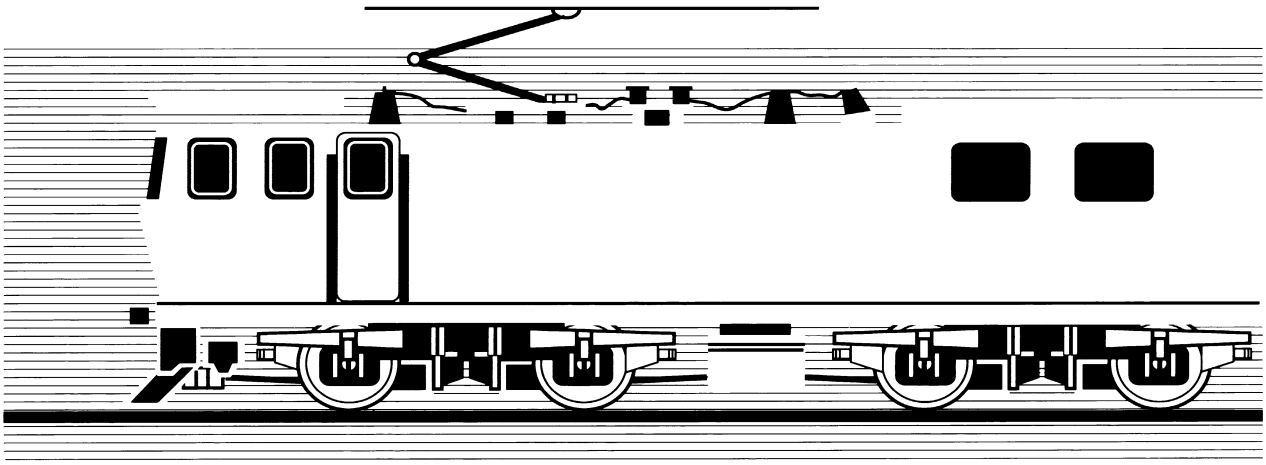
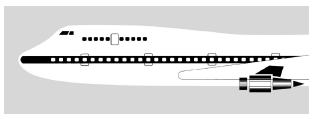
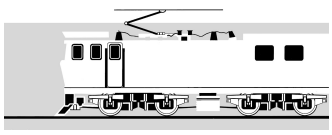


RAILWAY OCCURRENCE REPORT

02-117 Express freight Train 328, signal passed at stop, Te Rapa 31 July 2002


TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

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The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

Report 02-117

express freight Train 328

signal passed at stop

Te Rapa

31 July 2002

Abstract

On Wednesday 31 July 2002 at about 1040, express freight Train 328 passed 6 Signal, Te Rapa, at stop. The train then ran through No. 2 points at Te Rapa, set in the reverse position, and travelled a further 9 km on the North Island Main Trunk up main before being stopped at Horotiu.

A hi-rail excavator working on track between Te Rapa and Horotiu had just cleared the track before the train passed through the work area.

A safety issue identified was the probable fatigue-related performance impairment of the locomotive engineer leading to his loss of situational awareness.

Contents

Figures

Abbreviations

km	kilometre(s)
m	metre(s)
NIMT	North Island Main Trunk
Tranz Rail	Tranz Rail Limited

Data Summary

Train type and number:	express freight Train 328
Date and time:	31 July 2002 at about 1040[1]
Location:	Te Rapa
Persons on board:	crew: 1
Injuries:	nil
Damage:	nil
Operator:	Tranz Rail Limited (Tranz Rail)
Investigator-in-charge:	P G Miskell

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

1 Factual Information

1.1 Narrative

1.1.1 On Wednesday 31 July 2002, Train 328 was a scheduled Mount Maunganui to Auckland express freight service, consisting of a single DC class locomotive hauling 48 wagons for a gross weight of 830 tonnes and was 801 m long.

1.1.2 The locomotive engineer commenced duty at Westfield at 0340 that morning and drove Train 339 to Te Rapa, arriving at about 0600. He was rostered to drive Train 328 back to Westfield.

1.1.3 Train 328 was running late and while he waited the locomotive engineer watched television and had a nap for about one hour at the amenity. Train 328 arrived at about 1030.

1.1.4 After boarding the locomotive he checked the train work orders and was ready to depart at about 1040. He called the Te Rapa signalman[2] by radio and told him the train was ready to depart and started to move the train.

1.1.5 The signalman advised the locomotive engineer that he was unlikely to get clearance to depart Te Rapa. After this exchange the signalman left the panel temporarily.

1.1.6 When Train 328 had travelled about 500 m, the locomotive engineer passed intermediate Signal 54494 displaying a yellow aspect, and after a further 1394 m passed Signal 13AC also displaying a yellow aspect. The yellow aspect indications acted as a warning to the locomotive engineer that the indication on the next signal in advance, 6 Signal, would be at stop (red).

1.1.7 As the train approached 6 Signal the locomotive engineer observed its red indication but was unsure whether the signal applied to his train. He stopped the train short of the signal and referred to the Description of Signals and Levers contained within the Te Rapa Signals and Interlocking Arrangements that stated:

6	Up Starting from B5[3]	NS[4] to B6

He did not refer to the Te Rapa Yard Diagram contained within the Signalling and Interlocking Arrangements.

1.1.8 The locomotive engineer decided that 6 Signal did not apply to his train so he restarted the train and about 300 m past the signal, the train ran through No. 2 points, which were set against the passage of the train. He did not hear or feel anything that indicated the points had been run through.

1.1.9 When the signalman returned to the panel, he immediately became aware that Train 328 had departed Te Rapa Yard, and in doing so had passed 6 Signal at stop and run through No. 2 points. After 2 unsuccessful attempts to communicate with the locomotive engineer by radio, he placed the Up Starting signal Horotiu, 554.3 km North Island Main Trunk (NIMT), at stop and advised train control.

1.1.10 Train 328 stopped short of the Up Starting signal at Horotiu, and the locomotive engineer was contacted by train control and advised of the signal passed at stop and points run through at Te Rapa. The train remained at Horotiu until a replacement locomotive engineer arrived to take the train on to Westfield.

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[2] Person responsible for local control of train movements between Killarney Road (541.44 km NIMT) and Ngaruawahia Bridge (560 km NIMT).
[3] B5 is the section of track between 13 AC Signal and 6 Signal.
[4] Normal Speed.

1.2 Site information

1.2.1 Te Rapa Yard was a major yard. For north departing trains the yard had an up main, an up through departure road and 2 departure roads (see Figure 1).

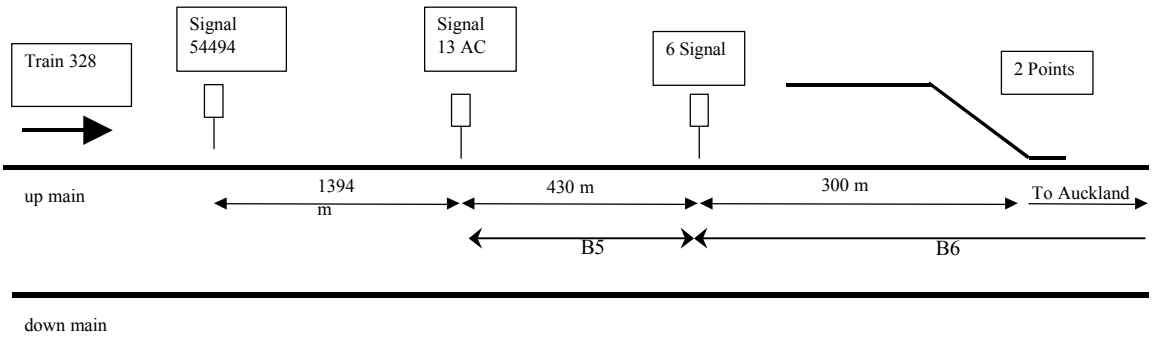

Figure 1
Layout of signals passed by Train 328 when departing Te Rapa up main
(not to scale)

1.2.2 Like Signals 54494 and 13 AC, 6 Signal was positioned on the left side of the up main. It was held at stop because a portion of the up main between Te Rapa and Horotiu was obstructed by a hi-rail excavator. The signalman had placed a collar over 6 Signal on his panel as a physical reminder that a section of track in advance of the signal was obstructed.

1.2.3 The hi-rail excavator had moved clear of the track before the arrival of Train 328. There were no other trains or track occupations on the up main between Te Rapa and Ngaruawahia, the next crossing station in advance of Horotiu.

Figure 2
Up Starting 6 Signal at Te Rapa

1.2.4 The weather was fine and the locomotive engineer had unobstructed view lines as he approached each of the 3 signals.

1.2.5 Tranz Rail had no records in their database of 6 Signal Te Rapa having been passed at stop previously.

1.3 Rules and Regulations

1.3.1 Rule 95 of Tranz Rail's Operating Rules and Regulations state:

> **Absence from Signal Box-** A signalman must not leave the immediate vicinity of his signal box for any purpose unless all the signals are in the normal position, and permission has been obtained from Train Control.

1.3.2 The rail corridor between Te Rapa and Horotiu consisted of an up main to Horotiu and a down main to Te Rapa. This is defined as double line running. Tranz Rail's Rules and Regulations provided the following definitions relevant to double line automatic signalling:

> **Double Line Sections** – A double line section is the section of either main line between two interlocked stations the entrance to which is governed by a fixed signal.
>
> **Intermediate Section** – Any division of a double line section the entrance to which is governed by an intermediate signal.
>
> **Interlocked Station** – A station for which control of the points and fixed signals is centralised and arranged to prevent conflicting movements. The operation of the points and signals may be manually controlled in addition to being controlled by track circuits.

1.3.3 Tranz Rail's Rule 58(a) divided Automatic Running signals into three main classes, viz:

> **Stop and Proceed signals**
> **Stop and Stay signals**
> **Departure signals**
>
> The light units of **Stop and Proceed** signals are "staggered", i.e., the lower unit is in a diagonal line to the right and not vertically below the upper unit.
>
> The light units of **Stop and Stay** signals and of **Departure** signals are in a vertical line, i.e., the lower unit is vertically below the upper unit.

1.3.4 Tranz Rail's Rules and Regulations defined the meaning of a red aspect as displayed on 6 Signal, a stop and stay signal as:

> Stop-
> Section is occupied, or for some other reason it is required that the train should be stopped.

1.4 Locomotive event recorder

1.4.1 The locomotive was fitted with an old style loco log event recorder, which retained detailed data of the last 10 minutes of the journey on the short log and the locomotive speed at 10 second intervals for the previous 7 days on the long log. Tranz Rail advised that the data from the event recorder was not available because it had been overwritten by the time the extraction was arranged.

1.4.2 Following a signal passed at stop on 23 February 2000 (Occurrence Report 00-102), the Commission recommended to the managing director of Tranz Rail on 15 November 2000 that he:

> Publish criteria for staff involved in occurrence investigation that ensures locomotive event recorder extraction follows serious incidences such as signal overruns. (95/00)

1.4.3 Tranz Rail accepted this recommendation on 15 November 2000, and an amendment was made to Clause 1.3 Section 2 of the Rail Operating Code, effective from 18 December 2000, which stated:

> "Significant operating incidents require the extraction of information from event recorders of locomotives involved in the accident/incident.
>
> The Network Control Manager is responsible for ensuring arrangements are made to have this information extracted…."

1.5 Signal testing

1.5.1 Tranz Rail advised that tests were normally carried out only when there was an allegation of a signalling irregularity. In this case, there was no report suggesting the signal had malfunctioned before the incident, so 6 Signal Te Rapa was not tested.

1.6 Personnel

Locomotive engineer

1.6.1 The locomotive engineer was certified for the duties he was undertaking and had 5 years experience on the Te Rapa to Westfield section of the North Island Main Trunk. He was appointed to a position of "minder driver"[5] during March 2001.

1.6.2 The locomotive engineer stated that he had not previously observed 6 Signal displaying a red aspect when he departed from Te Rapa for Westfield.

1.6.3 The locomotive engineer was on duty for 5 of the 7 days prior to the incident and worked a total of 39 hours 15 minutes. The rostered and actual hours worked by the locomotive engineer are shown in the table below (the actual start and finish times are shown in parentheses).

Dates in July	Start (hr)	Finish (hr)	Hours worked
Wednesday 24	0100 (0100)	0730 (0900)	8
Thursday 25	off-duty		
Friday 26	off-duty		
Saturday 27	0600 (0600)	1400 (1400)	8
Sunday 28	1000 (1000)	1600 (1600)	6
Monday 29	0505 (0505)	1415 (1415)	9.10
Tuesday 30	0340 (0340)	1315 (1315)	9.35
Wednesday 31	0340 (0340)	1315 (1415)	10.35

1.6.4 The locomotive engineer's self-reported sleep, as far as he could recall, during the days prior to the incident are given below:

[5] A locomotive engineer appointed to provide "on-the-job" training to trainee locomotive engineers.

Dates in July	Asleep	Awake	Nap	Total Sleep
Monday 29	2345			
Tuesday 30		0320	2 hr (1500-1700)	5 hrs 35 mins
Tuesday 30	2200			
Wednesday 31		0320	1 hr (0800-0900)	6 hrs 20 mins

1.6.5 In March 2002 he attended a Tranz Rail Alertness Management and Crew Resource Management training programme. Other topics covered included Defensive Driving Techniques for Locomotive Engineers.

Signalman

1.6.6 The signalman at Te Rapa was certified for the duties he was undertaking. He was an appointed Train Examiner Operations, but was also trained as a signal box operator. He worked in the signal box for a minimum of one week every 2 months to maintain his currency and competency. At the time of the incident, he was working his second of 5 consecutive day shifts in the signal box.

2 Analysis

Signalman

2.1 The signalman advised the locomotive engineer of Train 328 that an uninterrupted departure from Te Rapa was unlikely because he was awaiting confirmation from Train Control that the hi-rail excavator was clear of the track. He protected the work site by maintaining 6 Signal at stop. In accordance with company policy he placed a collar over the signal on his panel. The collar was a visual reminder to the signalman that the track ahead was obstructed, and an appropriate defence against premature release of the signal.

2.2 The signalman temporarily left the panel but he remained in the vicinity of the signal box. All signals under his control were in the normal position. His leaving the panel unattended temporarily, neither contravened any regulation nor contributed to the signal overrun.

Signalling arrangements

2.3 The signals, as set by the signalman, were appropriate for the situation as perceived by the signalman.

2.4 Double caution aspects are used where there is insufficient braking distance between the second caution and the signal at stop.

Locomotive engineer

2.5 The locomotive engineer confirmed that 6 Signal was clearly visible and displayed a red aspect as he approached it. He was an experienced driver and it was not clear why he had any doubts that the signal applied to his train.

2.6 The locomotive engineer was experienced at departing trains from the north end of Te Rapa yard. He passed intermediate Signal 54494 and 13 AC Signal each displaying a yellow indication and correctly stopped at the next signal, 6 Signal, which was displaying a red aspect.

2.7 The red aspect should have been expected, because the locomotive engineer had passed the previous 2 signals displaying yellow aspects, and the signalman had only moments previously advised him that the road ahead was unlikely to be clear. On his many previous departures from Te Rapa, on the same road, he had passed 6 Signal displaying a green aspect and considered the signal applied to his road on those occasions.

2.8 The locomotive engineer referred to the description contained within the Te Rapa Signalling and Interlocking Arrangements but had he cross-referenced the description to the accompanying diagram it would have confirmed that 6 Signal did apply to his train. Track section B5 was identified as the section of track on the up main between 13 AC Signal and 6 Signal. If, after consulting his reference material, he still had doubts that the signal applied to his train it would have been prudent and usual practice to contact the person controlling the signal and seek clarification. The signalman received no such call.

2.9 The locomotive engineer took over the train a short time before he passed 6 Signal at stop. Despite the cues and obvious signal to stop and stay he chose to continue, which indicated he had lost situational awareness.

Fatigue

2.10 The Commission considered whether fatigue contributed to the locomotive engineer's loss of situational awareness.

2.11 Fatigue assessment was based on a method developed by the US National Transportation Safety Board and the NASA Fatigue Countermeasures Programme[6]. The method seeks information on the following factors known to produce fatigue-related performance impairment:

- extended wakefulness
- acute sleep loss and cumulative sleep debt
- presence of a sleep disorder
- critical times in the daily cycle of the circadian body clock.

2.12 Falling asleep uncontrollably becomes inevitable when biological sleepiness[7] exceeds a certain threshold. Although the locomotive engineer did not fall asleep, his performance may still have been impaired by fatigue and exacerbated by biological sleepiness. The factors contributing to fatigue-related performance impairment are considered below in relation to this incident.

[6] National Transportation Safety Board 1994. Uncontrolled collision with terrain. American International Airways Flight 808. *Aircraft Accident Report 94/04.*

[7] Biological sleepiness is effectively a message from the brain that it requires sleep, similar to hunger indicating a need for food or thirst indicating a need for water. Biological sleepiness eventually becomes overwhelming, leading to falling asleep uncontrollably.

Sleep history

2.13 The accuracy of information on self-reported sleep history was limited because subjective reports of sleep duration and timing are not necessarily reliable due to the difficulty of remembering details of several days at the time of recall.

2.14 The locomotive engineer was an experienced shift worker, who supplemented his longer duration sleep time with naps and short-duration sleep to prepare himself for a shift. The practice of "split-sleep" is common among night workers and there is considerable scientific evidence to suggest that the sleep period prior to night duty is an effective means of improving alertness and performance during that shift.

Time of day

2.15 Biological sleepiness waxes and wanes across the daily cycle of the circadian body clock. Clinical tests have established that people are most prone to loss of situational awareness caused by fatigue during the early hours of the morning and again during the early afternoon.

2.16 A German study suggested that locomotive engineers' vigilance is at its worst in the early hours of the morning. Automatic brake applications, as a result of locomotive engineers' failure to cancel an alertness device were most likely to occur around 0300 and again in the early afternoon.

2.17 The signal at stop was passed at about 1040, which corresponds to the time in the cycle of the circadian body clock when the biological tendency to lose situational awareness was generally weak. It is normally a part of the cycle when people generally have difficulty falling asleep.

Time on shift

2.18 The German study also found that the elapsed time since a locomotive engineer had been on shift affected the level of alertness during the early hours of the morning. The 0300 peak in loss of situational awareness was more evident in locomotive engineers who were in the 4^{th} to 6^{th} hour of their shift, than in locomotive engineers who were in the first 3 hours of their shift.

2.19 At the time of the overrun the locomotive engineer had completed the 7^{th} hour of his shift and, consistent with the findings of the German study, his level of alertness was probably reduced. Additionally, he had just started the return trip to his home depot. His thought patterns could have been in what is sometimes described as "home-mode," which can also produce a reduction of alertness.

Duration of continuous wakefulness

2.20 Clinical tests consistently show that biological sleepiness increases the longer a person stays awake.

2.21 The signal overrun occurred within 2 hours of the locomotive engineer's last reported nap. Therefore extended wakefulness would not have been expected to contribute to the loss of situational awareness at the time.

Prior sleep loss

2.22 Insufficient prior sleep increases biological sleepiness at all times in the circadian body clock cycle. To be alert and to function well, a person requires a specific amount of night sleep. If the "sleep need" of an individual is not met, the consequences will be increased biological sleepiness, reduced alertness and impaired performance.

2.23 For most people, getting 2 hours less sleep than they need on one night is enough to consistently impair their performance and alertness the next day. The reduction in performance is particularly marked if less than 5 hours sleep is obtained.

2.24 The effects of several nights of reduced sleep accumulate into "sleep debt", with sleepiness and performance degrading. Recovery sleep after an accumulated sleep debt, is usually deeper and more efficient, and the lost sleep does not have to be made up on an hour-for-hour basis. It typically takes 2 full nights of sleep and daytime functioning to return to normal after sleep loss.

2.25 From the information available it was not possible to determine the amount of sleep the locomotive engineer required to feel well rested. For the days before the incident, the locomotive engineer started his shift at 0500 and 0340, and had another 0340 start on the morning of the incident. It is common for shift workers to lose significant amounts of sleep associated with the early starts because of difficulty in going to sleep early in anticipation the night before. Although the locomotive engineer reported going to bed at 2330 and 2200 on the evenings before the 0340 starts, he could not recall the actual time he went to sleep.

2.26 Assuming the locomotive engineer did manage to fall asleep within 15 minutes of his reported time of going to bed and also assuming an undisturbed sleep, then the maximum average night sleep prior to the two 0340 shift starts would have been about 4 hours.

2.27 Based on his self-reported sleep, it was likely that the locomotive engineer experienced some effects of acute sleep loss. The precise magnitude of the sleep debt could not be accurately determined.

Presence of a sleep disorder

2.28 The restorative value of sleep, in terms of reducing biological sleepiness and improving subsequent waking function, depends not only on the amount of sleep obtained but also on the quality of the sleep. Sleep that is restless and fragmented by frequent awakenings also leaves a person sleepy and at risk of impaired alertness and performance.

2.29 Although there are a large number of recognised medical disorders that can disrupt the quality of sleep, there was no evidence to suggest that a medical disorder was responsible for the sleep debt experienced by the locomotive engineer.

Opportunities for recovery from sleep debt

2.30 Breaks between shifts must also provide for all the other activities of life, including travelling to and from work, eating, interactions with family and friends, exercise and other activities of interest. When there is insufficient time for all these activities, there could be pressure on to cut back sleep time. The amount and quality of sleep that a person can obtain during a break is dependent on the time of day the break occurs, the conditions under which sleep is attempted and possible interruptions during sleep.

2.31 The locomotive engineer did take the opportunity and have a split sleep at home on 30 July and reported taking a nap of about one hour at Te Rapa prior to his return journey on 31 July. However, it is likely that he was still suffering fatigue caused by acute sleep loss.

Event recorder

2.32 It would have been appropriate, and in compliance with Tranz Rail's operating procedures, to capture the data available from the locomotive event recorder. The absence of such data has prevented the Commission reaching a more informed decision on the actual cause of passing the signal at stop.

3 Findings

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

3.1 The signalman was appropriately qualified for the duties he was undertaking.

3.2 The signals within Te Rapa yard were correctly set for the conditions prevailing at the time.

3.3 The locomotive engineer was appropriately qualified for the duties he was undertaking, and had local knowledge of operating practices within Te Rapa yard.

3.4 The locomotive engineer initially stopped at, but subsequently passed 6 Signal set at stop at a time when he had lost situational awareness, probably due to fatigue-related performance impairment.

3.5 No collision resulted from passing the signal at stop because the work group and the hi-rail excavator were clear of the track before the train passed, and there were no other rail service vehicles in the section.

4 Safety Actions

4.1 Following a Tranz Rail internal inquiry, the locomotive engineer has:

- successfully completed a series of locomotive engineer theory examinations
- received instruction on the signalling and interlocking arrangements at Te Rapa, including a re-induction site visit
- been observed on a full shift, before being returned to driving duties
- been placed in the safety support system, which consisted of monthly safety observations, followed by 3 bi-monthly safety observations in conjunction with 3 monthly theory examinations
- been suspended from participation in the minder driver programme
- been counselled in preparing himself for shift work.

4.2 As a result of the above actions taken by Tranz Rail and given that the locomotive engineer had recently completed the company Alertness Management Programme no further recommendation has been made regarding this issue.

4.3 Tranz Rail has introduced a flashing yellow over red advance caution signal aspect (second signal in advance at stop), which will be used instead of double caution aspects.

4.4 As a result of the above actions and previous changes made to Tranz Rail's Operating Code, in response to safety recommendation 095/00, no additional recommendation has been made regarding the issue of ensuring locomotive event recorder data is captured following serious operating incidents such as passing a signal at stop.

Approved for publication 26 May 2003

Hon W P Jeffries
Chief Commissioner

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