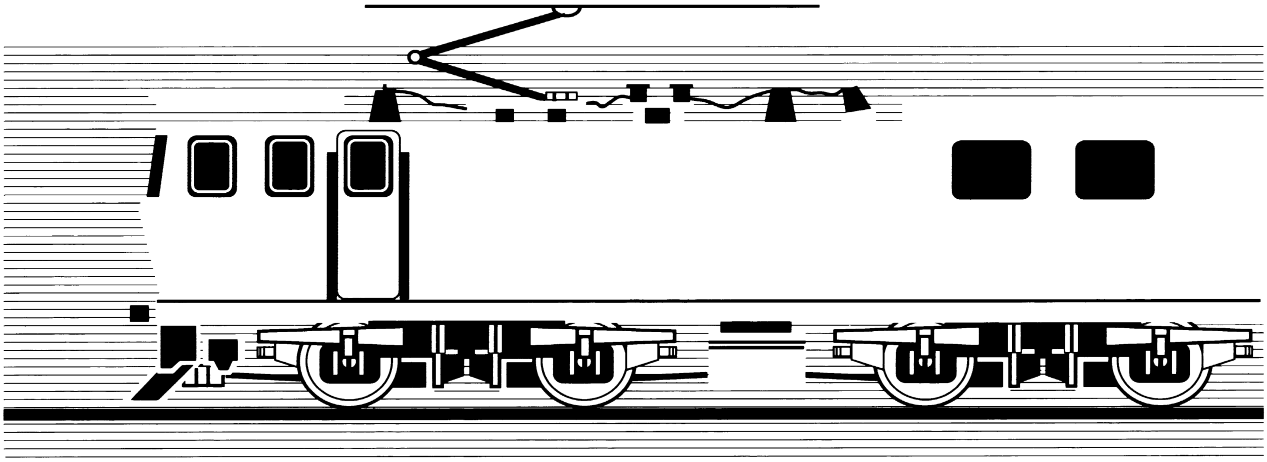
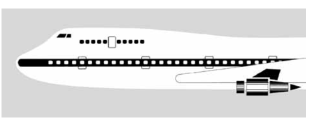
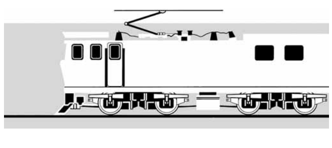


RAILWAY OCCURRENCE REPORT

04-112 **Diesel multiple unit passenger Train 2146, fire auxiliary engine, Boston Road** **16 April 2004**





TRANSPORT ACCIDENT INVESTIGATION COMMISSION NEW ZEALAND

Report 04-112

diesel multiple unit passenger Train 2146

fire in auxiliary engine

Boston Road

16 April 2004

Abstract

On Friday, 16 April 2004, at about 1725, smoke was observed coming from beneath Train 2146 as it departed Newmarket. The train stopped at the next station, Boston Road. The passengers were evacuated and the fire was extinguished with the assistance of the New Zealand Fire Service.

There were no injuries.

The safety issues identified were:

- the fittings connecting the oil inlet hose to the engine and the turbocharger
- the shroud panels surrounding the auxiliary engine.

One safety recommendation was made to the Chief Executive of Auckland Regional Transport Authority.

Contents

Figures

Abbreviations

Alstom	Alstom New Zealand Transport Services
DMU	diesel multiple unit
km	kilometre(s)
km/h	kilometres per hour
LEMU	locomotive engineer multiple unit
m	metre(s)
mm	millimetre
Toll Rail	Toll NZ Consolidated Limited
Tranz Rail	Tranz Rail Limited
UTC	coordinated universal time
Westrail	Western Australian Government Railways

Data Summary

Train type and number:	diesel multiple unit passenger Train 2146	
Year of manufacture	auxiliary engine	1983
	turbocharger	1983
Date and time:	16 April 2004 at about 1725[1]	
Location:	Boston Road	
Persons on board:	crew:	4
	passengers:	about 70
Injuries:	crew:	nil
	passengers:	nil
Damage:	minor fire damage to engine compartment, components and wiring.	
Operator:	Tranz Rail Ltd (Tranz Rail)	
Investigator-in-charge:	D L Bevin	

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

1 Factual Information

1.1 Narrative

1.1.1 On Friday, 16 April 2004, Train 2146 was the scheduled 1635 Tranz Metro[2] diesel multiple unit (DMU) passenger service from Britomart to Waitakere. It consisted of powered car ADL808 (for traction) and non-powered car ADC858.

1.1.2 Train 2146 was crewed by a locomotive engineer multiple unit (LEMU) driving from ADL808, a train manager and 3 passenger operators. Train 2146 was conveying about 70 passengers.

1.1.3 As Train 2146 approached Newmarket, the locomotive engineer saw on his driving console a low water warning light for No.2 engine on ADL808, so he stopped the train outside the signal box and replenished the water. The warning light extinguished so he moved the train on to the Newmarket platform for passengers to board and alight.

1.1.4 Shortly after departing from Newmarket, the crew of a passing passenger train alerted the locomotive engineer to smoke coming from under the rear car of Train 2146. The locomotive engineer continued on and stopped at the next station, Boston Road. He saw smoke and flames coming from the vicinity of the auxiliary engine, so shut down the engines and instructed the train crew to evacuate the passengers.

1.1.5 The auxiliary engine was enclosed on all sides by shroud panels, which hindered attempts by the train crew to extinguish the fire. Emergency services were called when the fire extinguishers carried on the train had been expended. The shroud panels were too hot for the train crew to handle, so when the Fire Service arrived they sprayed water on the panels before they were removed to allow access to the seat of the fire.

1.1.6 Passengers were transferred to a following service, and a relief DMU towed the disabled train back to the DMU depot at Westfield for repair.

1.2 Site information

1.2.1 Boston Road was the first station past Newmarket on the North Auckland Line. It had platforms adjacent to the main line and the loop (see Figure 1).

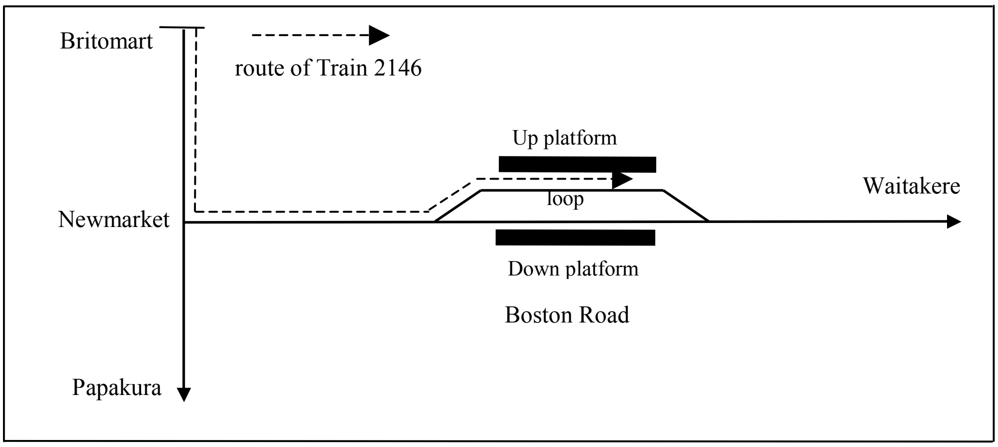


Figure 1
Route plan Britomart - Newmarket - Boston Road (not to scale)

1.2.2 The signalling and interlocking system was remotely controlled from the national train control centre in Wellington.

[2] Tranz Metro was the group within Tranz Rail with the responsibility for the operation of suburban services in Auckland.

1.3 Personnel

The locomotive engineer

1.3.1 The locomotive engineer was recruited by Tranz Metro Auckland on 27 January 2003 and underwent induction and theory training at Tranz Rail's Auckland training facility. His training had included fighting oil and electrical fires.

1.3.2 After a period of on-the-job training he was appointed to a full-time position on 20 November 2003. At the time of the incident he held the appropriate DMU driver certification. His last safety observation had taken place on 6 April 2004.

1.3.3 When he was alerted to the smoke coming from beneath ADC858, he decided to continue the short distance to Boston Road, because he said he considered it to be a safer location should it be necessary to evacuate the passengers. After stopping at Boston Road, he looked back from his driving cab window and saw smoke, then flames, coming from under the trailing car of his train. He immediately shut down the engines, including the auxiliary engine on ADC858, and instructed the train manager to evacuate the passengers.

1.3.4 After the passengers were evacuated, the locomotive engineer and the train manager fought the fire with the 2 dry-powder fire extinguishers carried on the train, but they could not direct the powder on to the auxiliary engine as it was enclosed by the shroud panels. Eventually the fire extinguishers were exhausted, at which time the locomotive engineer advised the train controller of the situation and requested him to arrange for the Fire Service to attend.

1.3.5 The Fire Service arrived shortly afterwards, and the locomotive engineer suggested they cool the panels so they could then be removed to allow access to the seat of the fire. Once the panels were removed the Fire Service was able to extinguish the fire.

The on-board train crew

1.3.6 All on-board train crew held current certifications. They marshalled passengers to an assembly point well away from the fire while alternative transport arrangements were made.

1.4 Locomotive event recorder

1.4.1 The DMU was not equipped with a locomotive event recorder.

1.5 Diesel multiple units

1.5.1 The ADL and ADC passenger cars were originally owned by Western Australian Government Railways (Westrail) and operated in Perth, Western Australia. ADL808 and ADC858 were built in 1984 by A. Goninan and Company Limited of Newcastle, New South Wales and were commissioned on the Auckland rail network during 1993.

1.5.2 The DMUs consisted of a permanently coupled ADL powered unit and an unpowered ADC car to make a 2-car set. Multiple 2-car sets could be coupled together to make 4-, 6- or 8-car consists.

1.6 DMU inspection and maintenance

1.6.1 Tranz Rail purchased the DMU fleet from Westrail in 1993, at which time it received the respective drawings and maintenance schedules, including the Goninan maintenance manual, and the Stamford alternator and Detroit model 471T engine manuals.

1.6.2 Tranz Rail's mechanical code M2000 determined that ADC cars were to be inspected at the following intervals:

• daily check	every night
• A Check	every 6 weeks
• B Check	every 3 months
• C Check	every 6 months
• D Check	every 12 months

1.6.3 The daily checks were carried out at the servicing depot by qualified maintenance staff during the DMUs overnight downtime and included checking defects reported by LEMUs.

1.6.4 The 6-weekly A Check required the following work on the auxiliary engine/alternator of the ADC cars to be carried out:

- change the oil and the oil filters of the auxiliary motor
- steam clean all engines (including inside the auxiliary motor shroud)
- check for fuel, oil, water and exhaust leaks
- repair any leaks found

The B, C and D Checks specified no other work to be carried out on the auxiliary engine, but the A Check was repeated for the higher order B, C and D Checks.

1.6.5 The most recent A Check on ADC858 was carried out on 16 March 2004. No defects or repair requirements were identified during that check.

1.7 The auxiliary engine

1.7.1 ADC858 was not powered for traction but was fitted with a turbocharged diesel engine coupled to a Stamford alternator that provided 125 kW of power. This auxiliary engine was used to provide electrical power for ancillary services such as the air conditioning, saloon and cab lighting and headlights for the 2-car consist.

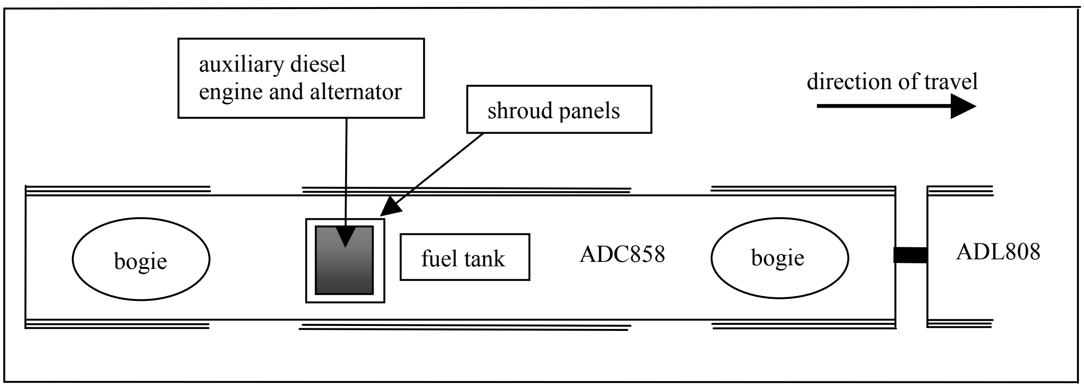


Figure 2
Under-floor plan of ADC 858 showing location of auxiliary engine (not to scale)

1.7.2 The auxiliary engine was manufactured by Detroit Diesel in the United States of America. It was a model 471T, 4-cylinder in-line diesel engine and was fitted with a Garrett turbocharger. The unit had been supplied by Detroit Australia as a standby generator and had been installed on ADC858 DMU during its construction.

1.7.3 Records covering the servicing history of the engine while operating in Australia were not available, but sometime between 1983 and 1993 the Garrett turbocharger was replaced by a Schweitzer turbocharger. Detroit Diesel advised that there were turbochargers from at least 6 different manufacturers that were compatible with the model 471T engine.

1.7.4 The refurbishment of ADC858 in 2003 by Alstom[3] was part of a program to extend the operational life of the DMUs. An overhaul of the auxiliary engine and turbocharger was included in that refurbishment.

1.7.5 The Tranz Metro DMU fleet maintenance supervisor arranged for ADC858 to be checked when it arrived back at the DMU depot after the fire. The auxiliary engine was restarted and as soon as the oil pressure began to build up a fine spay of oil came from about the middle of the oil inlet hose[4], and towards the hot exhaust pipe.

1.7.6 The oil inlet hose and other fire-damaged components were replaced, after which the auxiliary engine was left running for about 3 hours and was checked at regular intervals. The supervisor allowed the DMU to be placed back into service on the following Monday as the auxiliary systems were working correctly.

1.8 The turbocharger

1.8.1 Turbochargers were used to increase the power output and efficiency of an engine by compressing the air flowing into the engine and so allowing more fuel to be used, resulting in more power being developed from each cylinder. The turbocharger consisted of an exhaust-gas-driven turbine wheel and an air blower or compressor wheel separately encased, but mounted on a common shaft. Exhaust gases passed through nozzles in the turbine housing, causing the turbine to rotate; this turned the shaft, which rotated the compressor wheel. At service speed, the turbocharger shaft rotated at about 30,000 revolutions per minute and the turbine casing was at about the same temperature as the exhaust, which at service speed was about 450°C.

1.8.2 Because of the high-speed shaft rotations and high temperatures experienced in turbochargers, the shaft bearings required constant lubrication. On the Detroit Diesel 471T, lubrication was taken directly from the engine's lubrication system at a pressure of between 45 and 85 pounds per square inch. There was a flexible stainless steel braided feeder hose (the oil inlet hose) between the engine lubrication gallery and the turbocharger. The lubricating oil entered the top of the turbocharger casing between the turbine and the air blower.

1.9 The oil inlet hose and connector fittings

1.9.1 The oil inlet hose was manufactured by Parflex Fluid Connections of the United States of America and had been fitted by Alstom during overhaul in 2003. The hose consisted of an internal poly tetra fluoroethylene (polymer) tube with a stainless steel braided outer covering.

1.9.2 The oil inlet hose was connected to the engine and the turbocharger by straight fittings. Detroit Diesel's parts catalogue specified that a 3/8" elbow fitting be used when connecting the oil inlet hose to the model 471T engine, but there was no similar specification for connecting the hose to the turbocharger.

1.9.3 The straight fittings used to connect the oil inlet hose to the engine and the turbocharger resulted in the hose completing an unsupported 180° loop over the turbocharger air inlet (see Figure 3). This was Tranz Rail's preferred assembly rather than a route created by the angled connections between the turbo charger and the engine which, although shorter, would place the hose close to and over the hot engine block.

[3] In April 2002, Tranz Rail contracted out the inspection and maintenance of locomotives and rolling stock to Alstom New Zealand to standards set by Tranz Rail.
[4] The oil inlet hose carried heated oil from the auxiliary engine to the turbocharger.

Figure 3
The replacement oil inlet hose looped over the turbocharger air inlet

1.9.4 The model 471T engine was 20 years old and, along with spare parts, was no longer manufactured by Detroit Diesel, although some spares were still available on the Australian and New Zealand markets. Detroit Diesel expected local mechanical practices would be employed for the supply and maintenance of the oil inlet hoses and fittings on these engines, regardless of the type of turbocharger fitted.

1.9.5 A hose expert indicated that the inner tube of this type of braided hose was not susceptible to heat damage at temperatures below about 260^0C, and should not deteriorate with age. However, he said that the inner tube was vulnerable to torsional stress.

1.10 The shroud panels

1.10.1 As part of the refurbishment of the ADC non-powered units, the auxiliary engines were enclosed with shroud panels. This work was done for noise suppression, particularly while the vehicles were in the underground station at Britomart, as the auxiliary engines ran continuously. The panels fitted around the engine and provided working clearance and were removed for access during maintenance.

1.10.2 Consulting engineers, with experience in sound monitoring, were commissioned by Tranz Rail to measure existing noise levels, and together they worked to design the shrouds that reduced noise to acceptable levels.

1.10.3 Fire consulting engineers were contracted by Tranz Rail to investigate the DMU requirements for operation at Britomart based on relevant standards and current practice to ensure the refurbished DMUs met those standards. The noise suppression shroud panels were included in the DMU refurbishment acceptance criteria.

1.10.4 Once the shrouds were in place a spanner was required to remove them.

1.11 Fire damage

1.11.1 Because the Commission was not notified of the incident until Monday 19 April, it was not possible to inspect the fire damage to the auxiliary engine before repairs were made and the DMU returned to service. As a result a photograph of a reconditioned auxiliary engine (see Figure 4) has been used and the fire damaged parts identified.

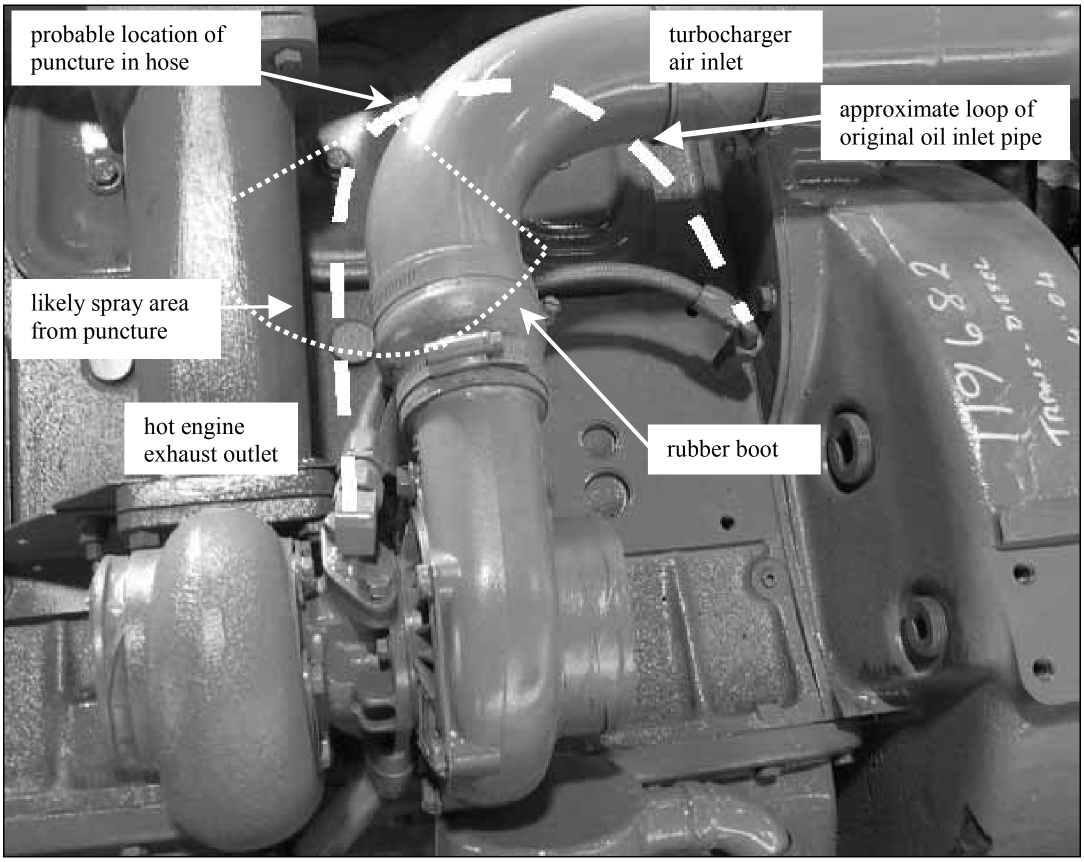


Figure 4
A reconditioned DMU auxiliary engine with probable fire damage details superimposed

1.11.2 The fire damage was limited to the turbocharger, the oil inlet hose and the immediate area around the exhaust manifold, with the turbocharger air inlet rubber boot showing evidence of burning.

1.12 Inspection of the failed hose

1.12.1 The outer surface of the steel braiding was darkened but exhibited no sign of breaks, kinks, cracks or corrosion. Figure 5 shows the blackened inlet hose, while the arrow indicates the approximate position of the pin-hole puncture in the hose.

1.12.2 The failed polymer tube was rigid near the ends but the mid-section was flexible. When cutting the flexible mid-section it was noticed that the internal tube appeared deformed.

1.12.3 Another cut was made into the hose about 50 mm from the original cut. At this point there was no polymer tube visible inside the braiding. However, while the hose was being moved, a small fragment of material fell out. Closer inspection revealed this to be a piece of heavily deformed and blackened polymer tube. The braiding on the hose was then removed to expose the remains of the internal tube. Figure 6 shows cross sections of the failed hose.

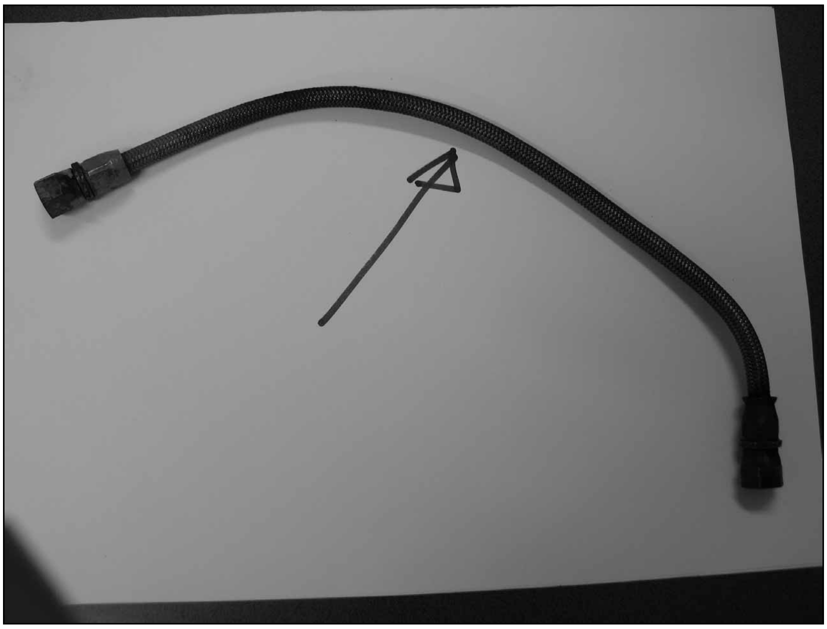


Figure 5
The failed oil inlet hose

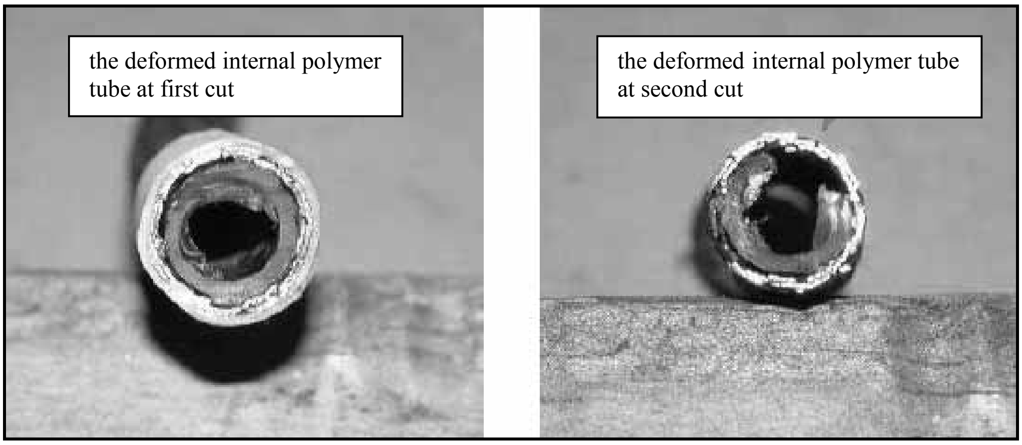


Figure 6
Damaged sections of the failed oil inlet hose

1.12.4 The damage to the internal polymer tube was localised along a section about 120 mm long, with the most severe damage being restricted to a length of about 50 mm (see Figure 7). The damage was more evident on one side of the polymer tube than the other. The tube was intact and undamaged in the more rigid parts of the failed hose, although the exterior braided tube surface was blackened.

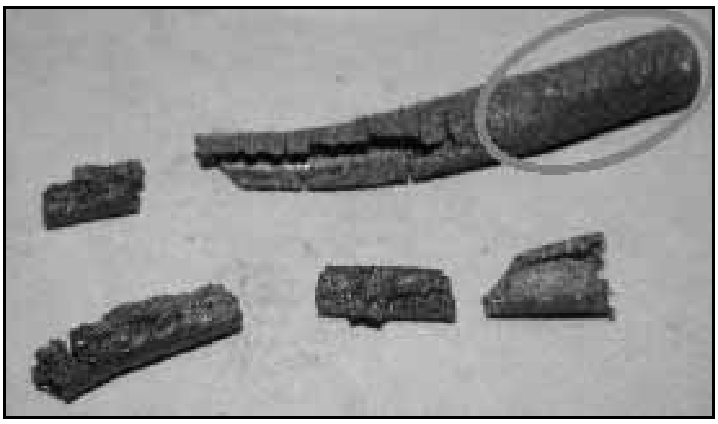


Figure 7
Remains of the internal polymer tube

2 Analysis

2.1 The delay in the Commission being notified of the incident resulted in the scene of the fire being corrupted before it could be properly examined. Consequently it was difficult to establish the precise cause of the fire.

2.2 The locomotive engineer's actions in continuing to Boston Road after being advised of the smoke from beneath his train were appropriate and, together with those of the train crew, ensured that the passengers were evacuated in a safe environment.

2.3 Although the noise suppression shrouds were designed to, and did meet, stringent fire safety standards, the fact that they could not be quickly removed, and were too hot to handle in a fire situation, prevented the train and fire service crews from getting immediate access to the source of the fire. While this delay did not have a significant impact in this instance, the potential existed for more serious consequences. A safety recommendation relating to this issue was made to the Chief Executive of Auckland Regional Transport Authority[5].

2.4 The unsupported and looped oil inlet hose was subjected to constant heat and vibration while in service. Also, it was probably rubbing against the turbocharger air inlet pipe, which t would have exacerbated that vibration. Because of the fire damage to the hose, it was not possible to determine exactly what had pierced the exterior. If the hose had been subjected to torsional stress since its installation, this would have been a permanent stressful situation on the hose, thereby compounding the effect of the vibrations.

2.5 Once the inner hose had become compromised, hot lubricating oil would have sprayed through the braided outer casing under pressure and covered various components around the turbocharger, including the air inlet rubber boot. The hot oil probably soaked between the stainless steel outer braiding and onto the exterior surface of the polymer hose, and ran down the hose, towards the turbocharger.

2.6 The turbocharger casing and the engine exhaust outlet operated at about 450^0C and probably ignited the oil mist as it drifted and landed on the hot surface. The flames would have quickly travelled to the oil-covered rubber boot a short distance away, which would have ignited. The rubber boot would have provided a source of fuel for the fire and, together with the burning oil mist and surrounding oil soaked dirt, would have created significant amounts of smoke.

2.7 The hot oil on the polymer hose would also have ignited, and the resulting fire would have exposed the exterior to temperatures in excess of the shrink temperature for the tube. These temperatures far exceeded the in-service temperatures for which the hose was designed, and the exterior stainless steel braiding would have offered little protection from the heat to the internal polymer tube.

2.8 The straight connection used to attach the oil inlet hose to the auxiliary engine did not comply with the manufacturer's specifications. Why a straight connection had been used could not be determined, but the use of such a fitting meant that the oil inlet hose had to be looped over the turbocharger exhaust outlet in order to connect to the turbocharger, instead of running between the exhaust outlet and the top of the engine.

[5] The owner of the suburban passenger train services in Auckland since August 2004.

3 Findings

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

3.1 The fire was most probably caused by the failure of the turbocharger oil inlet hose which allowed lubricating oil under pressure to spray over the turbocharger and engine exhaust outlet. The surface temperature of both of these components was above the oil's ignition temperature.

3.2 The pipe probably failed as a result of being fitted in such a manner as to be under torsional stress, subjected to constant vibration from the auxiliary engine, and was rubbing on the turbocharger air inlet pipe.

3.3 The straight connection used to attach the oil inlet hose to the auxiliary engine did not comply with the manufacturer's specifications.

3.4 The shroud panels surrounding the auxiliary engine were not equipped with a quick release mechanism and delayed the train and fire service crews reaching the source of the fire.

3.5 The actions of the locomotive engineer and the on-board train crew were appropriate and did not contribute to the incident.

3.6 The delay in receiving the notification of the incident hindered the investigation and the ability to determine the exact cause of the fire.

4 Safety Actions

4.1 On 14 October 2004 Toll Rail advised that fittings on the oil inlet pipe had been standardised with the fitting of a 45^0 elbow to the turbocharger mounting and a straight adaptor fitted to the auxiliary engine (see Figure 8). This allowed the hose to be fitted within the allowable curvature specification.

Figure 8
The new standardised fitting for the oil inlet hose

5 Safety Recommendations

5.1 On 4 May 2005 it was recommended to the Chief Executive of Auckland Regional Transport Authority that he:

> modify the side shroud panels of the DMU ADC cars to improve access to the auxiliary engines (008/05).

5.2 On 20 May 2005 the Chief Executive of Auckland Regional Transport Authority advised in part:

> ARTA confirms that we intend to implement the safety recommendation. ARTA intend to have the necessary work complete by December 31, 2005.

Approved on the 28 April 2005 for publication

Hon W P Jeffries

Chief Commissioner

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