Report 00-103

Train 2139

partial brake failure

Auckland

15 March 2000

Abstract

On Wednesday, 15 March 2000, at approximately 1928 hours, Train 2139, a diesel multiple unit passenger service, suffered a partial brake failure while descending the grade from Newmarket to Auckland. A permanent 25 km/h speed restriction on curved track approaching the station was negotiated at about 45 km/h before the service came to a stop some 40 m past its normal stopping place.

The partial brake failure was caused by a combination of a broken air pipe and a seized air valve.

A safety issue identified was the ability of brake efficiency tests to identify triple-valve defects.
Tranz Rail took action to address the safety issue, and no recommendations were made arising from this investigation.

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

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.

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List of Abbreviations

DMU	diesel multiple unit
EP	electro-pneumatic
km	kilometre(s)
km/h	kilometre(s) per hour
kPa	kilopascal
LE	locomotive engineer
m	metre(s)
Tranz Rail	Tranz Rail Limited

Data Summary

Train type and number:	diesel multiple unit (DMU) 2139
Date and time:	15 March 2000, at 1928 hours
Location:	Auckland
Type of occurrence:	partial brake failure
Persons on board:	crew: 2 passengers: 3
Injuries:	nil
Damage:	nil
Operator:	Tranz Rail Limited (Tranz Rail)
Investigator-in-charge:	R E Howe

1. Factual Information

1.1 Narrative

1.1.1 At about 1928 hours on Wednesday 15 March 2000, Train 2139, a DMU passenger service comprising ADC 855 (trailer car) leading and ADL 805 (power car) trailing was descending the grade from Newmarket into Auckland. On board were the locomotive engineer (LE), a guard and 3 passengers.

1.1.2 The descent down the grade to Tunnel 1 had been uneventful. The LE made a brake application to steady the train around the 50 km/h curve at the entrance to Tunnel 1 about 2.2 km from Auckland and the brakes responded normally.

1.1.3 When the train was part way through the tunnel at about 1.8 km the LE saw a green over red indication ahead on the Up Approach signal at 1.47 km, followed by a yellow over green on the Up Home signal at 0.97 km. He accelerated briefly on these proceed indications.

1.1.4 The LE recalled his speed being 70 km/h at about 1.1 km, which was when he made a further brake application to slow the train speed through the up main to down main crossover turnouts.

1.1.5 The LE described the sequence he went through to slow his train prior to the turnouts as follows:

- made a slight brake application to steady the train, then put the controller[1] into lap[2]
- realised that the brakes were having no effect
- thinking that he might be sliding, he put the controller into release
- then put the controller to full service braking
- again found no effect
- then put the controller into emergency braking.

Re-creation of this sequence showed an elapsed time of about 10 seconds.

1.1.6 At about this time the LE observed that the park brake light was illuminated and that the main reservoir pipe air pressure was 200 kPa instead of the normal 760 kPa.

1.1.7 The train speed reduced gradually, but the LE realised he would not be able to bring the speed down to the 25 km/h permanent speed restriction in place from 0.5 km to 0.2 km on a right-hand 150 m radius curve.

1.1.8 The LE estimated his train speed was 45 km/h and slowing as he negotiated the curve. He described the sensation as “the unit heeled over and rocked and rolled, it was the fastest I have ever been around that curve”, and said that he felt that his unit was going to come off the rails.

1.1.9 The next signal following the Up Home was the No. 4 Up Directing signal to the platform, which was displaying a red over yellow aspect (medium speed indication) as Train 2139 passed it, entered the platform area and eventually came to a halt about 40 m past the normal stopping point.

1.1.10 After the train had come to a stop the LE noticed that the main reservoir pipe air pressure was still steady at 200 kPa.

[1] On a DMU the control of both power and braking was in one handle termed a controller.
[2] Lap is a controller position which holds the brake in the selected application.

1.1.11 The LE inspected his train and found a broken air pipe on the number 2 bogie of the ADL power car. He isolated the brakes on that half of the unit, which had the effect of restoring main reservoir pipe air pressure and enabled the empty train to be taken to Otahuhu at reduced speed.

1.1.12 The guard was in the rear car as the train descended into Auckland. He stated he did not notice anything unusual until the train stopped beyond its normal stopping point. He didn't feel anything unusual going around the curve because, as he put it, "We learn to balance when taking turnouts." He was standing at the time and said there were no comments from the passengers regarding the transit around the curve.

1.2 Site details

1.2.1 The approach from Newmarket to Auckland was down a 1 in 45 grade. The last curve negotiated before entering the platform was a 150 m radius right-hand curve with zero cant[3]. Tranz Rail advised the zero cant was probably because there was a double track bridge in the centre of the curve, and turnout points between the platforms still within the curve at 0.2 km. Zero cant in a curve of this radius meant that the curve speed was required to be limited to 30 km/h to give an adequate factor of safety against overturning. However, the turnout points near the end of the curve required a restriction of 25 km/h. A speed of 25 km/h had been posted on the whole curve for simplicity.

1.2.2 Tranz Rail also advised that the sighting of No. 4 Up Directing signal just beyond the last curve was normally about 125 m, which was just adequate for a 45 km/h approach speed based on a minimum 10 seconds sighting. However, this view could be restricted if an outgoing train was heading towards Newmarket and therefore a maximum approach speed of 35 km/h was required to maintain sighting standards. The afore mentioned 25 km/h permanent speed restriction achieved this.

1.3 DMU braking system

1.3.1 The brakes on the DMUs were applied by air pressure pushing brake blocks against the wheels.

1.3.2 The basic brake was an automatic system in which the LE's controller applied and released the brakes by using the brake position on the controller to regulate the air pressure in the brake pipe. It was termed automatic because the brakes automatically applied without any input from the LE if the vehicles became uncoupled. The triple valve in each car responded to the variations in the brake pipe air pressure and applied the brakes, released the brakes and recharged the air reservoir as appropriate. There was one auxiliary air reservoir in each car for this automatic system.

1.3.3 Superimposed upon the automatic brake system was an electro-pneumatic (EP) brake system where separate positions of the LE's controller energised magnet valves which allowed main reservoir pipe air pressure into the brake cylinders to apply the brake blocks to the wheel. De-energising the magnet valves allowed the brakes to release. The main reservoir pipe was common to both cars and separate to the brake pipe and individual auxiliary reservoirs on each car associated with the automatic brake system. EP brake application did not affect the automatic air brake in any way. The EP brake was the one used by the LE for normal operation.

1.3.4 Because the main reservoir pipe serving the EP braking was common to both cars on the DMU, any loss of pressure affected both cars. Although each car had separate piping servicing the automatic brakes, which was independent from the main reservoir pipe, the 2 supplies were common at the brake cylinder. This meant that the brake cylinder pipe failure on one car would affect both brake systems on that car.

[3] Cant is the height of the outside rail of a curve above the inside rail to compensate for centrifugal force. In this case they were at the same level.

1.3.5 When an LE made an emergency brake application both the EP and the automatic air brake were applied.

1.3.6 The DMUs were also fitted with park brakes. The park brakes were not intended to stop a DMU in motion, but merely to hold them when stationary. The brakes were applied automatically by spring action when the main reservoir pipe pressure dropped below 360 kPa. When this happened a light was illuminated in the cab.

1.4 DMU inspections

1.4.1 The last maintenance check on this DMU was on 22 February 2000, at which time the required ADL/ADC brake maintenance and testing requirements had been carried out. No specific defects were found.

1.4.2 The brake efficiency tests forming part of the brake maintenance and testing requirements did not specifically require a check that an emergency brake application held.

1.5 Post-incident tests

1.5.1 The broken brake cylinder pipe was recovered and inspected in a laboratory. This revealed a fatigue failure consistent with having been caused by vibration.

1.5.2 The relatively poor braking response, even allowing for a broken brake cylinder pipe on the ADL car, prompted tests to recreate the events of the day. These showed a fault in the operation of the triple valve on the ADC car where the brake cylinder exhaust valve was found seized in its valve body. This would have allowed any air pressure required for emergency braking to vent direct to atmosphere. The interlock valve was also seized and would not slide in the valve body, but this would have had no affect on braking. An amount of corrosion powder and scale was found around the valve seats. Both valve stems had small quantities of corrosion powder around where they entered the valve body. The triple valve did not appear damp when dismantled. Considerable force was required to free the seized valves.

1.5.3 Further tests carried out following the incident showed that the handbrakes and a low EP brake application would check the speed on the 1 in 45 grade, but not adequately brake the DMU. They also showed that the handbrakes on both cars and a fully operational emergency brake on one car could effectively brake the DMU on this grade with the equivalent of about 60% of normal maximum EP braking effort. This latter test duplicated the situation for Train 2139 had the triple valve not been defective.

2. Analysis

2.1 ADL 805 brake pipe failure

2.1.1 The fatigue failure of a brake cylinder pipe due to vibration, while not common, could be expected to occur from time to time. Such a defect would not be easy to find during normal inspections before failure occurred.

2.1.2 Positive brake response early in the descent of the Newmarket grade showed that the air pipe failure occurred only a short time before the incident, probably after departure from Newmarket.

2.1.3 Failure of the air pipe on ADL 805 would not initially affect the EP brakes on the trailing car. However the continuous ducting of main reservoir pipe air to the atmosphere quickly reduced the air pressure in the brake cylinders, as the 2 cars had a common main reservoir pipe system. The reduction in main reservoir pipe pressure would continue until it reached the point where the compressor could maintain that pressure against the leak.

2.1.4 The effect of the brake pipe failure in isolation would greatly reduce EP braking on both cars of the DMU and nullify emergency braking on the ADL. However, as field tests carried out on the Newmarket grade showed, the DMU could still be effectively braked in demanding conditions by a combination of emergency braking on one car and reduced EP braking and/or automatic park brake application on both cars.

2.1.5 In normal circumstances, the emergency braking on the ADC car would have still functioned. However, the seized exhaust valve in the triple valve on that car exhausted the air and stopped the emergency brake application applying the brakes on that car.

2.2 ADC 855 triple valve failure

2.2.1 The difficulty in freeing the seized valves and the corrosion products present indicated that the valves had been seized for some time, possibly prior to the February maintenance check.

2.2.2 The brake efficiency tests for DMUs did not require a check that an emergency brake application held. This may account for the evidence of long-term valve sticking, despite an efficiency test only 3 weeks before the incident.

2.2.3 Tranz Rail advised that it was assumed, when these test procedures were written, that it would be obvious to any trained railway person that any brake application, once made, should be capable of being maintained. However, it could be inferred from a strict interpretation of the instruction that a check on the brake cylinder pressure being maintained was not required. Such a check on maintaining pressure was not carried out following the replacement of the brake cylinder pipe and resulting brake testing after the incident. Tranz Rail has taken action to clarify this requirement as detailed in section 4 of this report.

2.2.4 The seized exhaust valve on the triple valve of this car meant that air was only in the brake cylinders for a short time before it leaked away through the restriction in the brake cylinder exhaust port.

2.4.5 This defect would not have been apparent when using the controller with effective EP brakes as the EP brake effect would have hidden the triple valve failure.

2.2.6 The effect of such a failure in isolation would have been to nullify emergency braking on the ADC car, leaving an overall braking ability about similar to that resulting from a broken brake cylinder pipe alone.

2.3 Combined failure implications

2.3.1 The combined effect of the long-term triple valve problem, which had not shown up in normal operation and may have been present during the last inspection, and the sudden brake pipe failure was a loss of most EP braking and all emergency braking on both cars of the DMU.

2.3.2 The field test showed residual low EP braking, together with the resistance from the park brakes, was sufficient to check the speed on the steep grade but not adequately brake the DMU.

2.3.3 Triple-valve failures and brake-pipe failures are not common. The possibility of them both occurring together is therefore unlikely. However it did occur, and on one of the steepest grades in the Tranz Rail system. Despite this the DMU speed was slowed down the grade, which indicated the robustness of the total braking system.

2.4 Curve speed

2.4.1 The braking available reduced the DMU speed from about 70 km/h to 45 km/h before the curve was negotiated at approximately 1.5 times the permitted curve speed of 30 km/h. Based on previous overturning tests, and the low centre of gravity of the DMUs, a likely factor of safety against overturning of such vehicles is 1.8. Although the excessive speed would have caused severe movement, the DMU still had a residual factor of safety against overturning.

3. Findings

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

3.1 Train 2139 suffered 2 separate and unrelated brake defects as it descended the grade into Auckland.

3.2 The failure of the brake cylinder pipe on ADL 805 was caused by fatigue, probably due to vibrations. Evidence of fatigue stress would be difficult to detect during routine inspections.

3.3 The seizing of the triple valve exhaust on ADC 855 was due to corrosion products caused by water ingress. It was likely that the valve had been seized for some time.

3.4 The lack of a specific requirement to ensure an emergency brake application held, meant this exhaust valve defect may have gone unnoticed during the last inspection and testing.

3.5 The use of EP braking for normal operation meant that the deficiency in the automatic braking system was not detected until a situation requiring emergency application arose.

3.6 The DMU had sufficient brake system capacity to absorb a single failure of these types without losing effective braking.

3.7 Despite the unusual combination of 2 separate defects which each eroded the DMU’s braking ability, the LE was able to reduce train speed as he descended the steep 1 in 45 grade approaching Auckland.

4. Safety Actions

4.1 Tranz Rail has amended the DMU brake efficiency tests to include a check on the emergency brake cylinder pressure remaining steady, which will provide greater certainty that a faulty triple valve is detected.

4.2 For ADL/ADB DMUs an emergency brake application using the controller does not test the triple valve adequately due to the masking affect of EP braking. For these units Tranz Rail have introduced a new test requiring opening the cab brake-pipe cock to test the triple valve on its own.

4.3 In view of the safety actions taken by Tranz Rail immediately following this incident no recommendations have been made arising from this investigation.

Approved for publication 24 January 2001

Hon. W P Jeffries
Chief Commissioner