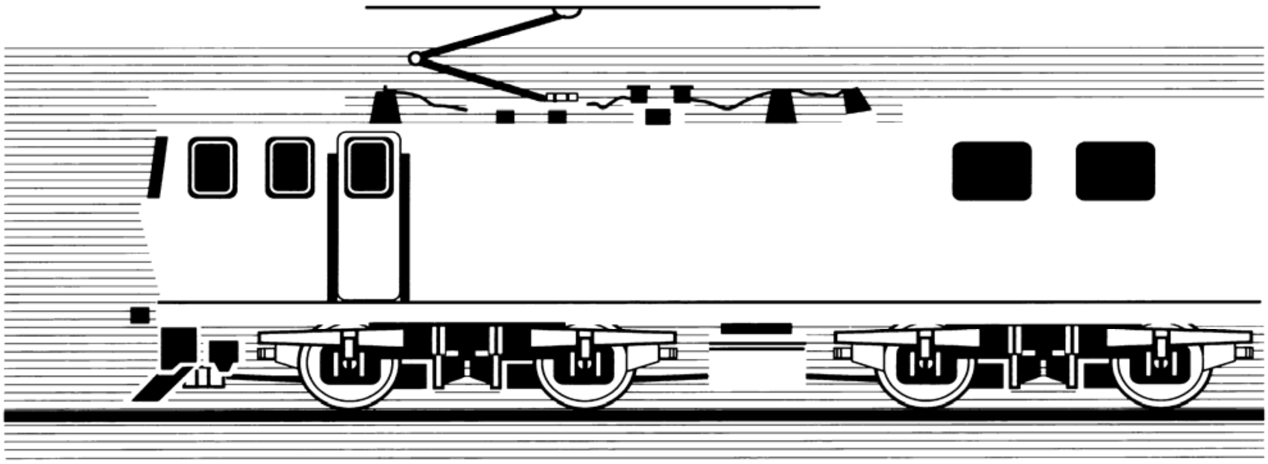

RAILWAY OCCURRENCE REPORT

05-119	**runaway wagons from Waingawa and subsequent collision with motor vehicle, Hodders Road level crossing, 74.35 km between Carterton and Dalefield**	**29 July 2005**

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

Report 05-119

runaway wagons from Waingawa

and subsequent collision with motor vehicle

Hodders Road level crossing

74.35 km between Carterton and Dalefield

29 July 2005

Abstract

On Friday 29 July 2005 at about 0506, a rake of 9 wagons that had been detached from the locomotives of Train 644 ran away to the south from Waingawa. The runaway wagons collided with a motor vehicle at Hodders Road level crossing, about 11.75 kilometres (km) from Waingawa, seriously injuring the driver. The wagons then continued for a further 2.75 km before stopping at about 70.50 km between Dalefield and Matarawa.

The driver of the vehicle was taken by ambulance to Wairarapa Hospital, and subsequently air lifted to Wellington Hospital.

Safety issues identified included:

- train braking and shunting procedures
- post-runaway response procedures.

Safety recommendations have been made to the Chief Executives of ONTRACK and Toll NZ Consolidated Limited to address these issues.

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Abbreviations

Alstom	Alstom Transport New Zealand Limited
CPR	Canadian Pacific Railroad
JNL	Juken Nissho Limited
km	kilometre(s)
km/h	kilometre(s) per hour
kPa	kilopascal(s)
LE 1	locomotive engineer who drove Train 644
LE 2	locomotive engineer who filled the second person’s role on Train 644
m	metre(s)
mm	millimetre(s)
TEM	train end monitor
Toll Rail	Toll NZ Consolidated Limited
UTC	coordinated universal time

Data Summary

Train number:	Date:	Time[1]:	Location:	Type of occurrence:
Train 644	29 July 2005	0506	Waingawa, Wairarapa Line	runaway
		at about 0525	Hodders Road level crossing at 73.25 km between Carterton and Dalefield, Wairarapa Line	collision

Persons on board train:	2
Injuries:	nil
Person in vehicle:	one
Injuries:	serious
Damage:	major to motor vehicle, minor to one wagon on runaway consist
Operator:	Toll NZ Consolidated Limited (Toll Rail)
Investigator-in-charge:	Vernon Hoey

[1] Times in this report are New Zealand Standard Time (UTC + 12 hours) and are quoted in the 24-hour mode.

1 Factual Information

1.1 Narrative

1.1.1 On Friday 29 July 2005, Train 644 was a scheduled express freight service from Wellington to Masterton on the Wairarapa Line. The train consisted of 2 locomotives and a rake of 9 empty wagons, with a gross tonnage of 191 tonnes and a train length of 186 metres (m).

1.1.2 Train 644 was crewed by 2 locomotive engineers. One locomotive engineer (LE 1) drove the train while the other (LE 2) occupied the second person position, being responsible for planned shunting duties en route. The locomotive engineers were rostered to drive separate passenger trains for their return from Masterton to Wellington.

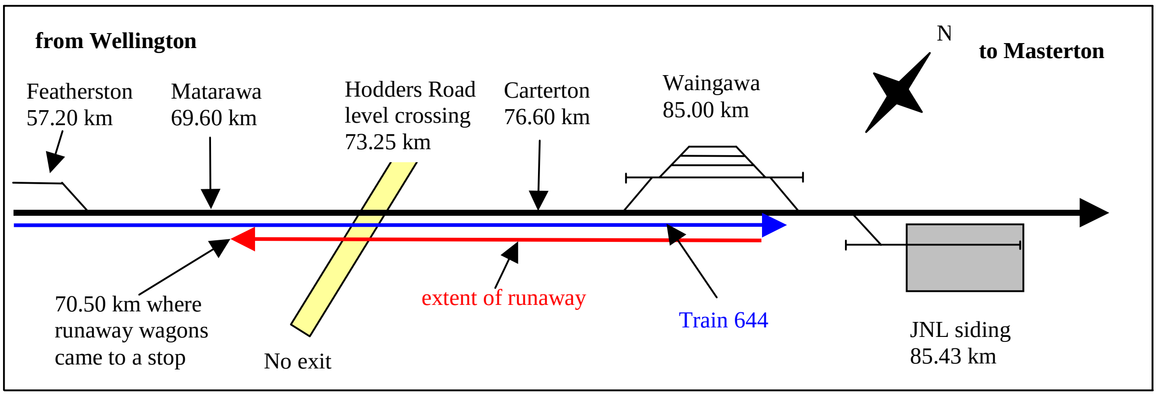


Figure 1
Plan of Wairarapa Line (not to scale)

1.1.3 At about 0506, LE 1 berthed Train 644 on the main line at Waingawa with the intention of placing the 9 wagons into Juken Nissho Limited's (JNL's) siding (see Figure 1). LE 2 alighted and cut off the wagons from the locomotives.

1.1.4 LE 1 moved the locomotives forward to the north end of Waingawa where they were routed into a siding. Shortly after the locomotives had moved away, the wagons began to runaway to the south, from where Train 644 had arrived.

1.1.5 At about 0509, the locomotive engineers realised what had happened, and they re-entered the main line at the south end of Waingawa to follow the runaway wagons in their locomotives.

1.1.6 At about 0525 hours, after the runaway wagons had travelled about 11.75 km, the front right corner of the then leading wagon collided with a motor vehicle being driven across Hodders Road level crossing (see Figure 2). The impact of the collision ripped off the 2 doors from the driver's side of the vehicle and wrapped them around the corner of the wagon. The driver was seriously injured.

1.1.7 At about the same time and while the locomotives were passing through Carterton, LE 1 telephoned train control to inform the train controller of the runaway incident.

1.1.8 Train control made arrangements to reverse a set of facing points at Featherston with the intention of diverting the runaway wagons to the loop and stopping them at a set of safety points installed at the south end, should the runaway wagons travel that far.

Figure 2
Hodders Road level crossing looking northwest

1.1.9 A nearby farmer heard the collision from his farmhouse and went outside to see what had happened. When he found the injured driver, he called to this wife to notify the emergency services.

1.1.10 The locomotives arrived at the level crossing shortly afterwards, and the crew rendered assistance to the injured driver.

1.1.11 After the collision, the wagons continued for a further 2.75 km before they came to a stop at about 70.50 km.

1.2 Site information

1.2.1 The Wairarapa Line ran from Wellington to Woodville over a distance of 171.50 km. The gradient profile descended steadily northwards from Matarawa, levelled out between 71.00 km and 74.00 km, then steadily but gently ascended to Waingawa. The track alignment between 70.50 km and Waingawa was straight except for two 600 m radius curves (see Figure 3).

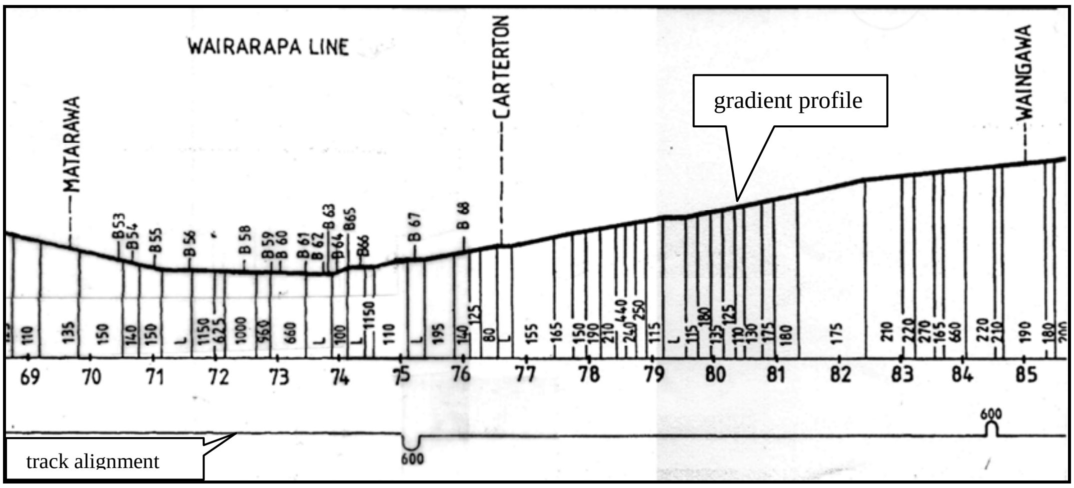


Figure 3
Gradient profile and track alignment detail
Referenced from ONTRACK's North Island gradient profile publication

1.2.2 ONTRACK's code required that tracks in yards and sidings be level where possible. The maximum allowable gradient in yards and sidings was 1 in 200 (0.5%). After the incident ONTRACK re-surveyed the gradient on the main line within station limits at Waingawa at 1 in 198.

1.2.3 When Waingawa was opened, shunting was carried out with wagons separated from the locomotive's air brake system. This nationally established practice was known as loose shunting and mostly occurred on tracks where trains were made up and broken up. Occasionally, uncontrolled movements occurred during shunting operations. To prevent such movements from entering the main line, safety points interlocked with the main line points were routinely installed, such as at Waingawa. When in the normal position, the safety points would route the uncontrolled movement to backshunts where it would be stopped by obstructions placed at the end of the tracks (see Figure 4).

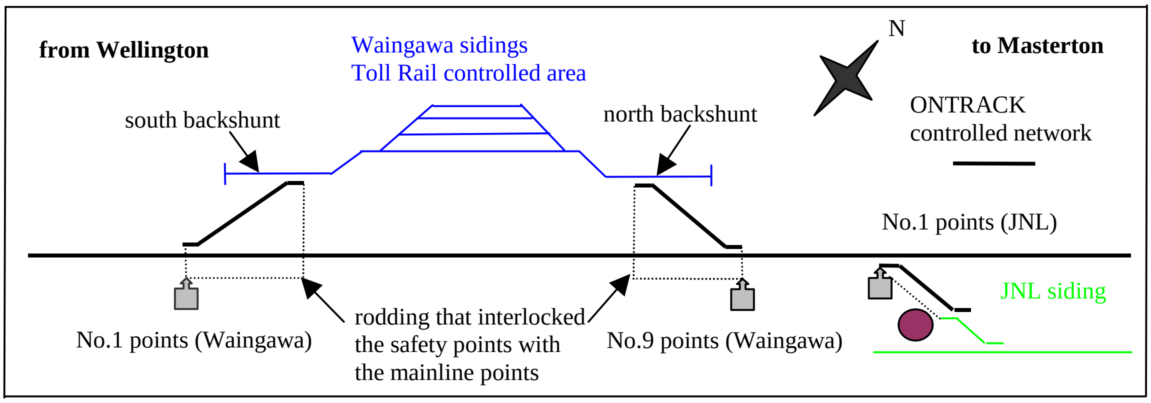


Figure 4
Interlocking arrangements at Waingawa and JNL siding (not to scale)

1.2.4 Beyond yards and sidings, the criterion for installing safety points on the main line was mostly limited to junction stations and other specific locations to provide operational flexibility. The rail industry in New Zealand decided at an early stage in its development to operate main line trains with a continuous air brake system. When such trains were required to shunt from the main line at specific locations, then the shunt was performed with the air pressure being retained, supported by the application of handbrakes. At these locations, safety points were not installed.

1.2.5 JNL siding was opened in 1992. Some time after that, northbound trains began to use the sidings at Waingawa to perform run-around manoeuvres so that wagons could be placed into JNL siding. A national program eliminated loose shunting, replacing it with controlled shunting practices that used air brakes to retard and stop wagons while they remained coupled to locomotives. This program was completed by 2001. Before separation from the locomotives, personnel were required to apply both air brakes and handbrakes to secure the unattended wagons.

1.2.6 Hodders Road level crossing was located at 73.25 km between Carterton and Matarawa and had passive controls with stop signs (see Figure 2). Signage and road markings were in accordance with Transit New Zealand and Land Transport New Zealand standards (dated February 1997) for level crossings with stop sign control and intermediate signs. No previous accidents had occurred at the level crossing.

1.2.7 Hodders Road was no exit beyond the eastern side of the level crossing, and was used only by private and commercial traffic to and from a small number of farms. The railway and road centreline intersected at the crossing on the side approached by the driver's vehicle at an angle of 35^{o}, the acute angle on the passenger side of the vehicle, and the obtuse on the driver's side, thus providing him with a better view of rail traffic approaching from Waingawa.

1.3 Operating systems

1.3.1 Train movements and track occupations on the Wairarapa Line were controlled from the national train control centre in Wellington. Between Wellington and Masterton, the maximum operating speed for express freight trains was 80 kilometres per hour (km/h). Between Featherston and Woodville, track warrant control was the operating system in use.

1.3.2 Radio coverage was not continuous between Upper Hutt and Woodville so did not meet Alternative Train Crewing[2] standards for single-person crewing. Therefore, under Toll Rail's crewing standard, trains operating between Upper Hutt and Woodville required a 2-person crew.

1.3.3 When shunting at Waingawa, train crews could berth on the main line and run the locomotives around in the sidings, as was intended on the day of the incident. Alternatively, they could berth in the sidings and run around in one of the adjacent siding tracks. In either situation, train crews undertaking the shunt used a local radio channel to communicate with each other. The timekeeping of southbound freight Train 633 determined which berthing and shunting method was used (see Figure 5).

1.3.4 On the timetable, Train 644 was scheduled to cross[3] Train 633 at Featherston and subsequently shunt at Waingawa and JNL. The timetable allowed 27 minutes for the shunt. In order to find the average time taken to shunt Train 644 from the main line at Waingawa, an audit of the train control diagrams for a 2-month period involving 22 shunts was conducted. The audit showed the average time taken was 20 minutes, with the shortest being 13 minutes and the longest being 33 minutes.

1.3.5 If Train 633 was running late, train control could advance Train 644 to Waingawa where it was locked into the sidings. When this was completed, train control authorised Train 633 to travel from Masterton to Featherston, but in the meantime Train 644 could undertake its run-around manoeuvre on an adjacent siding track, uninterrupted.

1.3.6 After Train 633 had departed from Waingawa, Train 644 could then be authorised to regain the main line and propel the wagons into JNL siding (see Figure 5).

1.3.7 In the 3-month period prior to the incident, Train 644 crossed Train 633 at Waingawa on 9 occasions and at Featherston on 28 occasions.

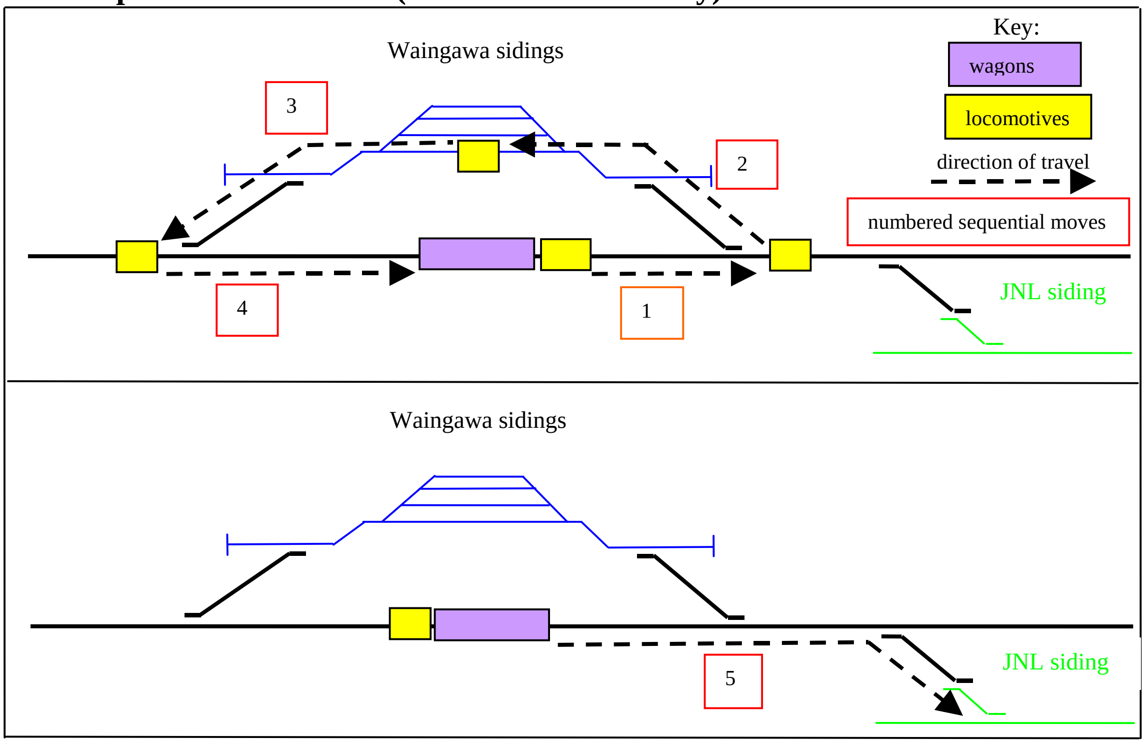
1.3.8 Southbound trains travelling to Wellington did not need to use the sidings at Waingawa when shunting wagons at JNL siding.

1.3.9 A joint operating plan between JNL and Toll NZ Consolidated Limited (Toll Rail) contained instructions for safe shunting procedures in JNL siding.

1.3.10 There were no propelling rights provided in the Working Timetable between Waingawa and JNL sidings, although Toll Rail and ONTRACK codes contained generic instructions for shunting procedures that were applicable at Waingawa. However, propelling rights were granted within the limits of the "work-between" track warrant as was issued on this occasion.

[2] A term used to describe single-person train operations.
[3] The passing of 2 opposing trains on a single rail line.

Shunt plan from main line (as intended on the day)



Shunt plan from sidings when required to cross Train 633

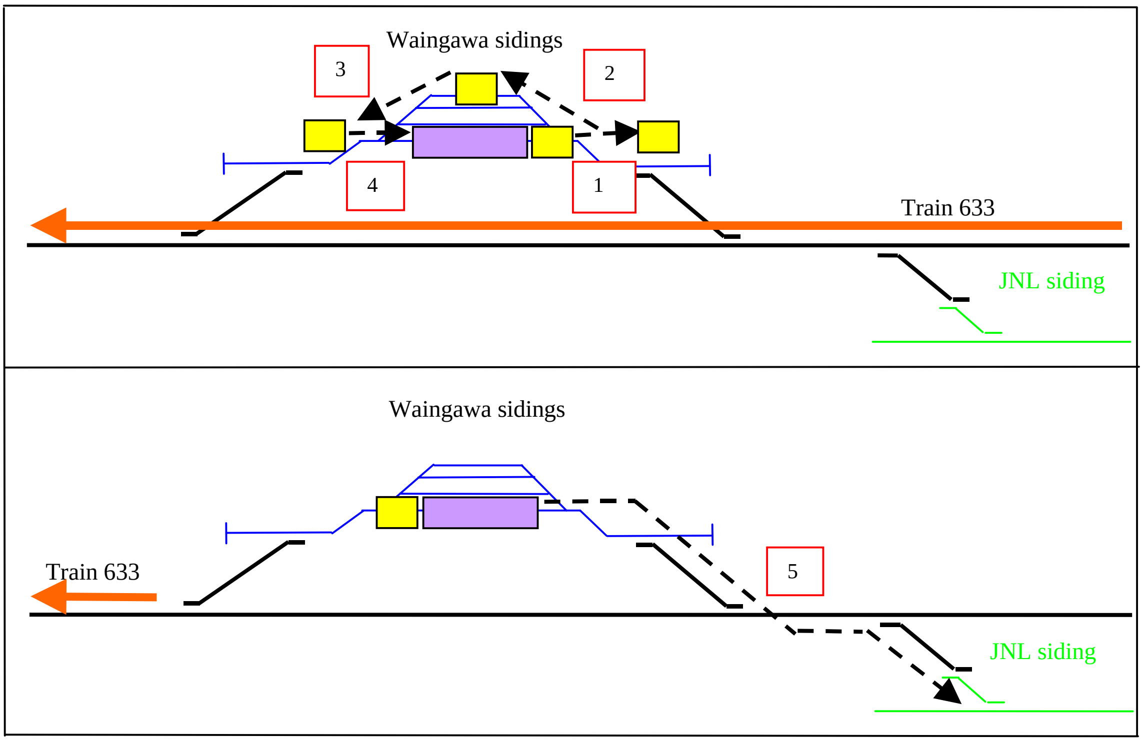


Figure 5
The 2 differing shunt arrangements (not to scale)

1.4 Personnel

Locomotive engineer 1

1.4.1 LE 1 drove Train 644. He was a Grade 1 locomotive engineer with 27 years' experience, mostly based in Wellington. His licence to operate was current. He underwent a yard activity safety observation on 15 December 2004, during which it was recorded that he met requirements for key tasks associated with the connection and the disconnection of vehicles, and application and release of handbrakes.

1.4.2 LE 1 was also qualified in core stationary shunting, having completed a one-off training package some years previously. He was familiar with operations on the Wairarapa Line, including shunting at Waingawa and JNL siding. LE 1 had received Crew Resource Management training on 15 July 2005.

1.4.3 On the day of the incident, LE 1 arrived at work earlier than his book-on time of 0155, gathered his train documentation and was told that Train 644 was ready to depart. He enquired from train control about the running of Train 633, read the train work order and saw that the terminal test[4] had been signed off as complete. He also noted there were no endorsements highlighting any wagon braking defects on the train work order.

1.4.4 Train 644 departed at 0250. On the journey north, LE 1 stopped at Trentham, near Upper Hutt, to allow LE 2 to board the train. After crossing Train 633 at Featherston, LE 1 obtained a work-between track warrant and departed Featherston for Waingawa. The work-between track warrant allowed Train 644 to move in either direction between Featherston and Masterton.

1.4.5 LE 1 said that the trip to Featherston was uneventful, but in several places he had to brake harder than usual, which he deduced was due to the weight of the locomotives being about equal to that of the wagons.

1.4.6 LE 1 said that before arriving at Waingawa, he discussed with LE 2 the plan for the shunt arrangements from the main line, which would incorporate a routine run-around manoeuvre through Waingawa sidings and a propelling movement into JNL siding. He drove the train to Waingawa and he said that he made a minimum train brake application to slow the train.

1.4.7 LE 1 said that, when he realised that he was braking too early, he released the brakes and then a short distance further on, made an almost full service application. He said that he did not bleed off the independent brake[5], as he wanted to keep the train couplings bunched to allow an easy uncoupling of the locomotives from the wagons. When the train had almost stopped, LE 1 said that LE 2 alighted from the cab to undertake the shunt. He said that it was his normal practice to leave the brakes applied until instructed to release them, and that was what he believed he had done on this occasion.

1.4.8 Shortly after the train had stopped, LE 1 said that LE 2 radioed him and instructed him to move the locomotives away from the wagons. He said that he then released the brakes. When he had proceeded beyond No.9 points, he was instructed by LE 2 to stop and then shortly afterwards, to reverse direction. He then drove the locomotives into Waingawa siding.

1.4.9 LE 1 said that he then waited for LE 2 to reset No.9 points and mount the running board of DX 5039, which was now the leading locomotive. He was then instructed to move the locomotives to the south end of Waingawa. Shortly afterwards, LE 2 radioed that he could not see the wagons on the main line. LE 1 said that he noted on the head end display unit that the brake pipe pressure was registering 420 kilopascals (kPa). The motion indicator on the head end display unit registered no movement of the wagons although he was aware that the function might not have been working.

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[4] The detailed examination of the air brake system when a locomotive-hauled train is made up at its origin.

[5] Part of the air brake system that applied brakes to the locomotive(s) only.

1.4.10 LE 1 said that he looked out from his cab window and could just see the wagons in the darkness as they crossed a level crossing at the south end of Waingawa. He added that they did not appear to be going very fast. After the locomotives had re-entered the main line at the south end of Waingawa, he said that he continued to drive from DCP 4605, the now trailing locomotive, up to a speed of about 50 km/h. However, he wasn't comfortable driving from there because he couldn't see very well, so he arranged to change driving ends as the locomotives neared Carterton. LE 2 then took over driving from DX 5039.

1.4.11 When the locomotives arrived at Hodders Road level crossing, LE 1 alighted from his cab and rendered assistance to the injured driver. He then returned to the cab and informed train control of the collision and received authorisation to use the portable radio for further communication.

Locomotive engineer 2

1.4.12 LE 2 was the second person on Train 644. He was a Grade 1 locomotive engineer with 23 years' experience, based variously in Christchurch, Auckland and Wellington. His licence to operate was current. He underwent a yard activity safety observation on 6 January 2005, during which it was recorded that he met requirements for key tasks associated with the connection and the disconnection of vehicles, and the application and release of handbrakes.

1.4.13 LE 2 was also qualified in core stationary shunting, having completed a one-off training package some years previously. He was familiar with operations on the Wairarapa Line, including shunting at Waingawa and JNL siding. LE 2 had received Crew Resource Management training on 15 November 2004.

1.4.14 LE 2 boarded Train 644 at Trentham and later said that he appraised himself of the paperwork on the train. After the track warrant was issued from Featherston, LE 2 said he discussed and agreed with LE 1 on the shunt plan for Waingawa.

1.4.15 LE 2 said that before he alighted at Waingawa, he extracted the portable radio from its cradle and tested it with LE 1. He also obtained LE 1's track warrant key to use in conjunction with his own key to facilitate the simultaneous opening of the points at Waingawa and JNL siding. LE 2 said that he alighted from the locomotive as the train was slowing to a stop and went straight to the couplings between DX 5039 and the lead wagon.

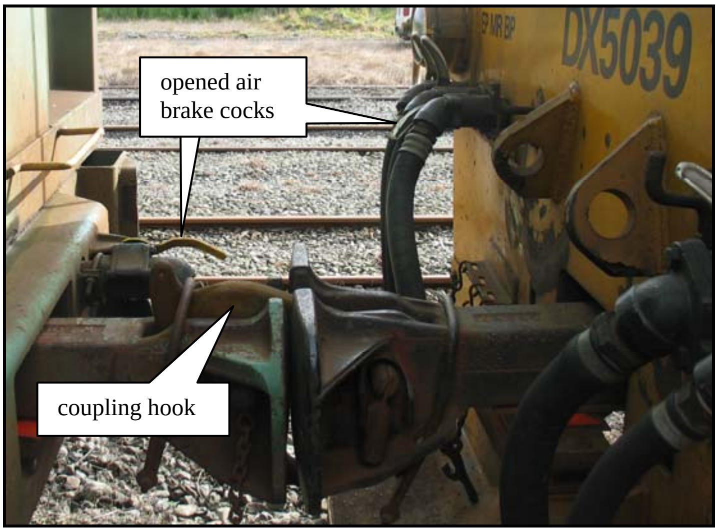

Figure 6
Coupling between DX 5039 and lead wagon

1.4.16 LE 2 said that he closed the brake cocks on the locomotive and wagon simultaneously, then lifted the coupling hook as the train was "solid and the brakes were applied" (see Figure 6). LE 2 also said that he did not need an ease up[6] to uncouple the train. He then radioed LE 1 to move the locomotives ahead while he walked alongside.

1.4.17 After the locomotives had entered the siding at Waingawa, LE 2 boarded the running board at the front of the then leading DX 5039. He said that he then saw by the headlight on the locomotive that the wagons "had moved, but it looked like they were going really slowly as if they had almost come to a stop". When the locomotives arrived at the south end of Waingawa, LE 2 said that he reversed No.1 points and instructed LE 1 to re-enter the main line.

1.4.18 LE 2 remounted the running board at the front of DX 5039 and said that he radioed instructions to LE 1 driving from DCP 4605 to not travel too fast as he thought the wagons might be stopped around a corner due to air brake leakage. LE 2 said that on 2 occasions, he thought he could see the wagons in the distance. When they were approaching Carterton, LE 2 arranged with LE 1 to cut in[7] and drive the locomotives from DX 5039.

1.4.19 LE 2 said that after restarting the locomotives and when he had rounded a curve beyond Carterton, he "noticed car headlights up in the air", and when he drove over Hodders Road level crossing saw that a motor vehicle had been hit. He stopped the locomotives beyond the level crossing, reversed closer to the level crossing and together with LE 1 went to the assistance of the injured driver.

The injured driver

1.4.20 The injured driver was a contractor who delivered newspapers throughout the southern Wairarapa area. On 6 days a week, he started work at 0215 from his home in Carterton and generally finished his deliveries by about 0530.

1.4.21 The driver later said that he followed a set routine that included making about 27 movements over several level crossings each morning, and he occasionally saw the early morning freight train heading to Masterton while on his rounds.

1.4.22 The driver said that on the morning of the accident, he had not seen the freight train. His deliveries on Hodders Road were the last to be done and he said that he had stopped, looked in both directions, north and south, before travelling each way across the level crossing, which was his normal practice.

1.4.23 The driver said that he had not seen the runaway wagons before they struck his vehicle. He later said that he had not seen the red flashing light of the train end monitor (TEM).

The farmer

1.4.24 The farmer lived adjacent to Hodders Road level crossing. He said that he was able to hear the passing road and rail traffic.

1.4.25 The farmer said that, while still in bed on the morning of the incident, he heard the vehicle delivering the newspapers drive away from his address and over the level crossing to the no exit end of Hodders Road. He said that, shortly afterwards, he heard what sounded like an approaching train, quickly followed by the vehicle returning. The next thing he said he heard was an "almighty noise that sounded like a whack, just one noise".

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[6] A small reverse movement on the locomotive(s) to free up a coupling hook for releasing.
[7] Transfer control from one locomotive to another while in multiple operation.

1.4.26 The farmer said that he jumped out of bed, and from his bedroom window saw the vehicle's headlights. He grabbed a torch and went outside to see what had happened. He said that while making his way to the level crossing, he heard the last of the wagons travelling past at what he thought was "normal speed for a freight train". He went to the vehicle, but when he called out to the driver, got no response. He then called out to his wife to contact the emergency services.

1.4.27 The farmer said that after a short period, he saw the headlights of an approaching locomotive and shone his torch in its direction to attract the attention of the locomotive engineer. The locomotives passed over the level crossing, stopped and reversed and stopped closer to the level crossing.

1.4.28 When the locomotive engineers had alighted, the farmer told them what had happened. The emergency services arrived shortly afterwards.

1.5 Train 644

Crew rostering

1.5.1 Two locomotive engineers were rostered to crew Train 644. Toll Rail allowed the locomotive engineers to decide between themselves who would drive and who would occupy the second person position. The crewing of 2 locomotive engineers was required because of incomplete radio coverage, but also fulfilled a need to have sufficient personnel at Masterton each weekday morning to drive separate passenger trains to Wellington.

Consist

1.5.2 Train 644 consisted of lead locomotive DCP 4605 and trail locomotive DX 5039 in multiple, hauling 9 empty ZG wagons. With the locomotives working in multiple, the air compressors on both locomotives were connected to a brake pipe, providing air pressure throughout the train.

1.5.3 Within a train consist there was slack movement and the amount of movement depended on the length of the train. As Train 644 was 181 m long, there was about 3.9 m of total coupling slack movement, made up of free slack and draft gear slack, between the front and rear ends of the train.

DCP 4605

1.5.4 After the incident, the following repairs were carried out on DCP 4605:

- the defective brake pipe and brake cylinder air gauges in the cab were replaced
- a small brake pipe air leak was found in one of the brake pipe headstock cocks on the short hood end and repaired
- the engine governor was replaced (a longstanding booking that had no effect on the incident)
- a dynamic brake fault was repaired (again a longstanding booking that had no effect on the incident).

Contractual commitments between Toll Rail and Alstom Transport New Zealand Limited (Alstom)[8], scheduling and resourcing issues within Alstom and delays receiving spare parts resulted in DCP 4605 being out of service for one month after the incident.

1.5.5 The defective brake pipe air pressure gauge in the cab was indicating 30 kPa higher than actual brake pipe pressure. The brake cylinder pressure gauge was indicating 20 kPa higher than actual pressure. Both gauges were non-compliant with Mechanical Code M 9103 limits of +/- 15 kPa for brake pipe and +/- 10 kPa for brake cylinder, so were replaced.

[8] Alstom was contracted to undertake the inspection and maintenance of rolling stock to standards set by Toll Rail.

1.5.6 The leak of 20 kPa per minute was 5 kPa per minute in excess of Mechanical Code M 9310 limits. The seals in these cocks tended to wear with use, resulting in small leaks. The locomotive brake pipe feed valve periodically compensated for the air loss so that braking performance on the train was not compromised. When air pressure in the equalising reservoir dropped by between 7 and 15 kPa the locomotive's air compressors automatically actuated, giving a visible signal to the LE on a flow meter in the cab.

1.5.7 DCP 4605 had its most recent full brake code test on 18 May 2004 during a C check performed by Tranz Scenic[9] at Te Rapa. An operating efficiency test was carried out during an A check on 21 April 2005 by Alstom for Toll Rail at Westfield. At the time of the incident, DCP 4605 had 21 000 km left to run until its next full brake code test.

1.5.8 A Loco 54D book was provided in the cab of every locomotive so locomotive engineers could record details of reportable and other faults encountered while driving trains. The Loco 54D book from DCP 4605 contained no entries detailing repairs or adjustments required to the air brake system, including the gauges inside the cab and brake control valves, in the period between 1 January 2005 and the date of the incident.

DX 5039

1.5.9 No repairs were required on the brake system on DX 5039 after the incident. The event recorder data showed that braking air pressure was constantly maintained in the train pipe, indicating that despite the leaks in DCP 4605 and on the wagons, the air compressor on DX 5039, together with DCP 4605, was sufficient to maintain the required pressure.

ZG wagons

1.5.10 The ZG class of wagon was a high volume "plug[10]" wagon, on a modified UK wagon underframe. The wagon livery was creamy white door sides with light green ends (see Figure 7). The ZG wagon had an average tare weight of 21 250 kg.

Figure 7
A rake of ZG wagons

1.5.11 The wagons were equipped with separate air brake systems to each bogie, negating the requirement for lengthy brake rigging between the bogies. Each wagon had a single handbrake that applied the brakes to one bogie only.

1.5.12 None of the 9 ZG wagons was in a "bad order" status at the time of the incident. All the wagons' code B and C check requirements were current.

[9] Independent operator of long-distance passenger trains before Toll Rail repurchased business.
[10] The sliding canopy door arrangement that allowed full access to any part of the wagon during loading/unloading.

1.5.13 To estimate the time the wagons took, from a standing start, to travel the first 400 m to the south end of Waingawa, the following formula was used:

$s = ut + \frac{1}{2}at^2$ – where *s* was distance travelled (400 m), *u* was initial velocity which in this instance was zero, *t* was time and *a* was acceleration.

1.5.14 To estimate the acceleration of the wagons down the gradient, the following formula was used:

$a = g.x - g.f$

where g was the acceleration due to gravity (9.8 m per second squared)
x was the location gradient rounded to 1 in 200
f was the equivalent gradient for friction (the friction of a wagon wheel on rail was assumed to be equivalent to a gradient of 1 in 400).

1.5.15 To estimate the speed the rake of wagons had reached after they had travelled 400 m, the following formula was used:

$v^2 = u^2 + 2as$ – where *v* was speed.

1.5.16 The above formulae were used with the premise that the rake moved from a standing start with no braking applied. No allowance was made for any subsequent braking on the wagons within the first 400 m of the runaway.

TEM/head end display unit

1.5.17 A TEM was mounted on the rear buffer of the last wagon on Train 644 with a hose connection to the air brake to monitor brake pressure. A short-range radio transmitter in the TEM relayed this information to a head end display unit, located in the cab of DCP 4605 (see Figure 8).

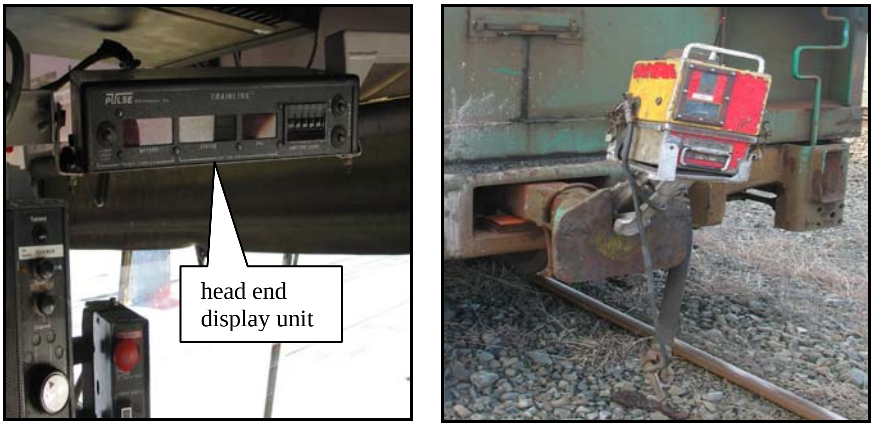

Figure 8
Head end display unit left, and TEM right

1.5.18 Amongst other things, the TEM transmitted the following information to the head end display unit at regular intervals and upon a change in status:

- brake pipe pressure in 10 kPa intervals
- last vehicle moving/stopped.

Notifications of changes in brake pipe pressure of 10 kPa were transmitted at regular intervals. A change in pressure of 20 kPa was transmitted immediately.

1.5.19 The red light on the TEM was flashing when track staff arrived on site at about 0630 but stopped flashing, as designed, at sunrise. The TEM was slightly damaged, but still functioning when examined on site at 0900 by a service manager from Alstom.

1.5.20 The head end display unit on DCP 4605 was working when its functions were exercised and checked during a terminal brake test before Train 644 left Wellington. During the test, the head end display unit indication of the end of train brake pipe response to the application and release of air brakes, was used to determine that the air brakes are correctly applying and releasing.

Locomotive event recorder

1.5.21 The locomotive event recorder from DX 5039 was supplied for analysis, rather than from DCP 4605. DX 5039 was equipped with a computer-based system that retained detailed short-term data for a much longer period. During the movement of the 2 locomotives from Waingawa to Hodders Road level crossing, the non-computerised short-term data on DCP 4605 was overwritten and the available long-term data could not provide the same level of detail as extracted from DX 5039.

1.5.22 Data downloaded from the event recorder from the time that Train 644 slowed to a stop and then moved off from Waingawa revealed the following:

- at 05:03:55, the locomotive throttle was placed in the idle position while travelling at about 65 km/h
- at 05:04:25, minimum service brake application was initiated
- between 05:03:55 and 05:05:24, the train coasted and speed gradually decreased with continued minimum brake application
- at 05:05:24, the train was travelling at 16 km/h and the brake pipe pressure was 465 kPa and service brake application was initiated
- at 05:05:30, the speed of the train had reduced to 6 km/h and brake pipe pressure had reduced to 377 kPa. Brake pressure was now at its lowest reading and started to increase
- at 05:05:34, the train stopped and the brake pipe pressure had increased to 442 kPa
- between 05:05:34 and 05:05:55, while the locomotives were stationary, brake pipe and brake cylinder pressure was not monitored
- at 05:05:55, the locomotives moved away from the wagons and the brake pipe pressure on the locomotives was registering 550 kPa.

1.6 Westinghouse air brake system

1.6.1 The Westinghouse air brake system was a standard, fail-safe train brake used by railways all over the world. It was based on the simple physical properties of compressed air.

1.6.2 A moving train contains energy, known as kinetic energy, which needs to be removed from the train to enable it to stop. The simplest way of doing this was to convert the energy into heat by applying a contact material to the rotating wheels. The material creates friction and converts the kinetic energy into heat. The wheels slow down and the train eventually stops. The material used for braking was normally in the form of a block.

1.6.3 The braking system uses compressed air as the force to push the blocks onto the wheel treads. The compressed air is transmitted along the train through a brake pipe. Changing the level of air pressure in the pipe causes a change in the state of the brake on each vehicle. It can apply the brake, release it or hold it on after a partial application (see Figure 9).

1.6.4 At the ends of each vehicle, brake (angle) cocks are provided to allow the ends of the brake pipe hoses to be sealed when a vehicle is uncoupled. The cocks prevent the air being lost from the brake pipe when vehicles are uncoupled from the train.

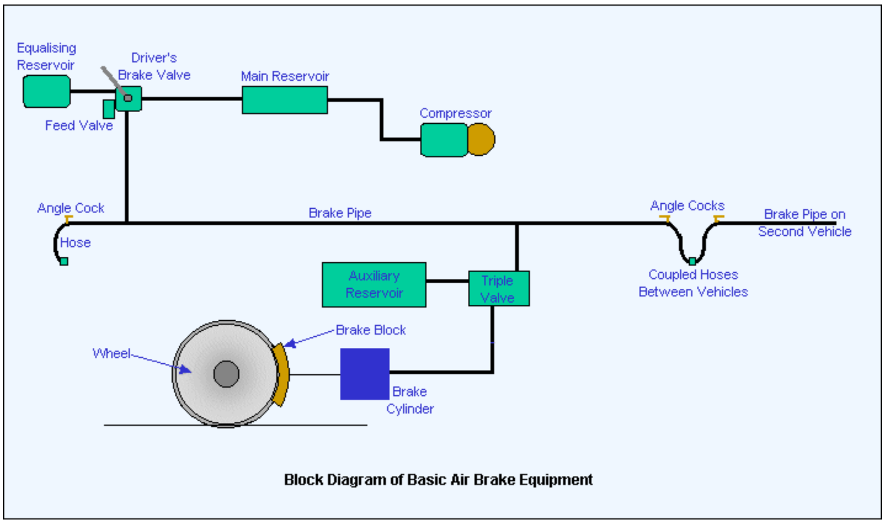

Figure 9
Diagram of basic air brake equipment

1.6.5 When a locomotive engineer applied the brake, air pressure in the brake pipe escaped. The loss of pressure was detected in the triple valve on each coupled vehicle. When the pressure on the brake pipe side of the triple valve fell, the auxiliary reservoir pressure on the other side pushed a slide valve over, opening a connection between the auxiliary reservoir and the brake cylinder. Auxiliary reservoir air was now fed through into the brake cylinder, forcing the piston to move against the spring pressure and causing the brake blocks to be applied to the wheels. Air would continue to pass from the auxiliary reservoir to the brake cylinder until the pressure in both was equal.

1.6.6 Over a period of time, the air pressure from the auxiliary reservoir would bleed off and the brakes will release. Therefore, it was important that the handbrake was also applied if a vehicle or vehicles was to be isolated for any length of time.

1.6.7 The brake pipe was connected between vehicles by flexible hoses, which can be uncoupled to allow vehicles to be separated. In order to initiate brake application, a reduction in air pressure must occur. Brake pipe pressure reduction could be achieved by the following actions:

- a controlled release by the locomotive engineer between minimum and full service applications
- a controlled, but, rapid propagated release by the locomotive engineer moving the brake handle to the emergency position
- a large uncontrolled rapid reduction caused by a burst hose, hose couplings pulled apart, ruptured train pipe or other mishap.

Minor leaks, even if larger than the permitted Code limits, were unable to initiate brake applications because the train pipe was replenished with air pressure from the locomotive equalizing reservoirs. The equalising reservoirs were replenished with compressed air from the main reservoirs, which in turn were replenished by powerful automatically actuated compressors.

1.6.8 When a locomotive engineer released the brake, air pressure in the brake pipe was replenished from the main reservoir on the locomotive. The change in pressure was detected by the triple valves and the reverse process applied, thus releasing the brakes from the wheels. When a brake release was initiated and the increase in air pressure in the brake pipe was greater than 21 kPa, the flow of air from the brake pipe to the auxiliary reservoir was slowed by a choke within the triple valve. This helped the rising air pressure to propagate through the coupled vehicles to the TEM as quickly as possible so the brakes were released along the length of the train in unison.

1.6.9 When the air pressure in the train pipe fell below the air pressure in a wagon's auxiliary reservoir, its triple valve actuated to allow air to flow from the auxiliary reservoir into the brake cylinder. The brake cylinder piston though does not begin to move to apply the brakes until the cylinder pressure was sufficient to overcome brake linkage friction and the resistance of the brake cylinder spring. The brake cylinder spring was sufficiently strong to ensure that when the brakes were released the brake blocks retracted clear of the wheel treads.

1.6.10 A minimum brake application was just sufficient to overcome resistance from the brake linkage friction and from the spring and ensure that all of the brake blocks on the wagons in a train began to exert a braking force on the wheel treads. As pressure continued to fall in the train pipe, the triple valve allowed more auxiliary reservoir air to enter the brake cylinder, increasing the air pressure on the piston and thus increasing the force of the brake block/wheel tread contact. When the train pipe air pressure and auxiliary reservoir air pressure had equalised, no further air pressure was applied to the brake cylinder. When a full service brake application occurred, the brake pipe air pressure was reduced in a controlled manner to about 390 kPa, and as a consequence, the brake cylinder air pressure and hence the braking effort, was increased to the maximum possible.

1.6.11 The minimum brake cylinder pressure to ensure all brake blocks were in contact was a release of about 75 kPa, and the maximum (determined largely by brake rigging slack adjustment) was a reduction to about 390 kPa, though these figures could vary from wagon to wagon within limits prescribed by maintenance codes. Permissible air leakage standards in the codes were well below the capacities of locomotive air compressors and main air reservoirs to compensate, and train pipe leakage rates would have to be very large to reduce air pressure in the train pipe sufficiently to initiate a brake application, for example, as in a burst hose situation.

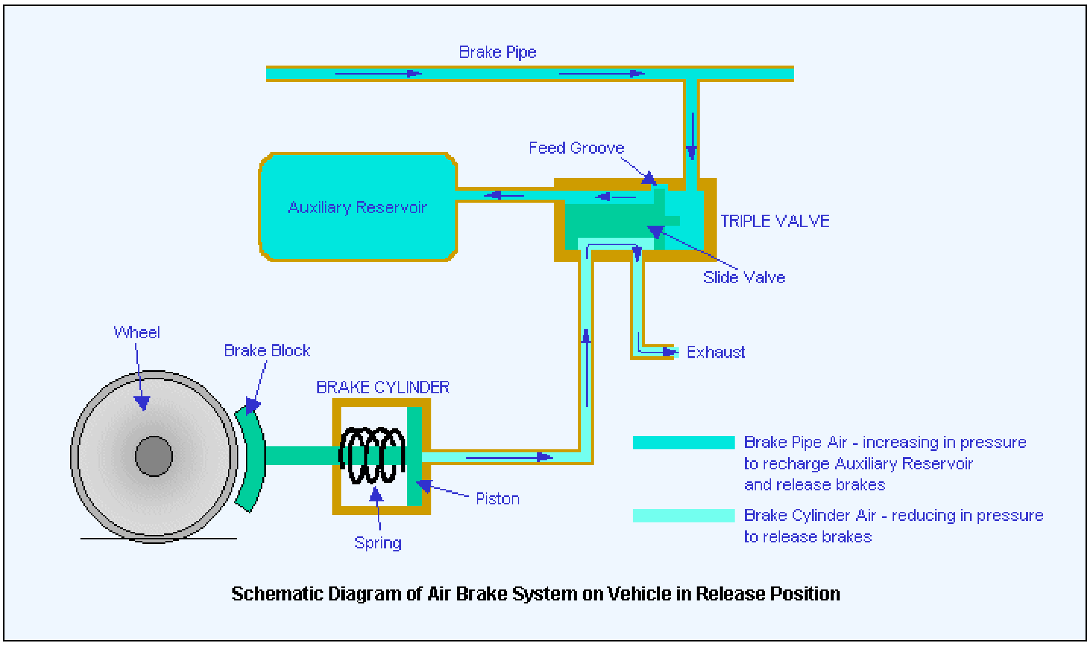

Figure 10
Diagram of air brake system in release position

1.6.12 The purpose of the brake (angle) cock was to open or close the air supply through the brake pipe between 2 rail vehicles, usually to enable coupling and uncoupling.

1.6.13 The handle rotated a round plug with a hole through it between 2 sealing rings. When the round plug was rotated to line up the hole with the brake pipe, air flowed from the locomotive, and/or from a locomotive-coupled wagon to another wagon. When the handle was moved 90°, air would not flow through the brake pipe but a vent allowed air pressure to escape from the coupling hose (see Figure 11).

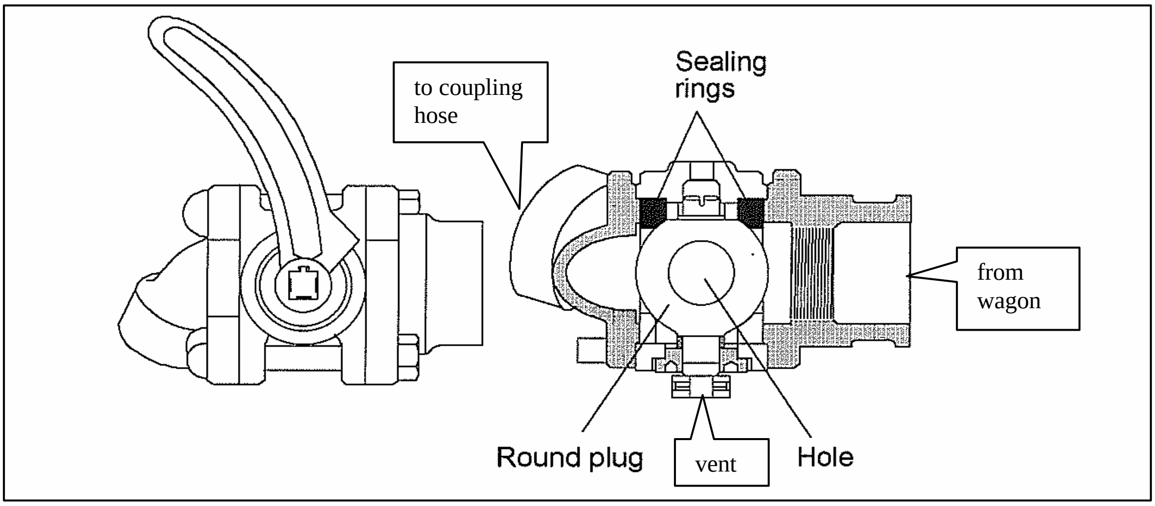

Figure 11
Brake cock detail

1.7 Post-incident inspection of the runaway wagons

Initial inspection at 70.50 km

1.7.1 A service manager who was based in Palmerston North and had about 30 years' experience in wagon and locomotive maintenance, travelled by road and arrived on site at 70.50 km at about 0900. En route, he drove past the locomotives still sitting at Hodders Road level crossing.

1.7.2 The service manager inspected the general condition of the wagons and the TEM. He said that without disturbing any equipment on the wagons, he and a colleague walked the length of the rake of wagons, starting at the TEM on ZG 265. They measured the amount of piston travel on each air brake cylinder, and the positions of the handbrake and brake cocks on each wagon. They found no handbrakes applied and that the brake cock on the northern end of ZG 309, where it had been coupled to DX 5039, was closed. All remaining brake cocks were open and brake hoses connected, including the connection of the brake hose to the TEM.

1.7.3 Using a steel bar, they tried to move each brake block to gauge the amount of contact force on the wheel tread. From this they found the air brakes on 4 of the 9 wagons were not applied, as the brake blocks could be moved sideways across the wheel tread and there was no piston travel. Using the same method they found the brakes on the other 5 wagons were applied to varying degrees with differing amounts of piston travel. On 3 of these 5 wagons, the brake blocks could not be moved as they were in firm contact with the wheel treads. On the other 2 wagons, the brake blocks could be moved with a small amount of sideways movement.

1.7.4 The following table shows the amount of piston travel at each piston and the corresponding amount of brake application on the 9 wagons:

Wagon	Piston travel at handbrake end	Piston travel at non-handbrake end	Amount of braking application
ZG 265	nil	nil	brakes released both ends
ZG 471	nil	nil	brakes released both ends
ZG 321	100 mm	90 mm	brakes applied both ends
ZG 246	nil	nil	brakes released both ends
ZG 119	nil	nil	brakes released both ends
ZG 85	68 mm	80 mm	brakes applied both ends but negligible brake force
ZG 125	83 mm	95 mm	brakes applied both ends
ZG 281	52 mm	83 mm	brakes applied both ends but negligible brake force
ZG 309	95 mm	94 mm	brakes applied both ends

1.7.5 Toll Rail's wagon brake manual stipulated that for maximum brake block pressure on ZG wagons, a reduction of air pressure to 400 kPa in the brake pipe must be achieved. Adjustments to maintain brake block force were achieved by altering the length of the slack adjuster control rod located near the brake cylinder.

1.7.6 When the service manager and his colleague reached ZG 309 they repeated the process in the reverse direction. When they reached the TEM, the service manager pressed the indicator button, confirmed its operational status and saw that the air brake pressure read zero. He opened the brake cock and confirmed that no air pressure had been retained in the train pipe.

1.7.7 The service manager arranged for the locomotives to be reattached to the wagons, the air brakes to be reapplied and, after being recharged to 550 kPa, a terminal brake test performed and results recorded. Air leaks in brake hoses were found on 2 of the wagons. The gauge in the locomotive cab showed the combined air loss to be about 10 kPa per minute.

1.7.8 During the conduct of the terminal brake test the brakes on all 9 wagons applied and released correctly. After the mechanical inspection was completed, the train returned to Waingawa where it was stabled in the sidings for a field examination.

Field examination at Waingawa

1.7.9 Following an established compliance test procedure developed for individual wagons, the service manager said that he and a colleague performed a number of brake tests on the coupled wagons. After each brake application, they moved from wagon to wagon and hand tested the brake blocks by shaking them to gauge the amount of tightness against the wheel treads. The service manager also said that the air leaks that were noticed at 70.50 km were corrected by uncoupling and re-coupling the air brake hoses.

1.7.10 The field examination incorporated 4 separate tests with the following results:

Test 1: The brake pipe pressure was charged to 550 kPa and the brake cock on the lead wagon closed. Then staff walked the length of the train to the TEM where the pressure was read as 510 kPa. Eleven minutes later the TEM showed 450 kPa and the brakes had not applied. The brake cock, connected to the TEM, was opened and all the brakes immediately applied.

Test 2: The brake pipe pressure was charged to 550 kPa and the TEM showed 530 kPa. Then the brake pressure was reduced leaving 420 kPa, as shown on the gauge in DCP 4605. All wagon brakes had applied and after the brake cock on the lead wagon was closed, brake cylinder travel on all the wagons was measured. After 34 minutes, the wagon brakes remained applied with 73 kPa remaining in the brake pipe. Additionally all the handbrakes were tested and found to work satisfactorily.

Test 3: The brake pipe pressure charged to 550 kPa and, after a 75 kPa pressure reduction, the brake cock on the lead wagon was closed. The gauge in DCP 4605 showed 475 kPa and by the time staff walked the length of the train to the TEM, the pressure there was showing 410 kPa. After 33 minutes, piston travel on all the wagons was checked and all were found to have extended to various lengths.

Test 4: The final test was to determine the effects of different sequential closings of the brake cocks between DX 5039 and the lead wagon, the same place where LE 2 had separated the wagons from the locomotives. This involved the brake pipe pressure being fully charged at 550 kPa but with no brake application in the locomotive cab. The results were:

	Action	**Result**
A	close locomotive cock first, then wagon cock	after 6 seconds brakes applied on all wagons
B	close wagon cock first, then locomotive	no brakes applied
C	close both cocks simultaneously	no brakes applied

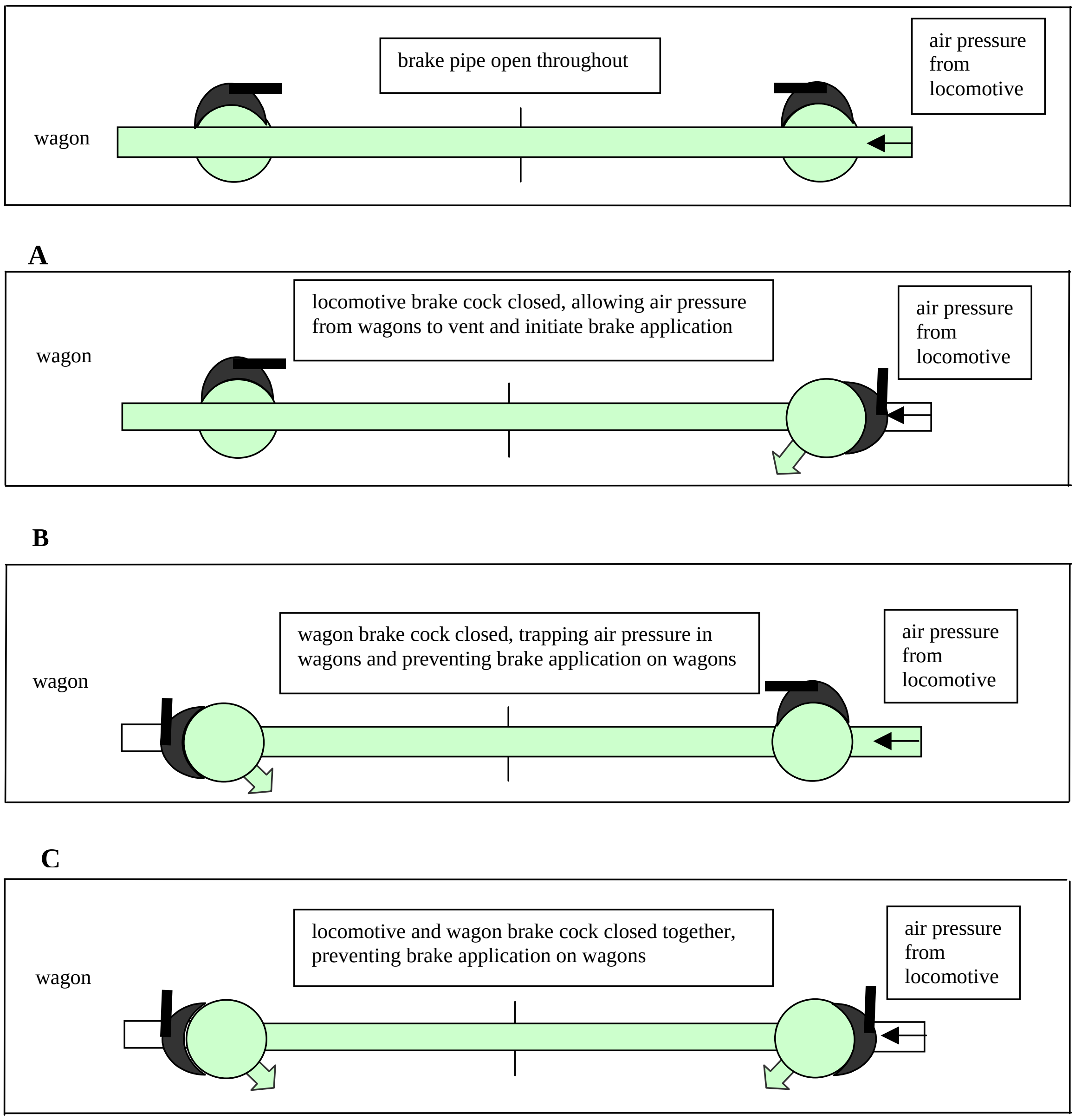

Figure 12
Schematic sequential air braking actions

1.7.11 At the completion of the examination at Waingawa, the service manager said he gave permission for the train to return to Wellington, where he and a team of Toll Rail engineers performed a detailed individual compliance check on each wagon.

Depot examination at Wellington

1.7.12 Toll Rail mechanical engineers carried out a series of tests with Alstom mechanical personnel and with the Commission's investigator in attendance, which expanded upon the tests that had been performed at Waingawa. A DX class locomotive was placed at one end of the rake of wagons and the air brake was coupled. Specialised equipment measured the amount of force the brake applied to the brake blocks with differing reductions in air pressure. After a brake reduction to 510 kPa, the locomotive was attached to the rake of wagons and an attempt was made to pull the wagons. There was no sign of movement in the wagons when power was applied up to notch 4.

1.7.13 All wagons passed the minimum requirement for the brakes to remain applied for at least 10 minutes following a full service brake application on a locomotive.

1.7.14 The tests found no faults that would have prevented the brakes operating correctly, even though some of the brake hoses on the 9 ZG wagons exhibited various levels of leakage at different locations. However, the air leak rate that was found during the testing was not sufficient to apply the brakes. The tests also concluded that:

- had the handbrakes on 3 wagons been applied with no air pressure, the wagons would not have moved
- had only one handbrake been applied in addition to a full service air brake application, then this would have been sufficient to hold all 9 wagons, even when the air brakes had bled off and became ineffective. In this instance the handbrake application on top of an air brake application provided a greater leverage of force, as the brake blocks were already firm against the wheel treads
- had an air brake application been made, it would have been more than adequate to hold the rake of wagons at Waingawa and would have not bled off for at least 30 minutes.

1.7.15 The wagons were returned to service on 30 July 2005.

1.8 Shunting/driving procedures

1.8.1 Tranz Rail's[11] Rail Operating Rules and Procedures applicable at the time of the incident stated in part:

Signals Rules

> **69(a) Train End Monitor**: To show red to the rear, displayed at the rear of the last vehicle; provided for the purpose of indicating to the staff that the train is complete.
>
> **(b) Head Lamp**: To show a White light forward displayed at the front of the train:
>
> (i) Head lamps must be illuminated by day and night on all trains travelling on the main line.

Operating Rules:

> **129. Shunting**
>
> **(a) Care in shunting**
>
> Every possible care must be exercised when shunting to minimise risk of accident to staff and avoid collisions, derailments, or other mishaps.

Air Brake Rules:

> **803 Securing Train before Locomotives or Wagons Detached**
>
> (a) Air brakes must not be relied upon to secure a train or any portion of a train when the locomotive is detached.
>
> (b) Before the locomotive, either with or without vehicles attached, is detached from a train, the Locomotive Engineer must apply the air brakes on the train by making a reduction of at least 75 kPa in brake pipe pressure. Staff detaching the locomotive must ensure that the air brakes are applied on the train before closing the air brake coupling cocks at the point of detachment and that sufficient handbrakes have been applied.

[11] The predecessor to Toll Rail and ONTRACK.

1.8.2 Tranz Rail's Rail Operating Code Section 1 General Instructions applicable at the time of the incident stated in part:

> **Induction, Certification & Monitoring of Employee Competence**
>
> **5.2.2 Yard Operating**
> **Core Stationary Shunting Duties**
>
> Provides training and certification for elementary ground based shunt operations. Typical of the groups covered by this training and certification are
>
> - Second Persons
>
> This training does not have an element of on the job training attached to it. Authorised trainers or suitably qualified nominees when conducting such sessions will clearly identify the nature of the operation at any given locality and provide sufficient training time before authorising a full and final certification.

1.8.3 Tranz Rail's Rail Operating Code Section 4 Operating Instructions for Locomotive Running Staff applicable at the time of the incident stated in part:

> **Train handling**
>
> **12.11.7 Stopping on Ascending Grade-Throttle Reduction**
>
> The throttle should be gradually reduced to "idle" and the train allowed to slow down under natural resistance.
>
> When nearing the point of a stop, make a minimum reduction to complete the stop and prevent train slack from running out. Increase the brake pipe reduction to 100 kPa after stopping and before initiating the brake release.
>
> The locomotive independent brakes are applied immediately the train comes to a stop.

1.8.4 Personnel trained in core stationary shunting were able to conduct a full range of shunting activities as necessary to move and assemble rail vehicles under all conditions. The training manual stated that shunting of rail vehicles was a collaborative effort between the locomotive engineer of the train (LE 1) and the ground shunt crew, who in this instance was LE 2.

1.8.5 The training syllabus specified the following trainers' actions to be demonstrated and participants' actions to be observed when separating locomotives from a rake of wagons. The training was recorded on a Staff 23 form and filed on the participants' training file. The training procedures were not documented as task instructions in any manuals.

- Stop train using both train brake and independent brake.
- Apply sufficient handbrakes on the wagon(s).
- Close brake cock on vehicle closest to locomotive(s) (refer Figure 12).
- Close brake cock on adjacent wagon.
- If necessary, ease front portion back to free coupling hook, lift bridle, then lift hook.
- Manually separate brake hoses.
- Hold hose and re-open brake cock on adjacent wagon to exhaust all air pressure remaining in brake pipe, leave brake cock open.
- Locomotive(s) can now move away.

1.8.6 This process would apply full air braking pressure to the rake of separated wagons, in addition to the number of handbrakes considered to be "sufficient".

1.9 Locomotive engineers' actions on the day

1.9.1 In stopping and shunting Train 644 at Waingawa on the day of the incident the following actions occurred:

- train slowed using train brakes
- train brakes released before train stopped
- no handbrakes applied on the wagons
- brakes cocks on locomotive and wagon closed together
- locomotives moved away.

1.9.2 Once the train brake had been released, the air pressure in the train pipe started to replenish and the event recorder showed that the pressure increased from 377 kPa to 442 kPa. On separation, the wagon brake cock was closed, stopping the replenishment. Subsequent testing of the wagons showed that the increased pressure was sufficient to have released the air brakes on the wagons.

1.10 Train runaway procedures

1.10.1 ONTRACK's Rail Operating Procedures Section 10.1, Operating Instructions for Train Control stated:

> Staff controlling signals are generally aware that some automatic warning devices at level crossings work in conjunction with a signal controlling entry of a train into the section ahead. In the case of a runaway rail vehicle such alarms would not operate in sufficient time to warn road users unless the signal ahead of the runaway was at "Clear Proceed".
>
> In the event of such a situation, signals should where possible, be cleared in order that level crossing warning devices be activated and may operate correctly.

1.11 Previous similar rail occurrence investigated by the Commission

Occurrence report 04-110, wagon runaway, Onehunga Branch, 5 April 2004

1.11.1 On Monday 5 April 2004, a wagon ran away for about 2 km down a descending gradient on the Onehunga Branch before it stopped of its own accord. The wagon had been detached from a shunt locomotive during shunting operations and was probably left unrestrained without the application of a handbrake or the air brakes.

1.11.2 A post-incident examination of the wagon determined that both the handbrake and air brake systems were working satisfactorily and had either been applied before the wagon had been detached from the shunt locomotive, the wagon would probably not have moved.

1.12 Comparative instructions for securing unattended wagons

1.12.1 In order to compare New Zealand instructions for the securing of unattended wagons with an overseas practice, the Commission approached Canadian Pacific Railroad (CPR), which was based in Calgary, Alberta, Canada. The Railroad provided freight transport over a network of 13 800 miles (22 080 km) in Canada and the United States of America. The Canadian railroad's network, although much larger, had similar characteristics to those of New Zealand.

1.12.2 CPR supplied a copy of its General Operation Instruction, Section 14, Hand Brakes – Leaving Locomotives, Cars [wagons] and Trains. The documented instruction, shown in full in the Appendix, covered the subject of handbrake and air brake applications when locomotives, wagons and trains were left unattended. All the information relevant to the application of handbrakes and air brakes under any circumstance was contained in one document.

1.12.3 The contents of the document referring to the securing of unattended wagons, that could apply to operations similar to those being undertaken at Waingawa, included:

In the following instructions, a car [wagon] or locomotive is considered "unattended" when no crewmember is close enough to the equipment to take safe and effective action to control its movement.

1.0 Hand Brake policy

IMPORTANT: Crewmembers are responsible to inquire and confirm with each other that equipment is left in accordance with these instructions.

1.1 Leaving railway equipment unattended; the following instructions apply:
When leaving railway equipment, the **MINIMUM** number of hand brakes must be applied as indicated in the following chart. Additional hand brakes may be required; factors, which must be considered, are:

- total number of cars [wagons]
- cars [wagons] loaded or empty
- track grade
- hand brake force applied

HAND BRAKE CHART			
Caution: Chart indicates the **MINIMUM** number of hand brakes to be applied			
cars [wagons]	hand brakes	cars [wagons]	hand brakes
1 – 2	**1**	60 – 69	**8**
3 – 9	**2**	70 – 79	**9**
10 – 19	**3**	80 – 89	**10**
20 – 29	**4**	90 – 99	**11**
30 – 39	**5**	100 – 109	**12**
40 – 49	**6**	110 – 119	**13**
50 – 59	**7**	120 plus	**(divide by 10 add 2)**

1.2 Testing Hand Brake Effectiveness

To ensure an adequate number of hand brakes are applied, release all air brakes and allow or cause the slack to adjust. It must be apparent when slack runs in or out, that the hand brakes are sufficient to prevent that cut of cars [rake of wagons] from moving. This must be done before uncoupling or before leaving equipment unattended.

2.0 Uncoupling and Leaving a Portion of a Train Standing With Emergency Air Brakes Applied

Example - Stopping a train enroute to lift/set off or switch [shunt].
BEFORE CLOSING the angle [brake] cock on the portion to be moved:

i) make a service application sufficient to prevent train movement
ii) the service exhaust must stop blowing at the automatic brake
iii) advise the crewmember when it is OK to close the angle [brake] cock on the portion to be moved.

The standing portion must be left in EMERGENCY with angle [brake] cock FULLY OPEN

NOTE: Crewmembers are responsible to inquire and confirm with each other that the standing portion has emergency brakes applied. The FULLY OPEN angle [brake] cock may be subsequently closed only when:

- the angle [brake] cock is FULLY OPEN on opposite end of the equipment, OR
- a locomotive is coupled on opposite end of the equipment, OR
- the equipment has been secured with hand brakes in accordance with the hand brake policy.

2 Analysis

Driving/shunting Train 644

2.1 When the 9 wagons were separated from the locomotives, they were to be left unattended on the main line while the locomotives ran around through the sidings at Waingawa and be repositioned to the other end of the wagons. Although the timetable allowed 27 minutes for Train 644 to complete the shunt at Waingawa, on this occasion there were no wagons for Masterton that needed to be set aside before running the locomotives around. The audit of the train control diagrams showed that shunting at Waingawa and JNL siding took an average of 20 minutes to complete. Allowing about half that time for the run-around manoeuvre, the wagons would be expected to be unattended for about 10 minutes. Being left unattended, even for such a short time, the wagons should have been secured using a combination of air brake and sufficient handbrake applications. Training on rules and procedures, reinforced with regular safety observations and on-line assessments, was in place to cover the securing of unattended wagons.

2.2 Detailed post-incident tests found no defects with either the locomotives or the wagons that would have prevented a successful application of the required handbrakes and/or air brakes to secure the wagons properly when they were separated from the locomotives at Waingawa. Neither was any defect found in the loco brake control equipment that would have allowed a release of the train brakes other than setting the brake control valve to the release position. The braking characteristics of every train was different and on this occasion LE 1 had adjusted his braking technique and applications to compensate for the unavailability of the dynamic brake on DCP 4605 and the even distribution of weight between the locomotives and wagons. In the absence of mechanical problems, the application of train braking and shunting procedures were the most likely contributors to the circumstances that led to the wagons running away.

2.3 Shunting operations at Waingawa and JNL siding, mostly performed by Wellington-based locomotive engineers, had been undertaken over many years without reported incident. Therefore, it was difficult to understand why, on this occasion, the locomotive engineers had not individually, and cooperatively, undertaken their requisite tasks, or what other circumstances may have led to the wagons being left unsecured.

2.4 Both locomotive engineers were experienced in train braking and shunting procedures, including the particular shunting arrangements practised at Waingawa and JNL siding. They had physically demonstrated prescribed shunting tasks when, separately, they had successfully met requirements during recent safety observations. Additionally, they had been trained and there was nothing unusual or exacting in the fundamental tasks that, had they been followed, meant the runaway incident would very likely not have occurred.

2.5 LE 1, in throttling off and drifting the locomotives some distance from Waingawa, showed that he was aware of the ascending gradient and was advantageously using the uphill gradient to gradually slow the train. Because of his experience, LE 2 would probably have been aware of the power reduction made by LE 1 due to noise abatement from the diesel motor on the locomotive and probably was aware of the reasons why.

2.6 Although LE 1 believed that he had not released the brakes until after LE 2 had advised that the locomotives had been separated from the wagons, the event recorder data showed otherwise. The data showed that 4 seconds before the train came to a standstill, the brake pipe pressure rose from a low of 377 kPa to 442 kPa. Such an increase would have initiated a release of the brakes.

2.7 On a moving train, an increase in brake pipe pressure could only be achieved by retracting the brake control valve from a brake application to the brake release position. The event recorder data confirmed that on this occasion, LE 1 released the brakes shortly before the train stopped. Why he did so could not be determined, but having done so, the securing of the wagons was then reliant on LE 2 properly releasing air pressure to apply the air brakes to the wagons, and also applying sufficient handbrakes.

2.8 With the air brakes releasing, but still partially effective, and with no power being applied to the locomotives, Train 644 slowed to a stop, assisted by the ascending gradient and the combined rolling friction in the wagons and locomotives. In the last few metres, the wagons were probably rolling more freely than the concentrated load of the locomotives, evidenced by the couplings between DX 5039 and the leading wagon being in compression when LE 2 separated the train. It was not known if any of the wagon-to-wagon couplings beyond that point would also have been in compression.

2.9 Regardless of LE 1's train handling techniques in stopping the train, he would have been reliant on the second person following the required braking application tasks when separating the train to ensure the isolated rake of wagons was secured.

2.10 LE 2 was probably already absent from the cab when LE 1 initiated the brake release. Had he been in the cab, he would likely have heard the distinct noise generated by the brake valve when the release occurred, possibly prompting him to question LE 1's action at that time. However, LE 2 alighted from DCP 4605 while it was still moving, and arrived at the rear of DX 5039 probably about the time the train actually stopped, or very shortly afterwards.

2.11 The sequence of uncoupling, in which locomotive engineers were trained, would leave a separated rake of wagons braked and secure. When LE 2 separated the train he used a shortened sequence with elements different from the standard procedures. He closed the brake cocks on the locomotive and the wagon together, followed by the lifting of the bridle and coupling hook. There may have been a momentary reduction in air pressure from the vent at the coupling cock on the wagon, but it would have not been enough to reverse the recharging process already underway and apply some braking pressure to the wagons. The effect of this quick action was to isolate the 2 parts of the train completely and leave the wagons sitting without any braking.

2.12 Once this was done, even if LE 2 thought that the brake reduction was still applied by LE 1, he should have pulled the brake cock down to the open position on the wagon after the air hoses had been uncoupled when the locomotives drew away. This would have released the residual air pressure in the brake pipe and, in doing so, fully apply the air brakes on the wagons. Why he did not do so could not be determined. When the locomotives moved away, both locomotive engineers focused their attention on their individual tasks. Even if they had looked back in their direction, the wagons would have been difficult to see in the darkness.

2.13 LE 2 had probably become reliant on locomotive engineers in the driving position prolonging the brake pipe reduction that had stopped the train, and he would have expected the brakes to be released only when he instructed the locomotive engineer to move the locomotives away from the wagons. Whatever the circumstances, the braking methods in which both locomotive engineers had been trained for ground-based shunting operations, and the operating rules, were clear. LE 2 should have applied both air brakes and sufficient handbrakes when he separated the locomotives from the wagons. However, not being aware of LE 1's actions on the day did not discharge LE 2 from following basic procedures that required him to apply braking pressure on the wagons when he separated the train.

2.14 Why LE 2 did not apply any handbrakes before uncoupling the train could not be determined. However, believing that the air brakes had been applied when the train came to a stop, he may have considered that to be sufficient to hold the wagons for a short period of time on the near-level track.

2.15 The flow-on effect of the brake pipe pressure rising when LE 1 released the brakes would have been to move the triple valve slides throughout the wagons and expose their brake cylinder exhaust ports. The auxiliary reservoirs would then have been recharging rapidly on the wagons with the increase in brake pipe pressure. This would then have connected the wagon auxiliary reservoirs to the brake pipe and initiated the release of the brake blocks from the wheels. When LE 2 closed the locomotive and wagon cocks, the recharging process would probably have ceased at about 442 kPa at the first wagon, and very likely at about 420 kPa at the last wagon, as LE 1 saw shortly afterwards on the head end display unit from his driving position.

2.16 Overall, the individual tasks carried out by the locomotive engineers were routine and repetitive. Even though the locomotive engineers had discussed the shunting method they intended to employ at Waingawa, their discussions probably agreed on the movement sequences only and did not extend to cover the braking techniques each would apply. Given the training and experience of the locomotive engineers involved, such a discussion should have been unnecessary with each understanding the rules and procedures and knowing what the other was required to do. However, had the locomotive engineers covered this subject in their discussions, it was very likely that one or the other would have ensured that the required braking applications were made and the incident would very likely not have occurred.

2.17 The primary defence against runaways, whether in yards or on main lines, was operating personnel complying with rules and procedures for the proper securing of rolling stock detached from a locomotive. The relevant rules had been applied in New Zealand for many decades and, if followed, were effective in preventing runaways as well as achieving other safety benefits, particularly when mandatory air braking was latterly extended nationally to all shunting operations in yards and sidings. Whilst effective, the rules could be improved, especially with the addition of brake testing at the time of train separation.

2.18 Although Toll Rail required an examination of the air brake system before trains departed from their origin, this examination did not extend to the operation of the handbrakes on the wagons. Therefore, it was likely that regular testing of handbrakes only occurred during the wagons' scheduled B or C maintenance check. When it came to leaving rakes of wagons unattended on the main line, such as occurs at Waingawa, the procedures required personnel to apply sufficient handbrakes but did not go so far as to require a test to confirm that enough handbrakes had been applied.

2.19 Although braking methods, as trained and audited, included the application of air brakes with the venting of the remaining air pressure in the train pipe, air leakage from the brake cylinder would mean a degradation of the effectiveness of the air brakes within a short period. Thus the application of handbrakes was vital and should have been routine.

2.20 In similar circumstances CPR's documented procedures not only required operations staff, to apply and test the effectiveness of an applied minimum number of handbrakes, but also required the locomotive engineer and second person to enquire about and confirm the results of the test between themselves. This ensured that unattended rakes of wagons were adequately restrained before the locomotive(s) was uncoupled. CPR's procedures required that an incremental minimum number of handbrakes, proportional to the number of wagons, were applied. Conversely, Toll Rail's rules required that "sufficient" handbrakes be applied, an instruction which was open to individual interpretation. Therefore a 4-point safety recommendation has been made to the Chief Executive of Toll Rail to enhance its rules and procedures in line with the parallel procedures in use at CPR.

Waingawa/JNL siding

2.21 Much of the main line rail network in New Zealand was laid on grades steep enough for gravity to cause unrestrained wagons to roll. Because long uphill and downhill sections were common, there were many locations where there was a risk of runaway incidents. In this respect, the New Zealand rail network was probably not unique. Usual practice to minimise the runaway risk, where possible, was to concentrate shunting activities in yards or sidings located on level or near-level gradients. Additionally, safety defences were generally installed in these yards and sidings to prevent uncontrolled movements usually, but not always, resulting from shunting operations, from entering main lines.

2.22 These safety defences would either purposely derail the uncontrolled movement or divert it to a dead end siding and thus avert the risk of a collision with a main line movement. In circumstances where unattended wagons were occasionally to be left standing on a main line, such as when shunting Waingawa, then the signalling system, which in this instance was the active track warrant, provided a defence against other trains encroaching into the area where the wagons were standing.

2.23 In the absence of a locomotive run-around facility at JNL siding, only southbound trains could directly shunt the siding. Travelling south, trains could stop on the main line adjacent to JNL siding and shunt the siding without requiring to use the facilities at Waingawa. Shunting arrangements such as this were still relatively common and were an accepted practice on the rail network. However, in the opposite direction, locomotives on northbound trains were at the wrong end of the wagon rakes and they needed to propel their wagons from a location provided with appropriate facilities. The sidings at Waingawa fulfilled that need adequately and provided a technically acceptable and conveniently located run-around facility.

2.24 The safety points at Waingawa had been installed when the yard was originally built and it was probable that shunting operations had been confined mostly to the sidings throughout its working life. However, the closure of the freezing works, followed shortly afterwards by the opening of a single-ended siding at JNL, meant a displacement of shunting arrangements from the sidings so that the main line was now regularly being used as a shunt track. This meant that staff needed to fully understand that the primary defences against a runaway event on the main line was the proper securing of unattended wagons with airbrakes and hand brakes.

2.25 The code for track gradient in yards and sidings stipulated a maximum gradient of 1 in 200. Although the code did not specifically state that this requirement was to facilitate safe shunting operations, yards and sidings were the locations where the majority of shunting was carried out. Therefore, it can be reasonably assumed that the limitation was imposed for shunting. No such maximum was stipulated for main line tracks where shunting was needed or elected to be carried out. Regardless of the gradient, rules stipulated that unattended rail wagons be secured with a combination of air brakes and handbrakes. The need for such a rule indicated the potential for unrestrained wagons to run away, even from near-level track.

2.26 The main line gradient at Waingawa, confirmed by level survey at 1 in 198, was slightly steeper than the maximum gradient allowed for yards and sidings. The gradient difference between 1 in 198 and 1 in 200 was minimal. This incident demonstrated that even had the gradient been at the maximum of 1 in 200 it would have been enough to allow an unbraked rake of wagons, with warm roller bearings, once rolling, to continue rolling under gravity. What initiated the movement could not be determined. However, in similar circumstances, wagons rolling away from the siding at Waingawa did not pose the same risk because they would have been diverted via the safety points to the backshunt and therefore stopped from entering the main line.

2.27 Regardless of the foregoing, the option of shunting Train 644 in the sidings at Waingawa was principally driven by the timekeeping of Train 633, rather than adherence to a prescribed operational plan between ONTRACK and Toll Rail. The sidings had been used for about 25% of the crossings between Train 644 and Train 633 because of the late running of Train 633. For the other 75% of the time, shunting at Waingawa to access JNL siding had been done on the main line, probably because that was seen to be more convenient and time efficient, however shunting at Waingawa had been carried out from the main line without incident for many years.

2.28 Whether other safety defences were available or not, the primary safety defence in preventing unattended wagons running away was the application of the required level of both air and hand brakes. Therefore, in view of the safety actions taken by Toll Rail since this incident and the acceptance of the safety recommendations relating to enhance procedures for the application of both braking mechanisms, no safety recommendations covering the use of available interlocking systems during planned shunting events have been made at this time. However, the Commission will continue to monitor future events that may indicate a need for such a recommendation.

The runaway

2.29 Had the wagons rolled back in the short time before LE 2 arrived at the couplings, he would have experienced some difficulty in lifting the coupling hook. This would have required LE 2 to instruct LE 1 to reverse the locomotives a short distance and probably would have prompted either locomotive engineer to apply the brakes on the wagons at that time. However, on this occasion, the buffers were reported as being bunched and there was no need to reverse the locomotives to free up the coupling hook.

2.30 When the brakes were sufficiently released on the wagons on Train 644 shortly before stopping at Waingawa, it was possible that the built up compression within the wagons began to play out quickly afterwards. Depending on the amount of actual compression, the playing out may have been the initiator of the wagons rolling. Regardless, estimations showed that it would have taken the unbraked wagons about 10 to 15 seconds to travel the first metre from a standing start. After 3 minutes, the wagons had probably travelled about 400 m and reached a speed of about 16 km/h. After a further kilometre their speed would have been about 30 km/h and probably the speed continued to increase up to a maximum of about 50 km/h.

2.31 After the wagons had run away from Waingawa, it was not clear what caused the brakes to apply and bring the wagons to a stop at 70.50 km. When the collision occurred at Hodders Road level crossing, the TEM was slightly damaged. The air brake connection to the TEM could have been stretched or sprung, which could have then resulted in a sharp drop in air pressure, consequently triggering at least a partial brake application and causing the wagons to come to a stop gradually, assisted by the uphill gradient beyond Hodders Road level crossing. As the 10 kPa per minute air leaks on the wagon were insufficient to apply the brakes, and based on the visible damage to the TEM, this scenario probably best described what occurred. After the wagons had come to a stop, air would have continued to leak at a rate of about 10 kPa per minute from the wagons. Because no handbrakes had been applied, when all air pressure had bled away, potentially the wagons could have run back downhill to the level track in the vicinity towards Hodders Road level crossing. However, by the time staff arrived on the scene, some braking was still applied.

2.32 Hodders Road level crossing carried only light road traffic volumes and this, combined with the relatively light rail traffic volumes, meant that the level crossing did not meet the criteria for the installation of automatic warning devices. The signage that was installed was in good condition, clearly visible and together with view lines, met the required standard.

2.33 As the runaway approached the crossing, the dull green paint on the leading end of the first wagon had neither high-visibility features nor bright lights. Although the doors on ZG wagons were creamy white, there was no natural or man-made illumination, so in the backdrop of the surrounding unlit rural countryside, they would have been nearly impossible to see in the darkness. Although the angle of the intersection of the road with the railway in the direction the motor vehicle was being driven provided the best view lines of trains travelling from Masterton, the TEM on the lead wagon was the only warning the driver could have had of the runaway. The intermittent flashing red light of the TEM was designed to focus along the track to alert other rail users to the rear of a train. The flashing light of the TEM was not designed to warn road users.

2.34 In any case, the driver said that he did not see the red light of the TEM as he entered the level crossing. This was understandable, because if a train were approaching he would have been looking out for and expecting to see the locomotive's illuminated white headlight, and/or listening out for the sounding of the locomotive whistle. Even if the driver were aware of the TEM and its function, and had seen it, it would have indicated to him that the movement was travelling away from the level crossing and he would not have associated it with an approaching train. The driver therefore had little, if any, chance of seeing the approaching wagons travelling towards him out of the darkness.

2.35 Although train controllers and allied personnel were probably not as familiar with track profiles as train operating and track maintenance staff, the action taken to reverse the set of points at Featherston to divert the runaway was appropriate. The attempt to stop the runaway at the first opportunity showed initiative and probably indicated the level of concern in train control at the time.

2.36 Train runaway procedures required train controllers to, where possible, clear signals controlling entry of the runaway movement to level crossings in its path. Clearing those signals would activate warning devices at any protected level crossings. However, no warnings would be activated at any unprotected level crossings, such as at Hodders Road. Therefore the procedures gave warning to some at-risk road users, but not all. However, in this instance, the procedures could not be applied because the area was under track warrant control where signals were not remotely operated by train control. Where possible the train runaway procedures gave a warning to at-risk motorists at protected level crossings, but could do nothing to contain the runaway. In view of the limited application of the current procedures, a safety recommendation has been made to the Chief Executive of ONTRACK to provide an appropriate selection of actions to enable a more effective response to a train runaway.

2.37 Although there were some air leaks and pressure gauge inaccuracies on DCP 4605, there had been no entries in the Loco 54D book to bring these matters to the attention of locomotive servicing personnel in the 7 months leading up to the incident. Therefore, the numerous locomotive engineers who had driven this locomotive throughout that time probably considered that these matters, if they were aware of them, did not need to be attended to. Nevertheless the faults, although in excess of code tolerances, had no effect on the braking capabilities to stop Train 644 at Waingawa and would not have prevented the application of the air brakes on the separated wagons with the opening of the brake cock once the locomotives had drawn away.

2.38 The sequence of braking applications, as taught during core stationary shunting sessions, was to bring the train to a stop using air brakes, keep air pressure applied, then apply sufficient handbrakes before separation. By applying the brakes in this sequence, staff applying handbrakes had the advantage of the force exerted by the air pressure on the brake block. Without that advantage, staff had to exert whatever amount of physical pressure they could muster to depress the brake handle as far as possible. Generally this applied sufficient brake block pressure, but the testing on the 9 ZG wagons found that handbrakes had to be applied over several wagons in contrast to a reduced number of handbrake applications if air brakes had remained applied. Toll Rail advised that it was reviewing operational procedures with a view of ensuring the correct sequence was followed. In view of this action no safety recommendation has been made.

2.39 The extensive tests carried out on the 9 ZG wagons had not identified any out-of-code conditions or any faults on the air brake or handbrake equipment. Maintaining the 10 kPa per minute air leak on the wagons was well within the capabilities of the locomotives. All 9 wagons were subsequently returned to traffic 2 days after the incident without requiring any repairs.

2.40 The extensive tests performed on the wagons concluded that even if a minimal air brake application had been made, and/or, sufficient handbrakes had been applied, it was very unlikely the wagons would have run away from Waingawa.

3 Findings

Findings are listed in order of development, not in order of priority.

3.1 Both locomotive engineers were appropriately certificated and trained to undertake the required shunting at Waingawa.

3.2 There were no defects in the wagons that would have prevented either air brakes or handbrakes being applied.

3.3 If followed, the rules and documented procedures for the securing of unattended wagons would have prevented the wagons running away.

3.4 The rake of 9 wagons ran away from Waingawa because it was left unsecured by either air brakes or handbrakes on a gradient that offered assistance to the runaway, once rolling.

3.5 The gradient on the main line at Waingawa was only slightly greater than the maximum allowable in yards and sidings where the majority of shunting operations took place.

3.6 Regardless of the gradient, had the wagons been secured with the combination of air brakes and sufficient handbrakes, the runaway would not have occurred.

3.7 The initiator of the first movement could not be determined.

3.8 In bringing Train 644 to a stop at Waingawa, the event recorder shows that the train's air brakes were released shortly before coming to a standstill, effectively leaving the wagons with no brakes.

3.9 Having released the brakes moments before coming to a standstill, LE 1 should have reapplied braking, thus leaving the train in what would have been normal condition before being instructed by LE 2 to move away from the separated wagons.

3.10 Train 644 stopped in such a manner that the buffers between the locomotives and the first wagon at least were in compression, which may have led LE 2 to consider that the air brakes were still applied at that time.

3.11 In separating the locomotives from the wagons, LE 2 isolated the wagon brakes from the locomotive brake pipe but did not release any residual or recharging air pressure from the wagons to apply the air brakes as he had been trained to do.

3.12 Regardless of whether air brakes were applied to the wagons, sufficient handbrakes should have been applied, but none was.

3.13 The rake of wagons was found to have some air brakes at least partially applied after it stopped. This application had probably been made as a result of brake pipe air loss caused by damage to the TEM during the collision with the road vehicle.

3.14 The air leaks found on the wagons were not sufficient to have initiated braking during the runaway.

3.15 During the preceding 3 months, the sidings at Waingawa had been used to facilitate the crossing of Train 644 and Train 633 for about 25% of the time, a situation that was principally driven by the timekeeping of Train 633.

3.16 Had on this occasion, the shunt taken place within the sidings at Waingawa and the south end points been restored to the normal position, then the runaway would have been contained.

3.17 When approaching Hodders Road level crossing, the driver of the road vehicle would not have had an audible or visual warning of the runaway wagons as would have been signalled by a normal train movement.

3.18 Once on the crossing, the driver of the road vehicle had no chance of avoiding the collision.

3.19 The reversal of the points at Featherston would have been the first opportunity to arrest the runaway wagons. However, with the track profile between Waingawa and Featherston, it was highly unlikely that the runaway wagons would have reached Featherston.

3.20 Toll Rail's presentation of train shunting and braking procedures across more than one document contrasted to CPR's policy of grouping procedures for similar activities in a single document.

3.21 Toll Rail's instructions had no requirements for operating personnel to apply challenge and response principles during routine train separation actions, which contrasted to CPR's instructions that required operating personnel to enquire and confirm during similar actions to provide a higher level of surety that unattended rakes of wagons were restrained.

3.22 Toll Rail's instructions contained no stipulated procedures for the application of a minimum number of handbrakes on an unattended rake of wagons, but rather, an individual was required to interpret on site what constituted an application of sufficient handbrakes. Conversely, CPR's instructions required a minimum number of handbrakes to be applied proportional to the number of unattended wagons.

3.23 Toll Rail's instructions contained no test effectiveness procedure for the applied handbrakes, whereas CPR's instructions required such a test to be performed. Without such a test, it could not be certain that the operation of the applied handbrakes would restrain a rake of unattended wagons.

4 Safety Actions

4.1 On 11 May 2006, Toll Rail advised that:

> Safety Actions taken or initiated by Toll Rail since this the incident include:
>
> - Special Safety Briefings were circulated to Toll Rail operating personnel requiring full compliance with procedures associated with securing wagons detached from trains.
> - Toll Rail operating managers were briefed on the importance of ensuring that all stationary wagons were correctly secured. Practices such as relying on air brake only (i.e. not applying handbrakes) to hold a rake of wagons and not ensuring a minimum reduction of 75 kPa in brake pipe pressure before detaching wagons were highlighted.
> - Targeted audits of compliance with correct procedures associated with securing wagons have been undertaken, particularly the application of handbrakes – this being the primary defence. These audits are ongoing and are now included within our safety KPI's.
> - Translog locomotive event recorder software has been redeveloped to enable brake pipe and brake cylinder pressure to be monitored when a locomotive has stopped. This is now being installed into existing Translog recorders and will enable braking procedures to be monitored during random event recorder extractions.
> - Toll Rail initiated a review of procedures associated with securing wagons detached from trains or shunting movements following a subsequent incident at Mercer after which it was possible to fully investigate what took place with the co-operation of the operating personnel involved. The first part of this review identified a number of procedural changes that are about to be introduced. Specifically, these changes include:
>   - Where two persons are involved, verbal interaction between the person controlling the locomotive and the person detaching the wagon/s as each step is completed.
>   - A specific sequence for application of the handbrake relative to the air brake to maximise brake block pressure.
>   - Code instructions will be changed to define procedures on a step-by-step basis.
>
>   It is important to note that both the existing and revised procedures will only be effective if fully complied with, particularly the primary defence requiring the application of handbrakes.
> - The second part of the above review is examining the compilation of a matrix defining the number of wagon and locomotive brakes to be applied relative to gradients. This part of the review has been initiated by Toll Rail Engineering, but some further analysis is needed to reach a conclusion.

5 Safety Recommendations

Safety recommendations are listed in order of development, not in order of priority.

5.1 On 12 May 2006 the Commission recommended to the Chief Executive of Toll Rail that he:

Enhance existing air brake and handbrake procedures to include:

- a minima number of handbrakes to be applied proportional to the number of unattended wagons
- a brake effectiveness test to be carried out before locomotives are separated from an unattended rake of wagons
- operating personnel required to communicate with each other at defined stages before wagons are left unattended on a main line
- consolidate instructions pertaining to the operation of hand brakes and air brakes applicable at train separation (030/06).

5.2 On 15 May 2006, the Chief Executive of Toll Rail replied in part:

> Toll NZ expects the recommendation to be completely implemented by 30 September 2006. It is likely to be implemented in stages as the separate elements advised in our safety actions progress. We have now expanded our review to include an assessment of "brake effectiveness tests" prior to detachment of a group of wagons from a train.

5.3 On 12 May 2006 the Commission recommended to the Chief Executive of ONTRACK that he:

Enhance existing procedures to incorporate appropriate actions to enable an effective response to an uncontrolled movement on a main line (031/06).

5.4 On 26 May 2006, the Chief Operating Officer of ONTRACK replied in part:

> ONTRACK accept this recommendation and expect implementation to be completed by end of September 2006.

Approved on 15 June 2006 for publication

Hon W P Jeffries
Chief Commissioner

Appendix

Glossary of terminologies pertinent to following document

• car	wagon
• block	rake
• derail	trap points/stop block/dead end backshunt
• spotted	placed
• multi-platform cars	articulated pairs of wagons that share common bogies
• cut	rake
• switching	shunting
• cars cut off in motion	loose shunting - not practised in New Zealand
• angle cock	brake cock
• double the hill	double banking a stalled train beyond the apex of a gradient

Section 14

Hand Brakes –

Leaving Locomotives, Cars and Trains

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NOTE: In the following instructions, a car or locomotive is considered "unattended" when no crew member is close enough to the equipment to take safe and effective action to control its movement.

NOTE: Reference to hand brakes on locomotives includes electric parking brakes on SD90MAC locomotives.

1.0 Hand Brake Policy

IMPORTANT: Crew members are responsible to inquire and **confirm** with each other that equipment is left in accordance with these instructions.

1.1 Leaving Railway Equipment Unattended; the following instructions apply:

A	A single car must ALWAYS be left with the hand brake applied.
B	More than two cars ALWAYS require at least TWO hand brakes.
C	Never leave a car with a defective hand brake by itself. It must be coupled to another car with an effective hand brake.
D	Individual blocks of cars must be secured with hand brakes on each block.
E	Hand brakes must be applied on the cars which are at the low end of a downward sloping track.
F	When leaving equipment in a track equipped with a derail, it should be left as close as practical to the derail (about 100 feet). This does not include cars which have been spotted for loading/unloading, repair or cars being handled while switching. Operating Rules which govern proximity to public crossings at grade still apply.
G	When leaving railway equipment, the **MINIMUM** number of hand brakes must be applied as indicated in the following chart. Additional hand brakes may be required; factors which must be considered are: - total number of cars - cars loaded or empty - track grade - hand brake force applied
	Continued →

HAND BRAKE CHART

CAUTION: Chart indicates the **MINIMUM** number of hand brakes to be applied

Cars	Hand Brakes	Cars	Hand Brakes
1 - 2	1	60 - 69	8
3 - 9	2	70 - 79	9
10 - 19	3	80 - 89	10
20 - 29	4	90 - 99	11
30 - 39	5	100 - 109	12
40 - 49	6	110 - 119	13
50 - 59	7	120 Plus	(divide by 10 add 2)

H	In reference to the minimum number of hand brakes in the preceding chart, it is acceptable to include the hand brakes applied on locomotives.
I	On multi-platform cars, each platform is to be considered one car. However, if a multi-platform car has only 1 or 2 hand brakes for 3 to 5 platforms, it may be considered that the minimum requirement is met for that car.
J	There may be situations where all hand brakes should be applied.
K	It will be acceptable to apply less than the minimum number of hand brakes when so specified in special instructions, subdivision footnotes or operating bulletin.

1.2 Testing Hand Brake Effectiveness

To ensure an adequate number of hand brakes are applied, release all air brakes and allow or cause the slack to adjust. It must be apparent when slack runs in or out, that the hand brakes are sufficient to prevent that cut of cars from moving. This must be done before uncoupling or before leaving equipment unattended.

1.3 Switching and Handling Equipment

A	While switching, when a car or block of cars is left standing without air brakes applied, always apply at least one hand brake. Increase the number of hand brakes as required until it is apparent that the number of hand brakes applied are sufficient to prevent that cut of cars from moving.

B	During switching, emergency air brake applications must not be relied upon to hold equipment stationary for short periods of time unless. **i)** there are at least 10 cars which are sufficiently charged with air AND **ii)** a crew member is in close enough proximity to safely apply hand brakes if unintended movement occurs.
C	After being coupled to, no car or cut of cars may be pushed or shoved until it is known that a proper coupling has been made. The slack must be taken or be seen to run out on all cars to be moved.
D	When it is required to remove cars from the low end of a downward sloping track, ensure that any cars to be left standing are properly secured.
E	After switching has been completed, and the cars are being left, comply with items 1.1 and 1.2 above.
F	When a car movement is to be controlled by hand brake(s), the hand brake(s) must be tested and determined to be in good order before car(s) are cut off.
G	Cars cut-off in motion (flat switching): **i)** Do not uncouple or allow car(s) to move under their own momentum onto standing cars unless it is positively known that the number of hand brakes applied on the standing cars are sufficient to prevent movement of all cars. To determine the minimum number of hand brakes required, add the total number of standing cars with the number of cars to be cut-off in motion. **For example;** • there are 9 cars standing (with 2 hand brakes applied). • it is intended to cut-off in motion 4 additional cars. • so that the total number of cars being left equals 13. • according to the chart in item 1.1, 13 cars requires 3 hand brakes and so on. • the 3rd hand brake must be applied before the additional cars are cut-off in motion.
	Continued →

	ii) In the application of the instruction above, do not rely on emergency air brake applications to prevent movement of the standing cars (i.e., instead of hand brakes) unless you have complied with item 1.3 (B) (e.g., there are at least 10 cars with emergency brakes applied etc.).

1.4 Hand Brake Application Procedures

A	Apply a hand brake with air brake released or brake cylinder bled off. Do not attempt to bleed a car off with SERVICE brake applications in effect as this can trigger an undesired release of all other cars.
B	It is not always practicable to apply hand brakes with the air brakes released (e.g., heavy grades with heavy cars or when providing 3 point protection). When an air brake application is required, it must be as light an application as possible to prevent movement while hand brakes are being applied.
C	When applying a hand brake, it must be applied fully.
D	Under winter conditions ensure braking surfaces are free of ice and snow.

1.5 Wreck Damaged Equipment.

When hand brakes have been damaged due to derailment or mishap, it may be necessary to secure equipment with wheel chocks or chains. These devices will be placed by Mechanical Services personnel and are designed for this purpose. In these cases, running trades employees should be governed by the officer in charge.

1.6 Releasing Hand Brakes

A	Hand brakes have the ability to provide far more brake shoe force than the air brakes; therefore to avoid damage to wheels, hand brakes must be FULLY RELEASED before moving car(s).
B	When releasing a hand brake, it may be determined that it is properly released by ensuring that the bell crank has dropped and that the vertical rod and chain are slack. **Note:** Do not depend on brake shoes being clear of the wheels as on many cars the hand brake applies on the "B" end only.
C	Hand brakes must not be released from cars or trains left standing on a grade until the train air brake system has obtained its fully charged state, unless movement can be prevented with locomotive brakes.

1

2.0 Uncoupling and Leaving a Portion of a Train Standing With Emergency Air Brakes Applied

Example - Stopping a train enroute to lift/set off or switch.

A	BEFORE CLOSING the angle cock on the portion to be moved: i) make a service application sufficient to prevent train movement. ii) the service exhaust must stop blowing at the automatic brake. iii) advise the crew member when it is OK to close the angle cock on the portion to be moved. **NOTE:** On trains equipped with TIBS: • the crew member must advise the locomotive engineer when the angle cock has been closed, and then • the locomotive engineer must activate the TIBS emergency braking feature.
B	The standing portion must be left in EMERGENCY with angle cock FULLY OPEN **NOTE:** Crew members are responsible to inquire and confirm with each other that the standing portion has emergency brakes applied. The FULLY OPEN angle cock may be subsequently closed only when: • the angle cock is FULLY OPEN on opposite end of the equipment, OR • a locomotive is coupled on opposite end of the equipment, OR • the equipment has been secured with hand brakes in accordance with the hand brake policy.
C	The following precautions against unintended movement must be taken because brake cylinder pressure might leak off: **IMMEDIATE** - If the standing portion is LESS THAN 10 CARS, secure with hand brakes immediately. **ONE HOUR** - On grades 1.5 percent OR LESS, if the standing portion is 10 CARS OR MORE, begin to secure with hand brakes or recouple the locomotive within 1 hour. **12 HOUR** - On grades GREATER THAN 1.5 percent, if the standing portion is 10 CARS OR MORE, begin to secure with hand brakes or recouple the locomotive within 1/2 hour.
	Continued →

	NOTE: Refer to subdivision footnotes to identify locations where grades are greater than 1.5 percent. **CAUTION:** Whenever it is possible that the portion left standing cannot be secured within the applicable time limit, hand brakes must be applied immediately. **EXAMPLE:** A train has stalled on an ascending grade and must "double the hill." It is doubtful that the portion left standing could be secured within the required time limit. This means it must be secured immediately.
D	In the application of this instruction, hand brakes may be applied near the head end of a train, regardless of low end or high end of a particular grade.
E	**Broken Drawbars on Light, Heavy and Mountain Grades** If it is not possible to test hand brake effectiveness because of a broken drawbar, and if it is possible that the portion of a train left standing on a grade cannot be secured within the applicable time limit prescribed in paragraph **(C)** (e.g., 30 or 60 minutes), hand brakes must be applied immediately as follows: • On mountain grades apply hand brakes on least 65 % of the cars (unless more than 65% is specified in Time Table subdivision footnotes). • On heavy grades listed in GOI Section 16, Appendix 1, Descending Heavy Grade Job Aid, item 2.0. - if the grade is 1.3% to 1.8%, apply hand brakes on at least 50% of the cars. - if the grade is 1.0% to 1.29%, apply hand brakes on at least 25% of the cars. • On grades listed in Time Table subdivision footnotes that are greater than 1.5 percent, apply hand brakes on at least 50% of the cars. • On all other locations, apply hand brakes as per the minimum number of hand brakes chart in item 1.1g).

2.1 Locomotives with Vented Brake Pipe Angle Cock

NOTE: Many leased and foreign locomotives are equipped with a "vented brake pipe angle cock". When closed, the vent will drain brake pipe pressure in the brake pipe hose. This can cause problems when uncoupling, because if brake pipe has already been vented to 0 psi, then the standing portion cannot be placed in emergency.
In the application of item 2.0 (A) above (e.g., leaving a portion of a train standing in emergency): • IF there is a leased or foreign locomotive in the consist, and • IF you are uncoupling immediately next to that foreign or leased locomotive, • **THEN BEFORE** instructing the crew member on the ground that it is OK to close the angle cock on the portion to be moved, • **PLACE** the entire movement in **EMERGENCY** using the automatic brake valve. This instruction applies on switching movements, on conventional trains and on Locotrol equipped trains; it applies if you are hanging on to the foreign or leased locomotive or uncoupling from it.
NOTE 2: This instruction also applies to all SOO locomotives.

3.0 Leaving a Train Unattended

• **with locomotive(s) attached**	
• **with engine(s) running**	
In reference to item 1.1 (E) of the hand brake policy (apply hand brakes on the low end of a downward sloping track), trains left unattended with locomotive(s) attached may be left as follows:	
A	On an ascending grade, train must be stopped with slack stretched; on other than ascending grade, stop with slack in or out.
B	LOCOMOTIVES must be ATTACHED with brake pipe coupled and angle cocks open.
C	Apply hand brakes on the head end of the train.
D	Test the effectiveness of hand brakes.
E	On the controlling locomotive, the control stand must be left as follows. • Independent brake cut-IN and FULLY applied. • Automatic brake cut-IN and handle in RELEASE. • Generator Field OFF, Engine Run ON, Control/Fuel Pump ON. • Reverser handle removed. • Take the reverser handle from the cab of all locomotives in the consist except as specified by Section 15 - item 10.3, or except as specified by special instructions, subdivision footnotes or operating bulletin.
F	Turn off all unnecessary lights and close all doors and windows.
CAUTION: It is imperative that all steps in this procedure be followed. Otherwise, apply hand brakes on the cars which are at the low end of a downward sloping track.	
Crew to Crew: When required to leave a train in this manner, the information relative to hand brakes applied and inspection performed must be documented on the Crew to Crew Form as required by GOI Section 5 Item 17.0.	

4.0 Leaving a Locomotive

4.1 When Changing off with Another Locomotive Engineer - Coupled With or Without a Train or Cars.

A	Complete Crew to Crew Form
B	Take the reverser handle from the cab of the leading locomotive.

4.2 Leaving a locomotive unattended

•	**no cars nor train attached**
•	**engines running or dead**
A	A hand brake must be fully applied on EACH locomotive. **EXCEPTION:** Apply at least one hand brake when leaving locomotives at the following diesel facility shop tracks; • Coquitlam • Alyth • Winnipeg • Toronto • St. Luc • Moose Jaw • Sutherland • other tracks which are specified by special instructions, subdivision footnotes or operating bulletin.
B	Test the effectiveness of the hand brakes as per item 1.2. Examine the hand brake system to ensure that the chain is in tension to the point of application.
C	On the controlling locomotive, the control stand must be left as follows: • Independent brake cut-IN and FULLY applied. • Automatic brake cut-IN and handle in RELEASE. *Continued* →
	EXCEPTION: EAB FAILURE It is not possible to cut-IN the automatic and independent brake on a locomotive on which the electronic air brake (EAB) system has failed. With a failed EAB system, the locomotive air brake backup mode defaults to trailing locomotive status only. This means the air brakes will eventually leak off. When setting off or leaving a locomotive on which the EAB system has failed, it is especially important that the hand brake effectiveness is tested. • Generator Field OFF, Engine Run ON, Control/Fuel Pump ON. • Reverser handle removed. • take the reverser handle from the cab of all locomotives in the consist except as specified by Section 15 - item 10.3, or except as specified by special instructions, subdivision footnotes or operating bulletin.
D	Turn off all unnecessary lights and close all doors and windows.
E	Where applicable, the Automatic Reporting Unit (ARU) must be connected for monitoring of locomotive.
F	Complete a Crew to Crew Form.

5.0 Locomotive Consist Separation

A	On locomotive(s) to be left standing apply hand brakes fully on all locomotive(s) and test their effectiveness. Release all air brakes and allow or cause the slack to adjust.
	It must be apparent when slack runs in or out, that the hand brakes are sufficient to prevent the locomotive from moving. Examine the hand brake system to ensure that the chain is in tension to the point of application. This must be done before uncoupling.
B	On the controlling locomotive, apply the independent brake FULLY.
C	Close the cocks on all air hoses between the locomotives to be separated.
D	On at least one of the locomotives to be left standing, the control stand must be set up as follows. • Independent brake cut-IN and FULLY applied. • Automatic brake cut-IN and handle in RELEASE. **EXCEPTION:** EAB FAILURE It is not possible to cut-IN the automatic and independent brake on a locomotive which the electronic air brake (EAB) system as failed. With a failed EAB system, the locomotive air brake backup mode defaults to trailing locomotive status only. This means the air brakes will eventually leak off. When setting off or leaving a locomotive on which the EAB system has failed, it is especially important that the hand brake effectiveness is tested. • Generator Field OFF, Engine Run ON, Control/Fuel Pump ON. • Reverser handle removed. • take the reverser handle from the cab of all locomotives in the consist except as specified by Section 15 - item 10.3, or except as specified by special instructions, subdivision footnotes or operating bulletin.
E	Remove the jumper cable(s) and disconnect walkway safety chains.
F	Uncouple the locomotives and separate.
G	Secure all hoses in the receptacles dummy couplings (if provided).

IMPORTANT: It is imperative that steps (A) through (D) in this procedure be followed. Otherwise the air brakes can quickly leak off of the locomotive(s) to be left standing.

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6.0 Winter Operation (Nov 15 – Mar 15) - Air Conservation Instruction

WINTER OPERATION AIR CONSERVATION INSTRUCTION	
This instruction applies to trains or portion thereof left unattended at Major Yards or Terminals and at Regular Crew Change Locations	
CONDITIONS... • This instruction is intended for fueling, set outs or lifts on run through trains only. • Temperature must be below minus five (-5) degrees Celsius. • Does not apply to Locotrol or ARC equipped trains. • Does not apply when it is anticipated that the equipment will be left unattended longer than two (2) hours.	
When at the locations specified and the conditions are met, the following may be applied:	
A	In the application of this instruction, GOI Section 14, item 2.0 (**C**) does not apply.
B	The train or standing portion must be secured in accordance with the Hand Brake Policy as outlined in Section 14, item 1.0. **Note:** Local Handbrake Special Instructions apply.
C	Once the train or portion thereof is secured with sufficient handbrakes and their **EFFECTIVENESS** has been tested, proceed to D.
D	Prior to leaving the standing portion unattended, the brake pipe must be reduced to "ZERO" at a rate that is no less than a service rate reduction, this is accomplished by placing the brake handle into the Handle Off position and waiting for the air to deplete from the train line. The SBU must be observed to ensure "ZERO Pressure".
E	TIBS emergency braking feature should not be tripped.
F	Once the air is depleted and there is "ZERO" pressure at the SBU, the standing portion ***must*** be left with the angle cock open.

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Price $36.00

ISSN 1172-8280