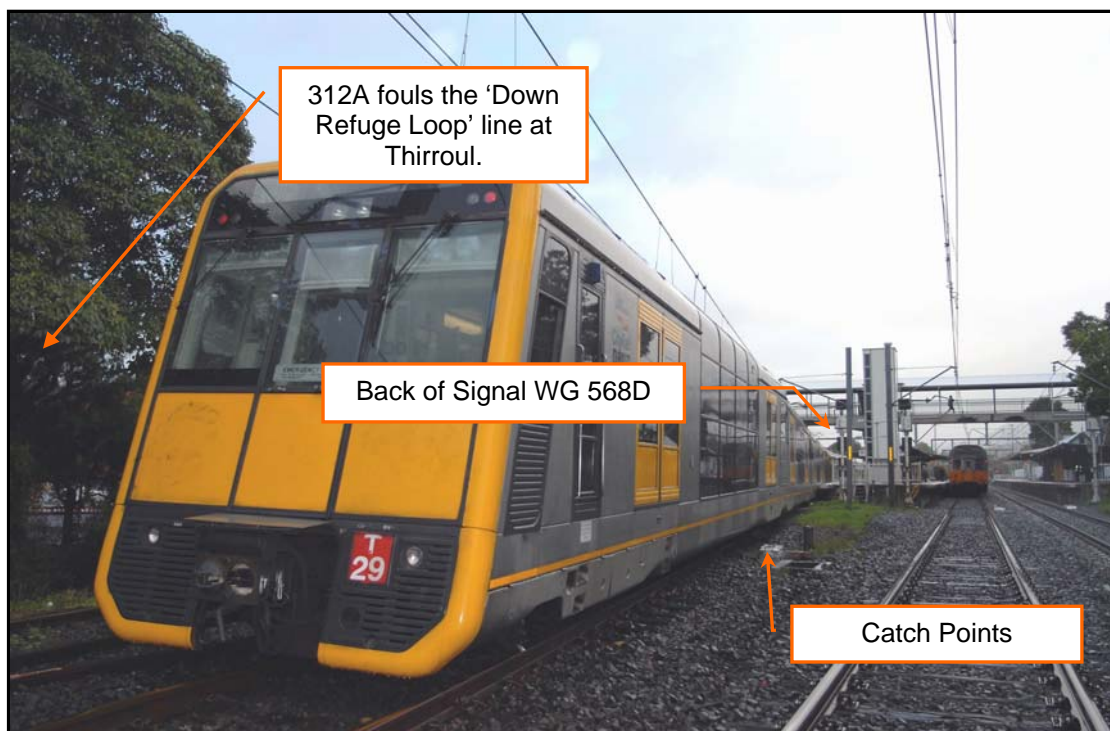


Photo 6: Tangara 312A located 46 metres past Signal WG 568D.

PART 2 ANALYSIS

Exclusions

- 2.1. Speed. Recordings taken from 312A's event recorder showed that the train was being operated at 25km/h as it negotiated the turn-out prior to No. 3 Platform track and that the train had slowed to 19km/h at approximately 100 metres prior to signal WG 568D. It was also confirmed the emergency brakes were applied approximately 20 metres prior to Signal WG 568D.
- 2.2. Signalling. An examination of the relevant signalling logs did not indicate any irregularities in signal functions or settings. The Driver was familiar with the route, and Signal WG 568D was visible at a distance that should have allowed 312A to have been brought to a stand prior to the signal despite the inclement weather.
- 2.3. Impairment and Fatigue. The Driver returned negative results when tested for the presence of drugs and alcohol. An examination of his roster for the preceding 10 days indicated that he was being tasked within industry guidelines.
- 2.4. Wheel and Bearing Defects. An examination was undertaken of data from the Wheel Impact Load Detector (WILD) system located on the 'Up Main' track at Penshurst past which the train had travelled the previous day. No anomalies were identified that would indicate the train had flat wheels or defective bearings.

Brake Testing Results

- 2.5. 312A was subjected to a static and running brake test in situ at the direction of RailCorp's Principal Brake Engineer. This testing was conducted on the 'Up Refuge' loop at Thirroul, rather than on the No. 3 Platform track. Before the tests commenced, an examination confirmed the disc brake pads, brake discs and wheels on all carriages were all in a serviceable condition. Had the train's wheels or the related axles locked-up, 'flat' spots on the wheels would have been apparent, but there were no such indications.

- 2.6. RailCorp's engineers used a portable decelerometer to measure speed, stopping distance and deceleration rates throughout the testing. During the first test, the brake controller was fully applied when the train's speedometer indicated that it was travelling at 25km/h, although the decelerometer indicated a speed of 22.3km/h. The train stopped within a distance of 31.7 metres, indicating a deceleration rate of 0.62m/s^2 . In a second test, braking was initiated at a speedometer reading of 23km/h, with the decelerometer recording a speed of 24.1km/h. The stopping distance was 31.3m, equating to a deceleration rate of 0.81m/s^2 . In the final test, the speedometer and decelerometer readings indicated 25km/h and 23.6km/h respectively. Full braking was followed, after a delay of two to three seconds, by the application of the emergency brake. The train stopped within 36m, a deceleration rate of 0.64m/s^2 . These results fell within the normal range for braking on wet rails so brake failure could therefore be eliminated as either a causal or contributing factor.
- 2.7. At the conclusion of testing, a relief driver returned the train to Mortdale and reported that the brakes had functioned normally during that journey. Further testing of the train's circuit boards and onboard computers at RailCorp's Mortdale Maintenance Centre identified that a fault had been recorded within the Wheel Slip Protection (WSP) circuit boards. However, this fault had been recorded on a day prior to the accident and there were no faults recorded on the day of the derailment.

Track Conditions

- 2.8. Both the No. 3 Platform and 'Up Refuge' tracks were inspected and found to be in generally good condition, although rust was apparent on the rail head. The rust on the 'Up Refuge' track, where the brake testing was undertaken, was embedded into the rail head. The rust on the No. 3 Platform track was superficial.
- 2.9. Rail friction experts at Monash University confirmed that embedded rust acts as an abrasive and assists braking, whereas superficial rust, when wet, acts as a lubricant and can inhibit braking. Superficial rust can also impact on track detection systems by forming a barrier between a train and the track

circuitry. For these reasons, RailCorp regards the circuitry on tracks that have not been utilised by rolling stock for more than 72 hours as unreliable and requires such tracks to be cleaned ('conditioned') before freight or passenger trains can again be operated over them.

- 2.10. Although trains effectively condition a rail-head when they pass over it, some trains do so more effectively than others by virtue of their length, weight and the type of brakes with which they are equipped. Long and heavy trains are more effective in conditioning the track, especially when they are equipped with treaded rather than disc brakes. The frequency with which trains pass over the track is also significant.⁶
- 2.11. The track on which the derailment occurred had not had a train pass over it in the preceding 58 hours during which time strong southerly winds and wet conditions had prevailed. It is considered highly likely that these conditions, in combination with salt spray generated by the extreme surf conditions at nearby beaches, would have promoted the superficial rust that was apparent on the No. 3 Platform track. There was clear evidence of skid marks over a distance of 46 metres under the Tangara (see *Photos 7 and 8*).



Evidence of rust
and the contact
band indicating
skidding

Photo 7: Evidence of rust emulsion and skid marks on the railhead.

⁶ RailCorp operates some trains for the express purpose of ensuring that tracks that would not otherwise have traffic over them are conditioned at least every 72 hours. However, some lines which may not be required to carry high volumes of traffic, such as branch lines located in metropolitan areas and sections that link yards and back platforms, are not necessarily included in this cleaning program.



Photo 8: Evidence of rust emulsion and skid marks on the wheel and rail.

2.12. In addition to having a clean running surface, effective braking is dependent upon proper contact between a train's wheels and the rail. This requires that the profiles of both the wheels and the rail fall within specified parameters. Provided they do, a band of contact is established through which braking effort can be transferred onto the track. This 'contact band' is depicted in *Figure 3*. The contact band on the No. 3 Platform track varied between 20-50mm and as such was within acceptable parameters.

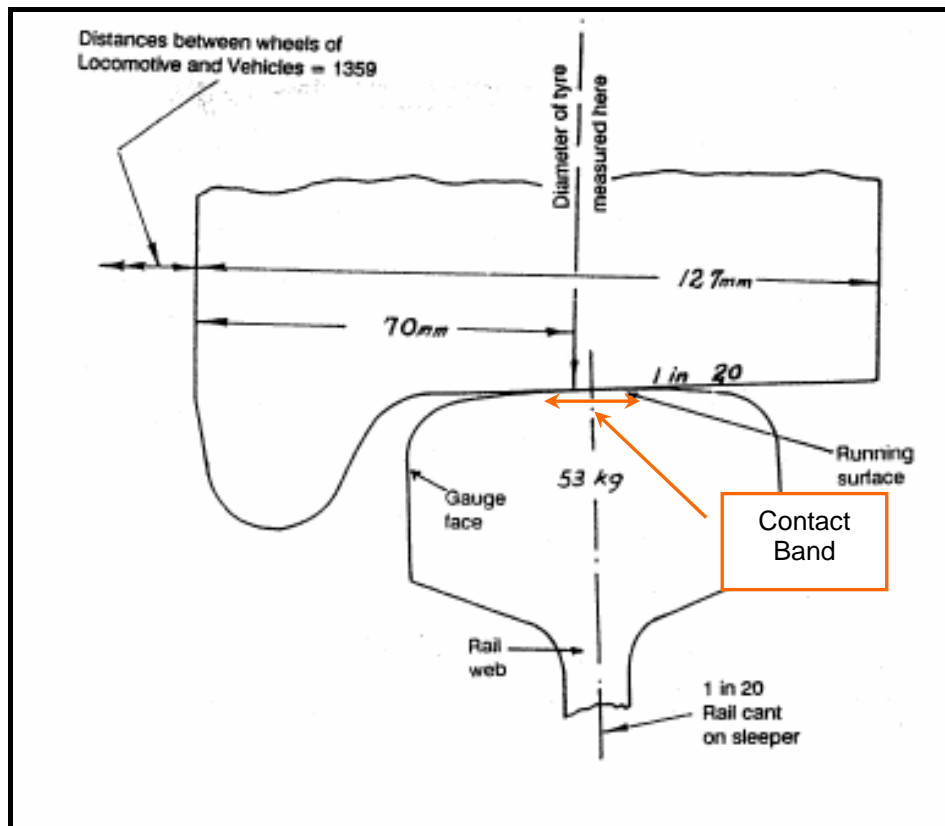


Figure 3: Wheel Rail Contact Band.

- 2.13. OTSI noted during its track inspections that there was nothing else on the track, such as vegetation or excessive lubrication, which might have inhibited braking. It was also noted that trackside lubricators in the area were appropriately positioned.⁷

Tangara's Braking System

- 2.14. In the course of the investigation, 24 drivers, four engineers and two rolling stock maintainers were interviewed. One of the common views expressed was that Tangaras could be "unpredictable" in wet conditions. All of the drivers interviewed, some of whom were driver trainers, indicated that they had been involved in at least one incident where they had either passed a signal at stop or overshot a platform in a Tangara in inclement conditions. During the period 1994-2006, there had been four specific instances when Tangaras had failed to stop at No. 3 Platform at Thirroul after braking at low speeds. Three of these instances resulted in derailments over catch-points.

⁷ The positioning of lubricators at the start of an incline or decline can also affect traction.

In each instance, the weather was inclement and the drivers were surprised by their train's lack of deceleration.

- 2.15. A detailed examination of the Tangara's braking system was undertaken in order to understand the comments made about braking performance in inclement conditions. While older style trains employ treaded brakes, Tangaras are fitted with disc brakes and with an electric/regenerative braking system which allows them to utilise energy generated by the power cars' traction motors to assist in braking. This has the advantage of reducing wear on brake pads and discs.
- 2.16. Senior RailCorp engineers advised that in dry conditions, and subject to wheel, brake and track components being in good condition, a good rate of deceleration for a Tangara is between 1.2m/s^2 and 1.6m/s^2 . In 'normal' wet conditions, this would reduce to between 0.8m/s^2 and 1.1m/s^2 . The presence of foreign materials on the track, such as wet leaves, might further reduce deceleration to 0.3m/s^2 . In this incident the WSP system started acting at a train deceleration of approximately 0.25 m/s^2 , indicating that wheel slip had already commenced at this very low rate of deceleration.
- 2.17. A number of RailCorp internal reports that were reviewed mentioned Tangaras "surging" at times and spasmodically 'dropping out of regenerative', particularly in wet conditions. One such instance occurred at Thirroul on 18 December 2002 resulting in the driver being unable to stop his train at the No.3 Platform. His train subsequently derailed on the catch-points. RailCorp provided evidence indicating that each of these reports had been investigated. Several of the occurrences were attributed to mechanical or electrical malfunctions and others were attributed to human error and/or the driver having a limited understanding of the Tangara's braking system (refer to the State Rail Internal Memo at *Appendix 2*). However, it was acknowledged in the Memo that:

"Tangara trains do incur more wheel-slide in low adhesion conditions due to their higher level of brake performance".

- 2.18. **Other Tangara Stopping Failures.** Evidence was found of 23 occurrences involving failure to stop at signals, overshooting platforms and/or derailing or colliding at dead-ends during the period August 1994 - September 2006 because of braking difficulties in wet and inclement conditions (see *Appendix 3*). Of the 23, 22 involved Tangaras and 14 occurred on the South Coast, and all occurred at similar or lower speeds than the incident under investigation. Of the 14, eight were at Thirroul, seven of them since November 2002. Examining safety issues was part of the terms of reference for investigations into these incidents but no safety issues or safety actions were identified as a result.

Wheel Slip Protection (WSP)

- 2.19. Tangaras and some of RailCorp's other types of trains are fitted with WSP systems. These systems incorporate axle-mounted sensors which detect axle rotation slowing relative to the speed of the train. Under certain conditions, the system can inadvertently release the brakes to alleviate what it diagnoses to be a locked-up axle, but which in fact is wheel slippage in conditions of low adhesion. This situation can be compounded by misconceptions over the way in which the WSP system operates. (See *Appendix 4* for a schematic of the WSP module's 'logic'.)
- 2.20. Some drivers stated that they altered their braking according to the sound emanating from the WSP module (which is located within the driver's cabin). On hearing noise from the WSP module, which they interpreted as wheels skidding, they effectively sought to override the WSP system by manually adjusting and momentarily releasing ('fanning') the brake control to try and eliminate the skidding. RailCorp is aware of such a practice and issued a memo recommending that drivers ignore the sound from the WSP module and when in doubt, or during braking difficulties, initiate emergency braking (see *Appendix 5*).
- 2.21. When interviewed, the Driver indicated that it was his understanding that applying the emergency brake in wet conditions would only cause the train to skid further, and that sound emanating from the WSP module was an indication of reduced adhesion. It was the latter indication that had

encouraged him to momentarily release the brakes. He further stated that at approximately 100 metres along the platform *“I looked down as I thought I was actually powering”*. This sensation could be explained by his attempt to stop the train at a time when the WSP had released air from the train’s braking system because of what it had interpreted as a locked-up axle.

- 2.22. One of RailCorp’s senior operations inspectors voiced his concerns about the WSP system in support of findings in an internal investigation report into a SPAD and derailment that occurred on 19 February 2003.⁸ In the same context, he described an incident in which he was driving a four-car Tangara set from Port Kembla to Thirroul during sleeting conditions in September 2002:

“I moved the brake valve handle to full service observed that full EP brake cylinder pressure (200kpa) was displayed on the consul (sic) gauge, but with the anti-skid system relay activated I sensed that braking effort was being reduced. I initially notched back on the brake valve handle with the anti-skid relay stopping. Each time I re-apply the EP brake the anti-skid activated. I left the brake valve handle in full service allowing the anti-skid to take over, with the train stopping three (3) cars beyond the departure end of the platform.”⁹

It is noteworthy that, in this instance, the driver ultimately reverted to the recommended course of action by allowing the WSP to function as intended.

- 2.23. The WSP system is intended to compensate for situations where an axle or several axles lock-up. It cannot compensate for situations in which the slippery state of the track is at issue. On 31 October 1996, an Endeavour train overshot a platform at Bombaderry and collided with a dead-end buffer stop. The subsequent investigation established that the track had become extremely slippery as a consequence of poison spayed in the vicinity of the track the day before and that under such conditions the WSP’s logic had become confused. RailCorp’s Principal Brake Engineer at the time stated that:

“This incident inevitably raises doubts about the wisdom of wheel slide protection in emergency braking mode. Due to the almost

⁸ This incident involved Service 375A at Signal WG 561.

⁹ State Rail Investigation, 18 December 2002 – Thirroul 375A Suburban Train Passed Signal WG561 at STOP and Derailed at #317 Catch Points.

impossibility of recreating freak adhesion conditions upon demand it remains open to conjecture”.

The Engineer identified that:

“Friction modifiers and/or braking systems independent of the wheel/rail adhesion are considered to offer the potential to address the problem of low adhesion conditions, however issues of interface with signals and cost effectiveness are a concern.”

and recommended that RailCorp’s senior management consider:

“... a system for warning drivers of a potential local adhesion hazard following herbicide track spraying.”

He also recommended that:

“Drivers be continually reminded through general orders of the adhesion problems posed by the first rain after any dry period, with special emphasis on tracks having a low traffic density.”¹⁰

2.24. Most suburban trains in the UK are fitted with a system that allows sand to be released onto the track to assist in maintaining traction in slippery conditions, and it has been mandatory to fit sanding equipment to all new rolling stock since 2003. Sanding also assists drivers to manage tractive power when departing platforms and to negotiate steep and difficult terrain. The UK Department of Transport Rail Accident Investigation Branch (RAIB)¹¹ notes that:

“Trainborne sanding equipment complements the WSP system. The application of sand is beneficial for adhesion in both traction and braking”.¹²

Such equipment is fitted to freight trains in Australia. Though it is less common for passenger trains to be equipped in this way, some in Victoria and South Australia are. However, none of RailCorp’s passenger trains are equipped to dispense sand.

2.25. RailCorp sought independent advice in 2003 on the feasibility of introducing Magnetic Track Brakes (MTB). MTBs incorporate a device, fitted to the underside of bogies, which is designed to drop onto the railhead when an

¹⁰ CityRail Fleet Engineering Memo dated 15 November 1996 Incident No. G014:31/10/96: KR3: Bomaderry: 2865,2815 *Endeavour Railcars Overshot Platform and Collided with Buffer Stop*

¹¹ RAIB Rail Accident Report 25 January 2007 *Autumn Adhesion Investigation Part 3: Review of adhesion-related incidents Autumn 2005*.

¹² There are two issues for trains negotiating a section of track: one is braking and the avoidance of slipping/skidding; the other is tractive power and the avoidance of wheel-spinning.

emergency application of the brakes is made. Therefore it does not rely on friction between the wheels and rail. RailCorp was advised that:

“... fitting magnetic brakes to new rolling stock is technically feasible for all new diesel and electric rail cars.”

“In financial terms the case for fitting magnetic track brakes to diesel cars is not justified. For electric cars the justification is marginal if based only on damage repair and wheel turning costs, but if un-costed operational and passenger safety benefits are considered then an economic case exists for fitting magnetic track brakes to electric cars.”¹³

A related report observed that sanding would:

“... improve the co-efficient of friction between wheel and rail ... Sand will not increase the performance of the brake beyond the normal braking rate but it will increase the confidence of drivers and operators in the ability of trains stopping in inclement conditions.”

Emergency Response

2.26. No emergency response as such was required. Instead, the focus was on re-railing 312A and ensuring that other services were not interrupted. These imperatives were addressed efficiently.

Other Related Safety Issues

Training

2.27. From the interviews with drivers and the existence of internal memorandums to drivers on the subject, it was apparent not all of RailCorp's drivers possessed a clear understanding of the Tangara's braking and WSP systems and that this was not a recent phenomenon. The Report of the *Special Commission of Inquiry into the Waterfall Rail Accident* observed in relation to electro-pneumatic braking systems that:

“... many train Drivers honestly held the belief that these systems were defective indicates that the State Rail Authority has not effectively communicated important information regarding the characteristics of its trains to its train Drivers in the course of their training or in response to defects reported by train Drivers. A lack of understanding regarding how a train may behave under certain conditions may lead to train Drivers making errors of judgement, with a consequential increased risk of safety-related incidents.”

¹³ State Rail Authority, *Capital Works & Development Strategic Review of Magnetic Track Brakes*, February 2003.

A 'Professional Driver Training' package is now in use which does include instruction on the WSP system.

- 2.28. Whether or not RailCorp trainees experience driving in wet conditions in training is purely reliant on the weather. Given the drought conditions that have prevailed across much of NSW over recent years, this has led to a situation where many drivers' first experience of such conditions is after they have qualified and while they are at the controls of a train in-service. The only practical alternative then is simulation. However, RailCorp no longer has sections of dedicated training track that could be used for such purposes and the driver training simulator at the Petersham training facility lacks the technical, programmable sophistication to simulate the environmental, motion and driving characteristics which prevail in adverse driving conditions.

Use of WSP Equipped Rolling Stock for Rail Conditioning

- 2.29. It is understood to be widely known through the rail industry that rolling stock with tread type brake units condition track more effectively than those with non-tread type brake units like the Tangara. In Victoria and South Australia there are rail sets that are specifically designed, incorporating a combination of both tread brake and non-tread brake units, solely for the purpose of conditioning the rail head.

PART 3 FINDINGS

Causation

- 3.1 The derailment occurred because passenger service 312A proceeded past Signal WG 568D, which was at 'Stop', and ran through a set of catch-points which performed in the manner for which they were designed. The Driver sought to comply with the signal by bringing his train to a stand but it failed to respond because an emulsion formed by rust, moisture and salt on top of the rails impeded the transfer of braking effort.

Contributory Factors

- 3.2 The No. 3 Platform had not been used for 58 hours prior to the derailment. If this had been in excess of 72 hours the track may have been conditioned using a train operating specifically for the purpose. However, the severity of the weather conditions would have promoted oxidation of the rail at a faster rate than normal. Tangaras are fitted with disc brakes which make them less effective in conditioning rail in the course of normal operation than trains fitted with treaded brakes, and as a consequence the rearward carriages would have had little benefit from conditioning by the leading carriages.
- 3.3 The braking performance of all trains is downgraded by wet conditions and this has contributed to a number of SPADs, and instances of overshooting platforms and colliding at dead-ends. A disproportionate number of these have been on the South Coast, especially at Thirroul. It is probable that this is due to the particularly slippery rail conditions resulting from the moist, salty environment on rails that may carry no traffic for extended periods.
- 3.4 No additional mechanical measures have been introduced to enhance or complement the Tangara's braking performance in adverse conditions. However, the dispensing of sand on the rail head is used extensively on suburban trains in the UK to enhance both traction and braking, on freight locomotives throughout Australia and in some Victorian and South Australian passenger trains.

- 3.5 Actuation of the WSP module earlier in the trip was followed by a more cautious braking technique by the Driver for a short period, but this same degree of caution was not in evidence on the approach to Thirroul.

Other Related Safety Issues

- 3.6 RailCorp does not have a training area that is conducive to teaching trainee drivers how to control their train in difficult conditions or to reassessing qualified drivers in the same competencies. RailCorp's training simulator also has limited utility in this regard.
- 3.7 There may be more effective alternatives to using Tangaras in the rail conditioning role.

PART 4 RECOMMENDATIONS

- 4.1 In order to prevent a recurrence of this type of incident, It is recommended that the following remedial safety actions be undertaken by RailCorp:
- a. review the adequacy of current training, assessment and instructions to drivers in ensuring they have a thorough understanding of the operation of the WSP system;
 - b. review the adequacy of current training and assessment in ensuring drivers are aware of localities where comparatively very poor braking performance may result from particular environmental conditions, and are competent in the use of appropriate train handling methods for such conditions;
 - c. in relation to the above recommendation, investigate better use of simulation so that weather does not remain the sole determinant of the extent of training and currency of experience;
 - d. evaluate options for enhancing the Tangara braking performance in adverse conditions, and
 - e. evaluate alternatives to the use of standard Tangara sets in the role of rail head conditioning.

PART 5 APPENDICES

Appendix 1: Copy of Driver's Periodic Re-Assessment Report

TASK	ITEM NO.	ITEM DESCRIPTION	YES	NO	COMMENTS
A TRAIN OPERATION: STARTING					
	01	Use of whistle	✓		APPROPRIATE
	02	Operation of master controller	✓		SMOOTHLY.
B TRAIN OPERATION: ENROUTE					
	01	Operation of brake valve / controller handle	✓		CORRECTLY.
	02	Train handling (wet)	✓		SAFELY (DRY)
	03	Observance of speed boards	✓		CORRECT SPEEDS
	04	Observance of warning / caution boards	✓		SPEEDS ADJUSTED.
	05	Re-action to incidents			NONE OCCURS
	06	Driving under caution signals	✓		UNDER CONTROL
	07	Driving operations between stations	✓		EFFICIENTLY
	08	Vigilance control operation	✓		CORRECT USE.
C TRAIN OPERATION: STOPPING					
	01	Approach speed into stations	✓		UNDER CONTROL
	02	Operation of brake valve / controller handle Using E.P. and Regenerative braking	✓		CORRECTLY.
	03	Operation of brake valve / controller handle Using Automatic braking	✓		✓
	04	Correct stopping position on platform Maintain train stationary	✓		YES
	05	Terminating procedure	✓		TRAIN SECURES
	06	Cutting in / Cutting Out	✓		CORRECT PROCEDURE
	07	Train Management	✓		EFFICIENTLY.
D SIGNALLING					
	01	Signal identification	✓		DISCUSSED
	02	Route identification	✓		✓
	03	Passing signals at stop under procedures NSG 608 & NSG 610	✓		✓
E PUBLICATIONS and SAFETY EQUIPMENT					
	01	Timetable	✓		ON HAND
	02	(SPA) Special Proceed Authority (CAN) Condition Affecting the Network	✓		✓
	03	(OSP's) StateRail Operator Specific Procedures	✓		✓
	04	Watch / torch	✓		✓
	05	Safety vest	✓		✓
F COMMUNICATIONS					
	01	Train Radio / two way radio NGE 204 Network communication	✓		PROTOCOL
G MISCELLANEOUS					
	01	Dress standard	✓		NEAT.
	02	RIC Rules and procedures (eg. Pilot Staff Working)	✓		DISCUSSED
H TRAVELLED					
	01	Un-observed			
	02	Observed	✓		COMPETENT.

Appendix 2: Memo to Co-ordinator General Rail

Internal Memo



Quality Endorsed Company
ISO 9001 Lic No: QEC7712
Standards Australia

Prepared under a Quality System
certified as complying with ISO9001
by an Accredited certification body.

20th May, 2003

Passenger Fleet Maintenance
Quality and Technical Support
Level 2, Western Gateway
18 Lee Street
Chippendale 2008

To: [REDACTED]

StateRail

RECENT INCIDENTS INVOLVING TRAINS ALLEGEDLY POWERING AGAINST BRAKES OR SURGING

There have been a number of incidents following the Waterfall train where reports have been received from drivers that they have either experienced surges whilst braking or that the train has powered whilst braking.

The following five incidents are noteworthy:

1. 12th Feb 2003: Run 23-K: Set T34/T56: Campbelltown: Tangara reported powering whilst in Step 1 (initial) braking.
2. 16th Feb: Run W578: Set V68: Linden: Double Deck InterCity (DDIC) reported powering against brake whilst sitting at station.
3. 25th Feb: Run 3-J: Set T28/T1: Cronulla: Tangara reported surging whilst braking.
4. 14th April: Run N130: Set V36/V28: Hornsby: DDIC reported powering against brake at end of stop.
5. 11th May: Run K316: Set G6: Thirroul: Tangara reported powering against brakes.

All incidents received extensive investigations from PFM and included representation from Management of Train Crewing and Safety Division. In each case the trains were trialed with drivers and where possible with the driver involved. Any conclusions reached resulting from the trial were shared with the crew involved with the trial at the time.

Incident 1:

In the case of the above, no fault was found. Step 1 braking is designed to provide a very minimal deceleration rate, effectively zero, just enough air to fill the brake cylinders for a quick re-application. The driver had concluded that because his train was apparently not slowing down that his ammeter reading (traction current) must indicate power not regen. He was mistaken.

C:\Documents and Settings\Administrator\My Documents\PDFs\Rail\Related to Thirroul\High5.doc

Incidents 2 & 4:

These involved an electrical fault on the one DDIC car (8108) at the back of the train. In this case there was a defect but it was not found after the first instance. The nature of the fault was that the Notch 1 power command wire (train wire No.3) was being energised via a short circuited blocking diode that only came into play when the traction system protective relays were energised, thus making it intermittent. Originally (due to the weather conditions at the time) it was thought that water in a jumper receptacle had been to blame (this was a common problem years ago).

It should be noted that the above fault could only take effect when EP brakes are applied. In order to power, No.1 (Forward) or No.2 (Reverse) must also be energised, by applying the EP brake (with the Master Controller in OFF) the No.1/2 wire is energised.

Our investigations revealed that DDIC Chopper rolling stock behaves differently from Tangara. A DDIC presented with this spurious energisation of 3 wire whilst in regenerative braking (6 & 1 or 2 wire energised) will continue to regen down to the speed at which it normally drops out 5 km/h. After the regen amps drop to zero the traction system will then & only then power up. The EP brake system has more than enough power to hold the train against the traction system but this is detrimental for the traction motors (will cause overheating).

On the other hand, if the above situation occurred on a Tangara, it will neither power nor regen brake, the EP brake will function normally. This was proven on a separate trial conducted on T34 on 26th February 2003.

Incident 3:

This involved a report of surging (as opposed to powering against the brakes) on the Cronulla line. A fault was found in the brake chopper circuit of one of the Motor cars. The Tangara electric brake system is able to combine Regenerative braking with Rheostatic braking (through a brake resistor grid and brake chopper circuit) when the overhead is not fully receptive. Poor receptivity can be expected to be experienced more often on a single line such as Cronulla.

As a result when the overhead line could not receive the full current, the particular Motor car would trip out whenever attempting to fire its brake chopper circuit. Under normal blended brake conditions on Tangara, the electric brake is providing approximately 95% of the Motor cars braking effort and 60% of its associated Driving Trailer. Consequently, once electric braking is established, the EP brake cylinder pressures are reduced. Under fault conditions there is no gradual ramping down of the electric braking effort, so there is a momentary loss in braking (one to two seconds) whilst the brake cylinder pressures increase to make up the lost effort. The increase in stopping distance is generally insignificant, the momentary jerk is of minimal discomfort to seated passengers, the loss in deceleration does feel like a momentary acceleration. The fault in the brake chopper circuit was identified and fixed at Mortdale Maintenance Centre.

Incident No.5:

In the above, a Tangara driver encountered a localised patch of low adhesion conditions, correctly made an Emergency brake application and stopped his train short of any SPAD or overshoot. The only problem was that he failed to notice the wheel-slip light indication and wrongly concluded that the train was powering against the brakes. The Event Recorder (or data logger) was used in analysing this incident.

Additional Incident:

In addition to the 5 incidents highlighted above, a further incident was reported last week (15th May). On Run 1-F, the driver of a Tangara overshot Hurstville platform by 3 car lengths, alleging that this was due to the Regen dropping out. The Event Recorder download clearly shows that the driver inadvertently failed to shut off the Master Controller and was powering against the brakes in Notch 3 for most of the stop. After he shut off power, the train rapidly stopped.

Conclusion:

Tangara trains do not suffer from uncommanded power applications, they do however have a human factors issue with the direction of movement of the Master Controller being opposite from that of Double Deck Suburban & InterCity trains.

Tangara trains do (like all other electric trains) occasionally suffer minor longitudinal jerks due to protective circuit operation in the traction system. This does not necessarily mean that there is a problem, unless it happens repeatedly to a particular car. Based upon current knowledge, I do not consider that there is a design issue associated with so called "surging".

Tangara trains do incur more wheel-slide in low adhesion conditions due to their higher level of brake performance. Most of the time it does not present a problem. However when track adhesion is extremely low (eg first light rain after a dry spell), the conditions will determine stopping distance, rather than the train.

Appendix 3: Summary of Incidents involving WSP-Type Rolling Stock

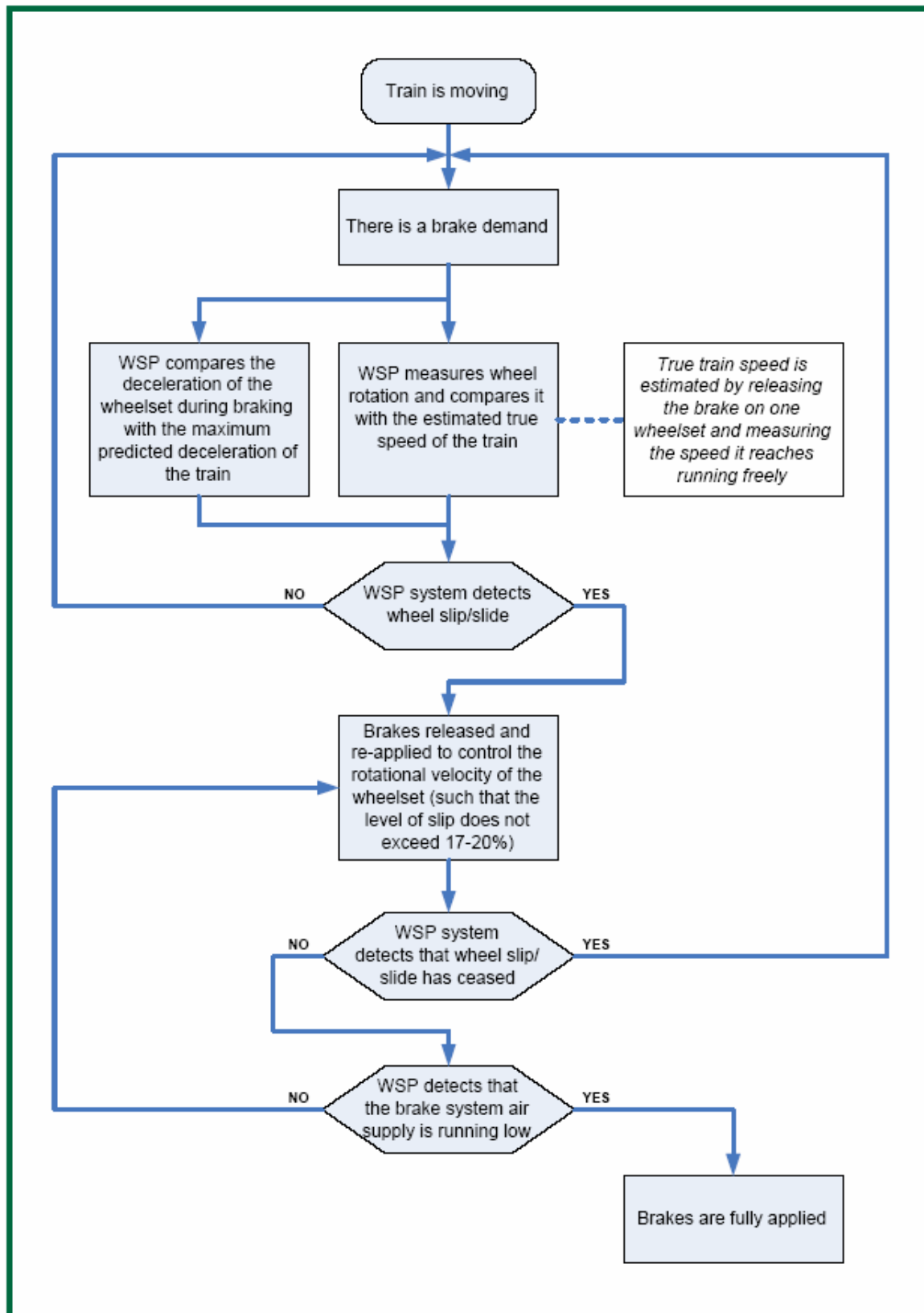
Date	Run No.	Weather Conditions	Incident	Identified as a 'Safety Issue	Location
14/09/06	20-N	Wet	Overshot Platform	No	Loftus
11/09/06	312A	Wet	SPAD/Derailment	Yes	Thirroul
24/08/06	306A	Wet	SPAD	No	Thirroul
30/05/06	312B	Wet	SPAD	No	Thirroul
01/05/06	361H	Wet	SPAD	No	Thirroul
11/05/05	K316	Wet	Difficulty in stopping	No	Thirroul
30/03/05	3BC	Wet	Overshot 2 platforms	No	Heathcote, Engadine
18/07/04	65AF	Wet	SPAD	No	Pymble
09/07/04	303A	Wet	SPAD	No	Thirroul
18/12/02	375A	Wet	SPAD/Derailment	No	Thirroul
24/05/02	72AB	Wet	Collided dead end	No	Hornsby
03/02/01	C406	Wet	Overshot 3	Yes	Nth Wollongong,

			platforms		Bellambi, Bulli
17/02/00	64A	Wet	Collided dead end	Yes	Richmond
03/02/01	C406	Wet	Overshot 2 Platforms	Yes	Bellambi
22/05/99	817C	Wet	Overshot end of siding	No	Rhodes
30/11/98	6A	Wet	Collided dead end	NR	Cronulla
04/08/97	72C	Wet	SPAD/Derailment	NS	Rhodes
06/03/97	222A	Wet	Collided dead end	NS	Hornsby
24/05/97	63B		Collided dead end	NS	Richmond
19/11/96	71	Wet	Collided dead end	NS	Hornsby
22/01/96	65	Wet	Collided dead end	NS	Hornsby
15/03/95	K334	Wet	Over shot two platforms	NS	Wollongong/Fairy Meadow
18/8/94	308A	Wet	SPAD/Derailment	NS	Thirroul

NS - Not Supplied

NR - Not Recorded

Appendix 4: Wheel Slip Protection Module 'Logic'¹⁴



¹⁴ RAIB, op. cit.

Appendix 5: Memo from Principal Brake Engineer to CityRail Drivers

FILE

OPERATIONS DIVISION
OFFICE OF THE MANAGER TRAIN CREWING
LEVEL 1 - 18 LEE STREET, CHIPPENDALE
GENERAL ORDER 8-2003
17 March, 2003

TO: ALL CITYRAIL TRAIN DRIVERS

ENHANCED DRIVING TECHNIQUES

When a Driver is operating in Endeavour / Explorer, Tangara or Millennium rolling stock in adverse conditions, they should adopt the following Train Management Technique:

As when driving an Anti-lock Braking System (ABS) equipped motor vehicle, do NOT attempt to correct for wheel-slide with the brake valve, instead make the appropriate brake application for the speed and intended stopping point and allow the Wheel Slide Protection (WSP) systems to correct any slide.

In the event of the train appearing likely to fail to stop at a designated point (whatever the reason), make an emergency brake application at the **earliest point in time**, rather than after it is clear that the designated point will be exceeded. An emergency brake application will attract more WSP activity but will still provide the shortest possible stopping distance achievable in the conditions.

Drivers are to be aware of the increased likelihood of low adhesion in the initial period of rain following a dry spell and must be prepared to make necessary allowances.

Drivers are also reminded that they **MUST** report the problem to Mechanical Control as soon as possible.

Further technical instructions regarding speed, braking distance and gradient are attached to this general order.

TECHNICAL INSTRUCTION – Braking Distance vs Speed

The Principal Brake Engineer wishes to advise all CityRail Train Drivers to please be aware of the relationship between speed, stopping distance and gradient.

Stopping distance goes up with the square of the speed. A falling gradient can further exaggerate this effect. For example the difference in stopping distance on a 1 in 100 falling grade (eg approaching Rooty Hill on the UP), between 70 km/h and 80 km/h is an extension from 389 metres to 528 metres, an increase of 139 metres (7 car lengths). See table below for maximum DD Suburban Full Service Electronic Pneumatic (FSEP) brake stopping distances. ie Controlling speed is critical on falling grades.

R/S-set Full Service E.P. - (Load Compensated) - Max Stopping Distances											
Speed	Rising grade, 1 in						Falling Grade, 1 in				
(km/h)	30	40	60	100	200	LEVEL	200	100	60	40	30
0	0	0	0	0	0	0	0	0	0	0	0
10	7	8	8	9	9	10	10	11	12	15	19
20	22	23	25	27	28	30	32	35	39	46	57
30	44	47	51	54	57	61	65	70	78	92	113
40	73	79	85	92	97	104	111	120	134	158	193
50	112	121	132	142	151	161	173	187	209	248	306
60	161	174	191	206	220	235	253	275	311	372	466
70	221	241	264	287	306	329	357	389	443	538	687
80	293	319	352	383	411	443	482	528	606	746	974
90	373	408	450	492	529	572	623	685	791	983	1303
100	457	500	553	604	649	703	766	842	973	1209	1603
110	538	587	647	705	757	817	887	972	1115	1368	1777
115	574	625	687	747	800	861	933	1018	1161	1409	1799

Apparent differences in braking performance between different ends of the same train are generally the result of invisible changes in wheel temperatures. As the wheels get hotter, the brake block friction level tends to reduce, particularly at speeds above 60 km/h. At low speed the effect of high wheel temperatures is generally not as obvious, due to the short stopping distance and the frictional character of the braking material.

Tread-braked rolling stock (DDS/DDIC) has a frictional characteristic that tends to climb as speed reduces. With temperature rise, this characteristic usually becomes more pronounced. Lower friction exists at high-speed, and greater friction towards the end of the braking application, with the climb starting at about 40 km/h, see example deceleration trace below.

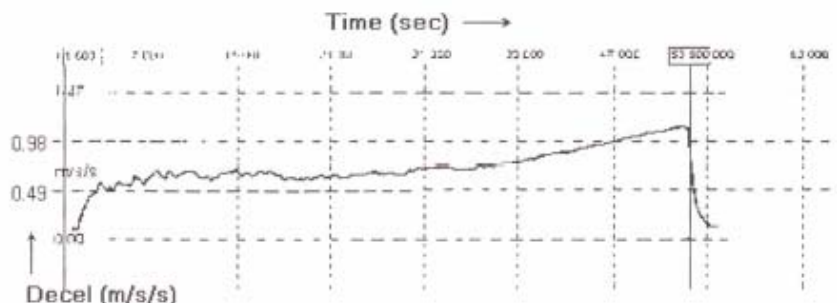


Fig A Typical DDS Full Service EP Brake Application from 110 km/h

Heavy falling grades, high ambient temperature, brake-rigging deficiencies, frequent stopping and high speed braking all contribute to a rise in wheel temperatures. Drivers must be aware of these factors and make appropriate allowances to ensure that their train is under control at all times.

When stopping at platforms that are close to level grade, it is recommended that the approach speed be reduced to 50 km/h or lower **before** the platform is reached. On stations on severe falling grades such as Denistone (1 in 40) the speed should be 40 km/h or lower. Drivers are advised to apply the maximum service braking available as **early as possible** if it appears that the approach speed may be above the recommended limits. This will minimise the risk of platform overshooting and the brake application can most likely be reduced towards the end of the stop to provide passenger comfort.

If doubt exists as to the correct functioning of the brakes, such that the chance of incurring a SPAD or platform overshoot appears likely, then an Emergency brake application should be made as early as possible.

In any emergency, an Emergency application via the Drivers Brake Valve gives the shortest possible stopping distance as this method applies both the EP and the Automatic air (Westinghouse) brake system, whereas the Deadman system applies only the Automatic air brake.

Appendix 6: Sources and Submissions

Sources of Information

- Rail Corporation NSW
- Independent Transport Safety and Reliability Regulator

References

Transport Administration Act 1988 (NSW)

Rail Safety Acts 2002 and 2008 (NSW)

Submissions

The Chief Investigator forwarded a copy of the Draft Report to the Directly Involved Parties (DIPs) to provide them with the opportunity to contribute to the compilation of the Final Report by verifying the factual information, scrutinising the analysis, findings and recommendations, and to submit recommendations for amendments to the Draft Report that they believed would enhance the accuracy, logic, integrity and resilience of the Investigation Report. The following DIPs were invited to make submissions on the Draft Report:

- Rail Corporation NSW
- The Independent Transport Safety and Reliability Regulator

Submissions were received from both of the Directly Involved Parties.

The Chief Investigator considered all representations made by the DIPs and where appropriate reflected those representations in this Final Report.