Report 97-114

Train 801

tunnel door closed on train

Otira Tunnel

12 November 1997

Abstract

On Wednesday 12 November 1997, at about 1140 hours, the door at the west portal of the Otira Tunnel closed on the side of Train 801, the westbound *TranzAlpine*. The impact caused minor damage and there were no injuries.

The door closed because of an unintended activation of the control system by Train 801. An optical sensor which could have prevented the closure was not functioning due to a loose electrical connection. Safety issues identified were a deficiency in the signalling design logic for the door control and the lack of a fail-safe optical sensor safety system.

Transport Accident Investigation Commission

Rail Incident Report 97-114

Train type and number:	Passenger 801
Date and time:	12 November 1997, 1140 hours
Location:	Otira Tunnel at 129.692 km Midland Line
Type of occurrence:	Tunnel door closed on train
Persons on board:	Crew: 5 Passengers: 273
Injuries:	Nil
Damage:	Minor damage to a passenger carriage, the van, and the tunnel door
Investigator-in-Charge:	R E Howe

1. Factual Information

1.1 Narrative

1.1.1 On Wednesday 12 November 1997 Train 801, the westbound (down) *TranzAlpine*, departed Arthurs Pass at approximately 1120 hours.

1.1.2 The consist was two DC locomotives, nine carriages and the van. On board were a locomotive engineer (LE), four train staff and 273 passengers.

1.1.3 The next scheduled stop was at Otira, some 13.3 km to the west with 8.5 km of the journey through the Otira Tunnel.

1.1.4 Normal train operations from Arthurs Pass to Otira were under Centralised Train Control (CTC) incorporating a "vital block section" through the Otira Tunnel controlled by axle counters[1].

1.1.5 The axle counter at the east end of the tunnel was not functioning on 12 November 1997. Tranz Rail Limited (Tranz Rail) had operating procedures to allow for such an eventuality and Train 801 was proceeding under a standard Mis 58/59 authority[2].

1.1.6 Once down trains had departed from Arthurs Pass the only signals displayed before exiting the west end of the tunnel were Signal RDTD (down tunnel door approach) 1400 m from the west portal and Signal DTD (down tunnel door) 100 m from the west portal. These signals advised LEs whether the tunnel door at the west portal, which was recently installed for ventilation purposes, was open or closed.

1.1.7 The LE observed a green indication as he passed each signal indicating the tunnel door was open.

1.1.8 At approximately 1140 hours the locomotive exited the tunnel at a speed of approximately 30 km/h. The LE stated the door was in the expected open position, and the train continued to Otira.

1.1.9 The LE was unaware that the door had started to close after the locomotive exited the tunnel. The door impacted on the right side of the rear passenger carriage and scraped along both this carriage and the van of the train as they exited the tunnel.

1.1.10 The position and status of the Otira Tunnel door was displayed in train control, Christchurch. At approximately 1140 hours the Train Control Operator (TCO) controlling the West Coast traffic noticed the "door moving" indicator was displayed.

1.1.11 Although Train 801 did not come under his control until Otira he was aware of its location and knew that there was something unusual about the "door moving" indication coming up at that time and he alerted the TCO controlling movements to Otira accordingly. He also recalled a red "door failure" light being displayed following the white "door moving" light.

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[1] Because of environmental conditions in the tunnel normal track circuiting was not technically possible and axle counters had been installed at each end of the tunnel to indicate a train in the block. The block was deemed to be clear when the number of axles recorded entering the tunnel was balanced by the number recorded as leaving.

[2] Mis 58/59 authorities are specific procedures to allow a departure signal controlling entry into a single line area to be passed when displaying a "stop" indication because the signal had failed to clear.

1.1.12 The LE called train control on his radio when his train was clear of the tunnel. This was standard procedure to allow train control to activate the manual tunnel ventilation for down trains. He was advised by train control that the tunnel alarm was operating.

1.1.13 There were 18 passengers in the last carriage of Train 801. One of the passengers in that carriage described a "jolt" which he likened to "hitting a telegraph pole" as the carriage exited the tunnel. He stated there was no subsequent exchange of information between the train staff and passengers in the last carriage as to the cause of the subsequent delay at Otira, or the passengers' experiences on exiting the tunnel.

1.1.14 As Train 801 continued towards Otira a separate, and unrelated incident became evident.

1.1.15 The LE of the coal train waiting at Otira saw the approach of Train 801 and noticed the trailing locomotive was emitting smoke from the rear. He radioed the LE of Train 801, who was unaware of any problem, and Train 801 was stopped at the east end of Otira station.

1.1.16 The local volunteer fire brigade were immediately alerted. Fire extinguishers on the locomotive failed to control the fire and the brigade finally extinguished it at approximately 1200 hours, some 15 minutes after arriving at the scene.

1.1.17 During this period one of the train attendants had occasion to walk to the van at the rear of the train and found signs of impact on the right hand side of the last carriage and the van, including heavy damage to the protruding window of the van.

1.1.18 The Signal Technician for the area was at Otira depot when he was advised of the fire and responded. He was assisting to extinguish the fire when the LE of Train 801 advised him of the information from Train Control regarding the operation of the tunnel alarm. As soon as the fire was extinguished the Signal Maintainer drove to the west portal of the tunnel. As he left Otira he noticed the damaged rear of the train but did not link it to any specific cause at that time.

1.1.19 On arrival at the west portal shortly after 1200 hours he found the tunnel door open, with visible damage to the vertical south end of the sliding door and realised that the tunnel door had closed on Train 801.

1.1.20 The initial impact on the right side of carriage AO152, the rear passenger carriage, occurred seven metres from the trailing end. Damage was limited to minor scraping on the strip beneath the windows and body work underneath, and damage to the hand rail. Van AG78 showed signs of impact over the first two metres of the leading end, with no sign of impact for the next five metres. The last eight metres showed only minor scraping. The only major damage was to the handrails and the protruding window towards the rear of the van.

1.2 Previous train movements

1.2.1 The last train in the vicinity of the west portal prior to Train 801 was Work Train 83 operating out of Otira recovering redundant overhead wire near the tunnel.

1.2.2 The axle counting system used as part of the CTC was based on reconciling the number of axles entering the tunnel with the number leaving. With the Arthurs Pass axle counter inoperative Work Train 83 had to run under Mis 58/59 authority.

1.2.3 Work Train 83 left Otira at 0900 hours as an eastbound (up) train and propelled wagons towards the tunnel to recover the overhead wire outside the tunnel near the west portal. The train propelled the last wagon to within approximately 50 m of the west portal during this operation before returning to Otira at 1100 hours.

1.3 Otira Tunnel ventilation

1.3.1 Traditionally trains through the Otira Tunnel had been operated by 1500v DC electric locomotives due to the restrictive effect of the 1 in 33 grade.

1.3.2 For a number of operational reasons Tranz Rail and its predecessors found it preferable to use diesel locomotives in place of the electric locomotives. This raised the problem of fumes in the 8.5 km tunnel and various methods of resolving this problem had been trialled.

1.3.3 Tranz Rail decided on a fan-based ventilation system with a sliding door at the west portal. This system was commissioned on 15 July 1997. A general view of the door in the closed position is shown in Figure 1.

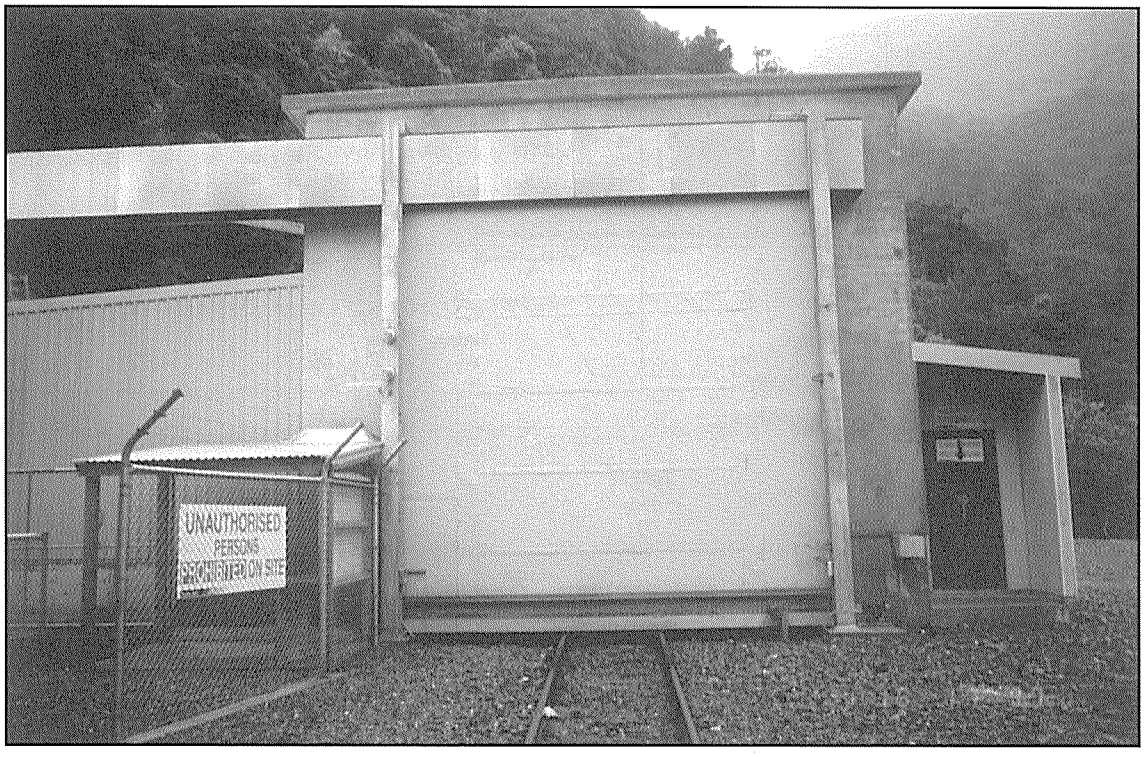

Figure 1
Looking east at the door in the closed position
(the door opens by sliding from south to north)

1.3.4 The system installed was based on three automatic cycles, involving pressure relief, cooling and flushing for up trains. During commissioning it was found that down trains also created a fume problem and a manual procedure for flushing the tunnel after each down train was introduced.

1.3.5 Ventilation for up trains was automatically controlled by train activation of jointless track circuits. Ventilation for down trains was manually controlled by train control at Christchurch.

1.4 Door control system

1.4.1 The signalling system installed to control the door movement is shown schematically in Figure 2.

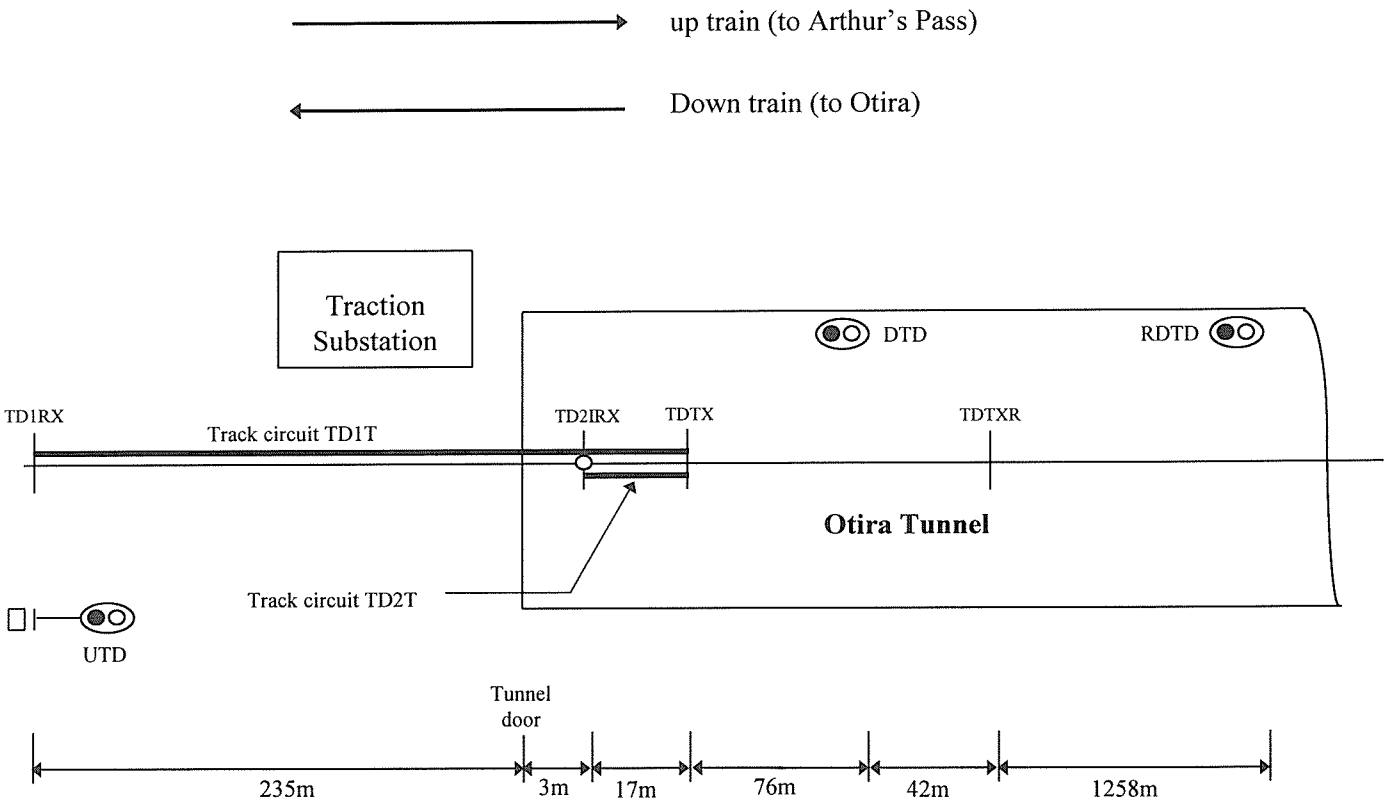

Figure 2
Schematic plan view of the west portal

1.5 Intended automatic operation of the tunnel door by up trains

1.5.1 Signal UTD (at green) indicated the tunnel door was open and allowed the train to enter track circuit TD1T. TD1RX was a jointless track circuit defining a track circuit limit. The normal passage of an up train was detected by track circuit TD1T being occupied before track circuit TD2T. This primed the door system to operate by dropping out a relay and initiating "pick up" of a matching relay. The matching relay was then ready to be energised by a later signal. This was a normal fail-safe operation, i.e. in the case of a failure the initiating relay dropped out indicating the track was occupied.

1.5.2 TD1RX could not differentiate between up and down trains but the logic system could detect an up train based on the sequence of signals received.

1.5.3 TD21RX was also a jointless track circuit defining a track circuit limit. It indicated the start of overlay track circuit TD2T. As for TD1RX, TD21RX could not differentiate between up and down trains. The purpose of overlay circuit TD2T was to determine which end of track circuit TD1T was occupied first. If circuit TD1T had been occupied before circuit TD2T (i.e. a normal up train indication) the door control system was primed at TD1RX. If circuit TD1T had not been occupied the first matching relay did not "pick up" and the door control system was not primed.

1.5.4 When the door system was primed the passage of a train over TDTXR, a train presence detector located 138 m inside the tunnel, energised the "up" matching relay and completed the circuit for the door control demand. TDTXR could not differentiate between up and down trains. Unlike the three track circuit limits, which initiated a relay to drop out, the train presence detector initiated a relay to pick up to indicate the train was present.

1.6 The effect of down trains on door control

1.6.1 Down trains were not intended to be linked to automatic door control. A normal down train passing and activating train presence detector TDTXR would have no effect on the doors as they would not be primed.

1.6.2 On reaching TDTX the simultaneous occupation of track circuits of TD1T and TD2T would prevent priming of the door system when the train reached TD1RX.

1.7 Sequence of events

1.7.1 On 12 November 1997 Work Train 83, travelling in the up direction, claimed track circuit TD1T as it crossed TD1RX some 235 m outside of the tunnel. This immediately primed the door control system as circuit TD1T had been claimed before circuit TD2T.

1.7.2 Work Train 83 returned to Otira at 1100 hours. This cleared section TD1T but left the door control mechanism primed anticipating the normal progress of an up train.

1.7.3 At 1140 hours, Train 801, a down train, was in the tunnel and approaching the west portal with green "door open" indications on Signals RDTD and DTD. When the train reached train presence detector TDTXR the primed door control system circuit was completed and the door closing cycle commenced.

1.7.4 There was a delay of 40 seconds built in before the door started to move. This was necessary to allow the rear of an up train to clear the tunnel portal.

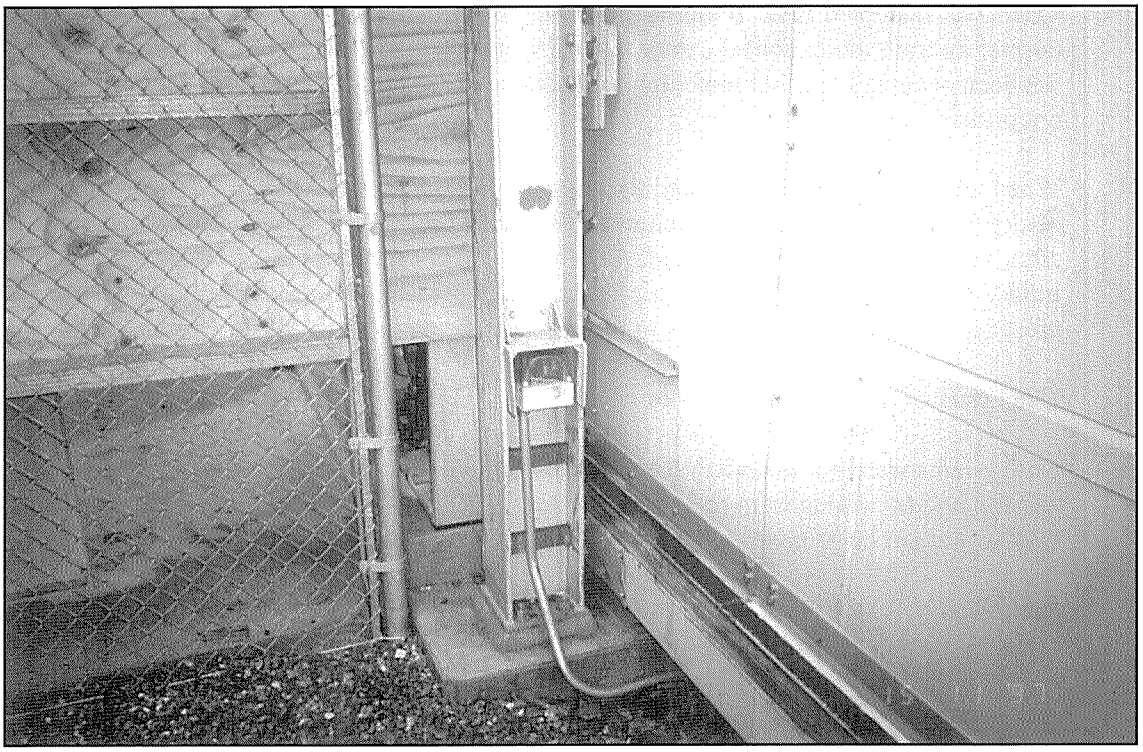

Figure 3
The optical sensor on the north side just outside the tunnel exit

A similar sensor is fitted just inside the tunnel. Two reflectors on the south side return the beams when the open doorway is unobstructed.

1.8 Optical sensor safety circuit

1.8.1 The Otira Tunnel door actuator was fitted with a safety circuit which, when activated, was intended to prevent the door from closing. The safety circuit was connected to two optical sensors which were designed to prevent the door closing if it was obstructed.

1.8.2 The safety system was installed to protect personnel and insulated track equipment in the vicinity of the door when closing. It did not form part of the signalling system and was not linked to it in any way.

1.8.3 Two optical sensors were employed, one on the inside of the door and one on the outside (see Figure 3). Each sensor transmitted a beam across the door opening to a reflector mounted on the other side. The reflector then reflected the beam back to the sensor. If the door opening was obstructed the beam was broken and not received back at the sensor.

1.8.4 The type of sensor used was defined as "dark on" which meant that the output relay controlled by the sensor was energised if the beam was broken and de-energised if the beam was received back at the sensor. This meant that if power was lost to the sensor (which put the output relay into its de-energised state) the system thought that the beam was unbroken and the door unobstructed.

1.8.5 The power to the safety circuit was supplied from the door actuator control box situated just outside the west portal. A detailed check of the door actuator wiring by Tranz Rail electrical staff following the incident revealed a loose terminal block connection supplying power to the safety system which prevented the safety relay from energising.

1.8.6 The terminal block connections were a screw down type which if tight provided a secure connection. Tranz Rail advised it had been standard practice to remove the wire from that particular terminal in order to bypass the safety circuit for testing purposes and that it appeared that after the last such occasion the wire was not terminated correctly.

1.8.7 Tranz Rail did not specify a fail-safe design requirement for the optical sensor safety circuit, and the system as designed and installed did not provide such protection.

1.9 Door details

1.9.1 As part of the safety system the design of the sliding door incorporated features to ensure that when in the closed position it presented a minimum obstruction to a train. This was achieved by a strong portal frame structure with a "knock through" centre.

1.9.2 The contract documents required the actuator to apply on the door a minimum force of 500 kg. Tranz Rail advised that with the current hydraulic relief valve setting on each actuator (approximately 17000 kpa), the stalled door exerted a force of approximately 645 kg in the direction of door motion.

1.9.3 The contract documents required the door to close in 15 seconds or less. This translated to a door speed not less than about 0.4 m/s. The door as installed closed in about 13 seconds which gave a mean door speed of about 0.42 m/s.

1.10 Fire in locomotive DC4634

1.10.1 The fire in locomotive DC4634 occurred because a frayed wire prevented a cooling fan operating. The lack of the fan caused one of the four locomotive dynamic brake grids used as a heat sink to overheat. The heat generated caused local combustion of deposited debris and cabling. The damage was limited to two dynamic brake grids and the compressor compartment underneath.

1.11 Risk assessment

1.11.1 The Otira Tunnel ventilation system was a major work involving significant change to the operational arrangements for the Otira Tunnel. Tranz Rail managed the installation as a project by co-ordinating consultants, a series of main contractors, and their own signalling "design and install" capability to achieve the desired end result.

1.11.2 Tranz Rail's Company Procedure C/004, "Safety Manual" was the key document underpinning the approved safety system under which Tranz Rail operated. It required a new risk assessment to be carried out before new processes or methods were introduced to elements of the safety system "which may affect their level of safety". Although Tranz Rail advised risk assessment principles were applied at various stages of the project no formal risk assessment of the operating system was carried out prior to commissioning of the ventilation system.

2. Analysis

2.1 Automatic door operation

2.1.1 The door closure was initiated by a combination of trains which had not been anticipated when the program was designed for the logic controller which received input from the signalling system to automatically operate the door and fans for up trains.

2.1.2 The running of work trains is a standard part of Tranz Rail's operations. The operation of the work train in the vicinity of the west portal was a predictable event, particularly when considering the demand for:

- access for the planned removal of the overhead following commissioning of the ventilation system, and
- possible future access for maintenance purposes to the bridge immediately outside the portal.

2.2 Optical sensor safety circuit

2.2.1 The optical sensor safety circuit was not part of the signalling system and was not intended as an element of the safety system to avoid the tunnel door closing on a train. Its purpose was to prevent a door closing on personnel and insulated vehicles using the tunnel entrance.

2.2.2 The likely cause of the loose connection which rendered the optical sensor safety system inoperative was the failure to terminate it correctly following testing.

2.2.3 Had the sensor system been operational the incident under investigation would have been avoided. The continual breaking of the beam by the passage of Train 801 would not have permitted the door to close.

2.2.4 Had the sensor system been fail-safe, i.e. a power failure energised the output relay and made the system respond as if the beam was broken, an improved level of protection would have been provided to personnel in the vicinity of the door when the door closure was initiated. This should have been a performance requirement for the door operation.

2.2.5 A fail-safe sensor system, although not intended to provide protection for trains, would have prevented the door closing on Train 801 due to the combination of train movements which occurred on 12 November 1997.

2.3 Door details

2.3.1 Although the "knock through" design permitted a train to pass through the light central door structure, this safety feature did not provide protection for the combination of factors which caused the incident on 12 November 1997.

2.3.2 It was fortuitous that the door closed on a carriage rather than on a gap between carriages. If the door closing had coincided with the 0.9 m gap between carriages the relative speed of the train and the door could have resulted in a maximum 55 mm protrusion of the structural door frame impacting on the following carriage with the likelihood of more serious consequences. There was no obvious indication that the door had moved in the gap between the rear carriage and the van after impacting on the carriage, and it is likely that the 0.13 seconds which elapsed as this gap passed the door was too short to allow any significant movement of the door from rest.

2.4 Risk assessment

2.4.1 The system for operating the integrated signalling system and door and fan operation was a first for Tranz Rail, and involved original designs and new processes and methods. Such "one off" design solutions for particular problems are likely to involve increased risk. The nature of the project was such that it is considered a formally structured risk assessment was essential before commissioning. A structured risk assessment should have revealed both of the factors which contributed to this incident.

2.5 Fire in locomotive DC4634

2.5.1 Overheating of dynamic brake grids is not uncommon, although not usually due to inoperative fans. This fire was not directly linked to the incident under investigation and is not dealt with further in this report.

2.6 Failure of the Arthurs Pass axle counter

2.6.1 The failure of the axle counter at Arthurs Pass was not related to the incident. If normal CTC operations, including the axle counters, had been in effect the work train would still have primed the door when working near the tunnel. With the door primed for an up train the down departure signal at Arthurs Pass would not have been able to display a proceed indication for Train 801. Mis 58/59 procedures would then have been used to allow Train 801 to proceed with the likely same end result as applied on the day. The failure of the Arthurs Pass axle counter is not dealt with further in this report.

3. Findings

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

3.1 Train 801 was travelling under authorised operating procedures and was operated correctly.

3.2 Work Train 83 was travelling under authorised operating procedures and was operated correctly.

3.3 The signals indicating the status of the tunnel door operated as intended.

3.4 The logic of the integrated signalling and door control system did not allow for the situation of a train entering and leaving the vicinity of the west portal without entering the tunnel.

3.5 The operations of a work train, in the vicinity of the west portal, which did not enter the tunnel, was a likely and predictable scenario.

3.6 Although the door sensor system was not intended to supply protection for trains it could have overcome the signalling design deficiency and prevented this incident if the wiring had been correctly terminated or the system designed to be fail-safe.

3.7 Tranz Rail's failure to design a safety system for the predictable and authorised train operations which initiated this incident was not picked up during the planning, design or commissioning stages of the project.

3.8 The lack of a formal risk assessment of the operating system prior to commissioning prevented a chance to identify and correct the signalling design inadequacy or appreciate the possible significance of the "dark-on" principle of sensor operation.

4. Safety Actions

4.1 Door control system

4.1.1 Immediately following the incident Tranz Rail track-locked the door actuator control which meant the door could not close when track circuit TD1T was occupied. This interim modification overcame the design deficiency, although it had the operating disadvantage of not permitting manual overriding of the system.

4.1.2 Since DC traction was removed from the area Tranz Rail have redesigned the signalling on conventional insulated joint track circuitry involving two adjacent track circuits. The new system allows for automatic ventilation for both up and down trains, and will be able to detect and allow for the direction of each train. The new system is programmed for installation by July 1998.

4.2 Optical sensor safety circuit

4.2.1 Tranz Rail have redesigned the safety circuit system to a fail-safe "light-on" operation and the modification will be made when the new signalling system is installed.

5. Safety Recommendation

5.1 On 17 July 1998 it was recommended to the Managing Director of Tranz Rail that he:

5.1.1 Take steps to ensure that before introducing operational innovations such as the Otira Tunnel ventilation system that adequate structured risk assessments are carried out, and recorded, to achieve the intent of the company safety system. (048/98)

5.2 In his response of 13 August 1998, the Managing Director of Tranz Rail stated that although Tranz Rail considered the issue at Otira was a design issue, and not a risk assessment issue, Tranz Rail would conduct adequate structured risk assessments for significant operational innovations.

Approved for publication 5 August 1998

Hon. W P Jeffries
Chief Commissioner