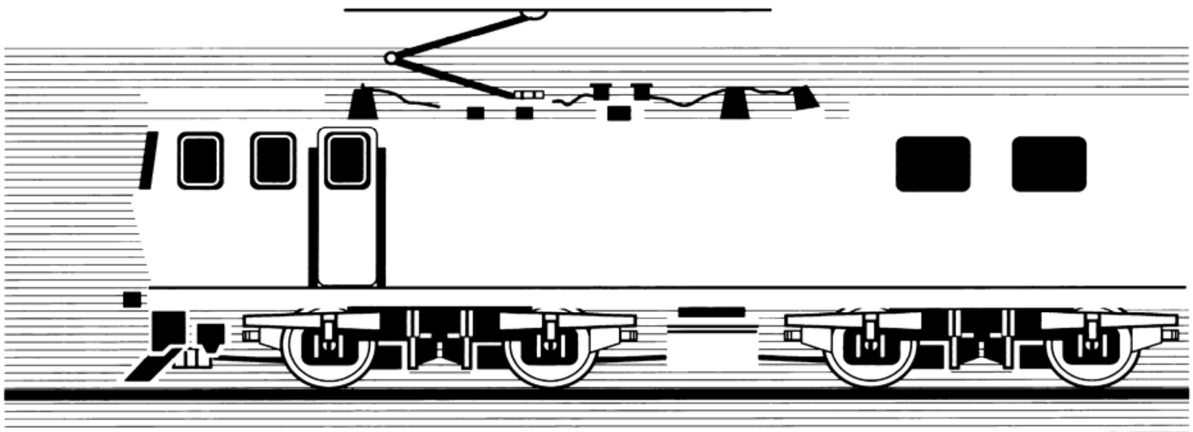
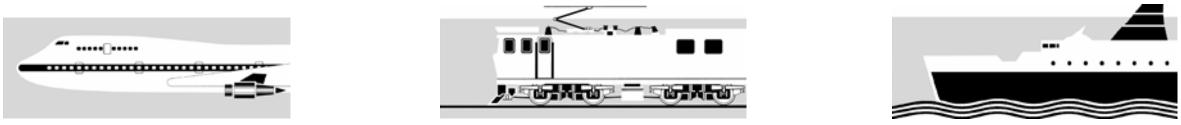


R A I L W A Y O C C U R R E N C E R E P O R T

06-101	**Report 06-101, diesel multiple unit passenger Train 3163, fire in diesel auxiliary engine, Manurewa**	**15 March 2006**



TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

Report 06-101

diesel multiple unit passenger Train 3163

fire in diesel auxiliary engine

Manurewa

15 March 2006

Abstract

On Wednesday 15 March 2006 at about 1710, the auxiliary diesel engine beneath the rear car of diesel multiple unit passenger Train 3163 caught fire when lubricating oil sprayed from a loose hose connection onto the hot surface of the turbo charger. The train manager became aware of the fire when the train stopped at Manurewa station.

The train was evacuated and the fire extinguished by the New Zealand Fire Service. There were no injuries.

The safety issues identified were:

- the process for fitting the oil inlet hose to the turbocharger
- the accessibility of the auxiliary engine
- the cleanliness of the auxiliary engine surround
- the monitoring and recording of maintenance and spare parts
- the lack of a fire detection and suppression system.

In addition to previous safety recommendations made to Auckland Regional Transport Authority following previous similar investigations by the Commission, a safety recommendation covering the appropriateness, security and reliability of the oil inlet hose has been made in this report to the General Manager, Infrastructure and Rail, Auckland Regional Transport Authority.

Contents

Figures

Abbreviations

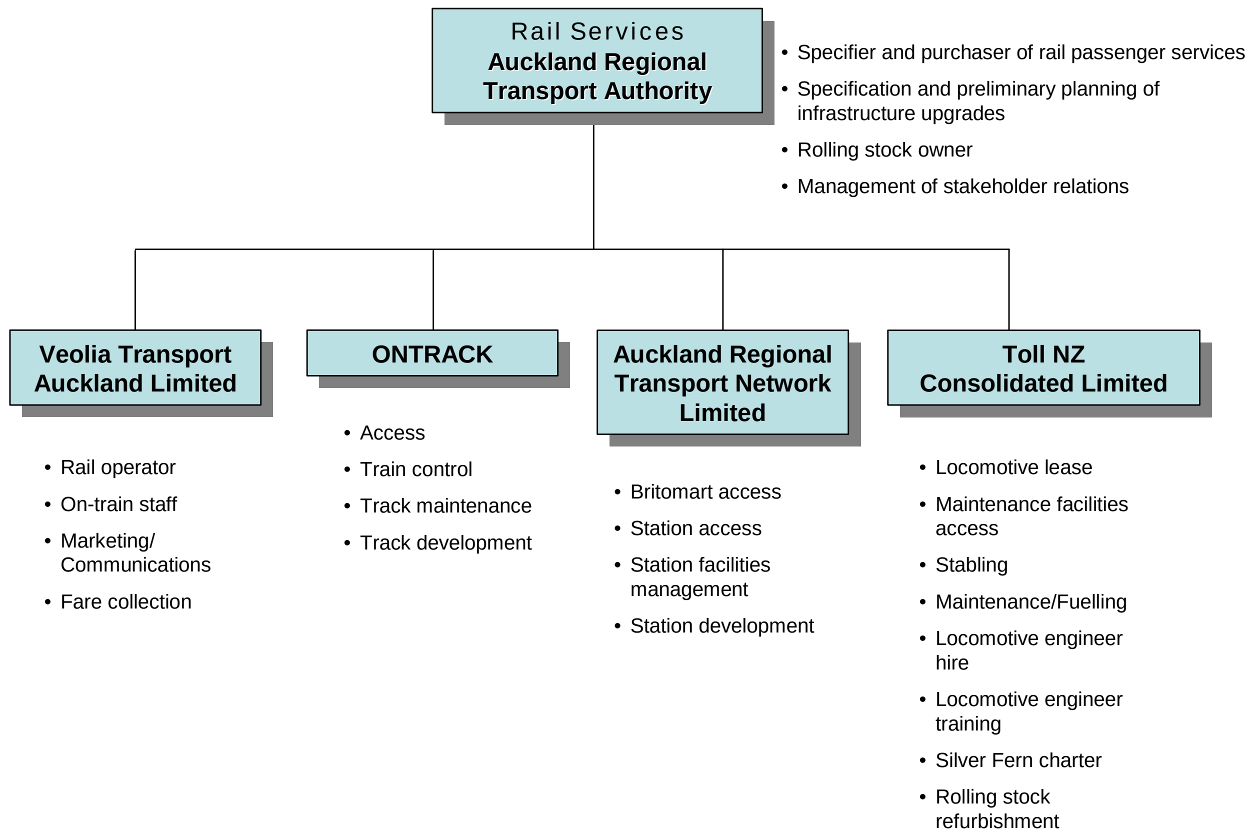
ARTA	Auckland Regional Transport Authority
DMU	diesel multiple unit
LES	locomotive engineer suburban
Toll Rail	Toll NZ Consolidated Limited
Tranz Rail	Tranz Rail Limited
UTC	coordinated universal time
Veolia	Veolia Transport Auckland Limited
Westrail	Western Australian Government Railways

Data Summary

Train type and number:	diesel multiple unit passenger Train 3163
Date and time:	15 March 2006 at about 1710[1]
Location:	Manurewa
Persons on board:	crew: 3 passengers: about 100
Injuries:	nil
Damage:	extensive fire damage to engine compartment, components and wiring
Operator:	Veolia Transport Auckland Limited
Investigator-in-Charge:	D L Bevin

[1] Times in this report are New Zealand Daylight Times (UTC + 13) and are expressed in the 24-hour mode.

Auckland rail passenger system: roles and relationships



1 Factual Information

1.1 Narrative

1.1.1 On Wednesday 15 March 2006, Train 3163 was the scheduled 1634 Veolia Transport Auckland Limited (Veolia)[2] diesel multiple unit (DMU) passenger service from Britomart to Papakura via Newmarket. The train consisted of powered car ADL807 and non-powered car ADC857.

1.1.2 Train 3163 was crewed by a locomotive engineer suburban[3] (LES) driving from ADL807, a train manager and one passenger operator. The train was conveying about 100 passengers.

1.1.3 As Train 3163 approached Homai Station the LES was alerted to smoke coming from the roof of ADC857 by the crew of a northbound train. He decided to continue to the next passenger stop at Homai where he would check the train. At Homai the LES together with the train manager went back along the platform to check the train for reported excessive smoke coming out of the exhaust stack on the roof and to see if any smoke had entered the passenger saloon.

1.1.4 The train manager found no smoke in the passenger saloon. The LES could not see any smoke coming from underneath the train, and thought that the smoke coming from the exhaust on the roof did not appear to be any more than usual. He did not consider it excessive and thought maybe the filters needed cleaning or the engine was burning some oil.

1.1.5 Having found no evidence of a fire, the LES decided to continue. Before departing from Homai he checked his driving console and saw that there were no warning lights illuminated. As the train moved away from the platform it responded normally to the controls.

1.1.6 When the train berthed at Manurewa, the train manager opened the doors for passengers to alight and board and saw smoke rising from under the rear car so he went back to check before going to the driving cab to advise the LES. Both the LES and the train manager went back to inspect the rear car. They saw smoke and flames coming from under the rear car where the auxiliary engine was located so they decided to evacuate the passengers.

1.1.7 The train manager and passenger operator managed the evacuation of the passengers while the LES returned to the driving cab to advise train control of the situation and requested emergency services to attend. He also shut down both the main and auxiliary engines.

1.1.8 As the passengers were being evacuated, the train manager entered the DMU driving cab to remove the fire extinguisher with a view to tackling the fire. Because the auxiliary engine was enclosed by shroud panels on all sides, he could not access the seat of the fire. All passengers had evacuated the train by the time Fire Service personnel arrived and were taken to their destination by taxis.

1.1.9 When the fire service arrived personnel were unable to remove the shrouds so they bent back the top of one corner of the shroud to enable a hose to be inserted and directed to the seat of the fire.

1.1.10 A following train propelled the disabled DMU to Papakura from where it was later returned to the DMU maintenance depot at Westfield for inspection and repair.

1.2 Site information

1.2.1 Manurewa station was 2 km south of Homai station between Papakura and Otahuhu on the North Island Main Trunk railway. It had platforms adjacent to the Up Main line and Down Main line (see Figure 1).

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[2] Veolia was the operator of suburban rail passenger services in Auckland, under contract to Auckland Regional Transport Authority, who owned the rolling stock.

[3] Locomotive engineers employed by Veolia who were qualified to drive DMUs only. They were not qualified to drive freight trains or diesel locomotive hauled passenger trains.

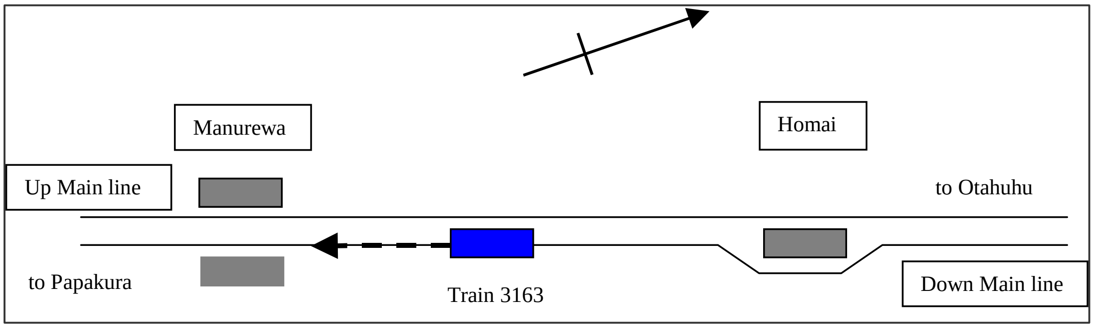

Figure 1
Route of Train 3163 (not to scale)

1.3 Personnel

The locomotive engineer suburban

1.3.1 The LES was recruited by Tranz Metro[4] in March 2001 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 He transferred to Connex Auckland (renamed Veolia) in August 2004, while he was part way through his LES training. He was certified as an LES in October 2004. At the time of the incident he held the required DMU driver certification. The most recent safety observation for the LES, which he had completed satisfactorily, had taken place on 9 September 2005.

The train manager

1.3.3 The train manager was recruited by Tranz Metro in March 2003 and underwent induction and theory training at Tranz Rail's Auckland training facility. His training had included procedures for the evacuation of passengers in the event of a fire, and the use of a fire extinguisher. He transferred to Connex Auckland (now Veolia) on 23 August 2004.

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. ADL807 and ADC857 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.

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[4] Tranz Metro was the group within Tranz Rail that had the responsibility for the operation of Auckland suburban rail services. Connex Auckland (remaned Veolia) became the operator of the Auckland suburban rail network on 23 August 2004.

1.6.2 Ownership of the DMU fleet transferred from Toll Rail to Auckland Regional Transport Authority (ARTA) in March 2005. Maintenance and servicing was undertaken by Toll Rail in compliance with its Mechanical Code M2000.

1.6.3 The Code determined that ADC/ADL 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

1.6.4 The daily checks were carried out at the servicing depot by maintenance staff during the DMUs downtime overnight and included checking defects reported by drivers as recorded in the Loco 54D book.

1.6.5 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

Toll Rail advised that the cleaning of the engines was done with a hot water pressure wash and that steam cleaning had never been used.

1.6.6 B -, C - and D-Checks included maintenance of other components of the train, as well as the A-Check items for the auxiliary engine.

1.7 ADC857 refurbishment, repairs and maintenance

1.7.1 ADC857 was overhauled in 2002 by Alstom[5] and returned to service in December of that year. Although there was no documentation to confirm it, Toll Rail believed that the overhaul had included the auxiliary engine and turbocharger, as part of a program to maintain the operational life of the DMUs.

1.7.2 The auxiliary engines on all ADC cars, including ADC857, were replaced with rebuilt engines of the same model in April 2004 as part of a further refurbishment program.

1.7.3 The most recent B-check on ADC857 was done together with an A-check on 6 January 2006.

1.7.4 On 11 January 2006, following the reporting of smoke flowing from the auxiliary engine, ADC857 was withdrawn from service and repair work was undertaken. This work included replacing the oil inlet hose, the oil filter to sump hose and the oil filter. The auxiliary engine and the interior of the side shroud were pressure washed before ADC857 returned to service.

1.7.5 The cylinder head on the auxiliary engine was removed on 17 January 2006 because of a burnt valve and the oil inlet pipe was also changed again at that time. Toll Rail were unable establish if the same oil inlet hose was refitted on 11 and 17 January.

[5] In April 2002, Tranz Rail, the predecessor to Connex (later Veolia), had contracted out the inspection and maintenance of locomotives and rolling stock to Alstom New Zealand, to standards set by Tranz Rail.

1.7.6 The next A-check was carried out on 23 February 2006. A hot water pressure-wash of the auxiliary engine and the inside of the shroud panel, was recorded as having been undertaken during both checks.

1.7.7 The A-Check also required a check to be made for fuel, oil, water and exhaust leaks and for any leaks to be repaired. There was no recorded evidence to suggest that any leaks had been found in the oil inlet hose or its connections during the scheduled checks, on 6 January and 23 February, nor during the unscheduled work on 11 and 17 January.

1.8 Fleet review auxiliary engine oil useage

1.8.1 Oil replenishment data for all ADC auxiliary engines for the period 1 December 2005 to 14 March 2006 was requested from Toll Rail to compare the oil usage of ADC 857 with other units in the fleet. However Toll Rail advised that the only records they had been able to recover from that period were for 17 days between 1 and 23 December 2005 and from 21 February to 14 March 2006. The data from 21 February was from a new data base introduced on 20 February .

1.8.2 Prior to 20 February the method of measurement was based on the servicing person's assessment of how much oil had been topped up rather than an accurate measure obtained from a meter. Toll Rail considered that although it was not a precise measurement and was subject to some variability it provided sufficient information to draw attention to instances of high usage.

1.8.3 The auxiliary engine sump on ADC857 held 25 litres when full but only 7 litres remained when the sump was drained at Westfield the day after the fire.

1.9 The auxiliary engine

1.9.1 ADC857 was not powered for traction but was fitted with a turbo-charged diesel engine coupled to a Stamford alternator that provided 125 kilowatts 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.

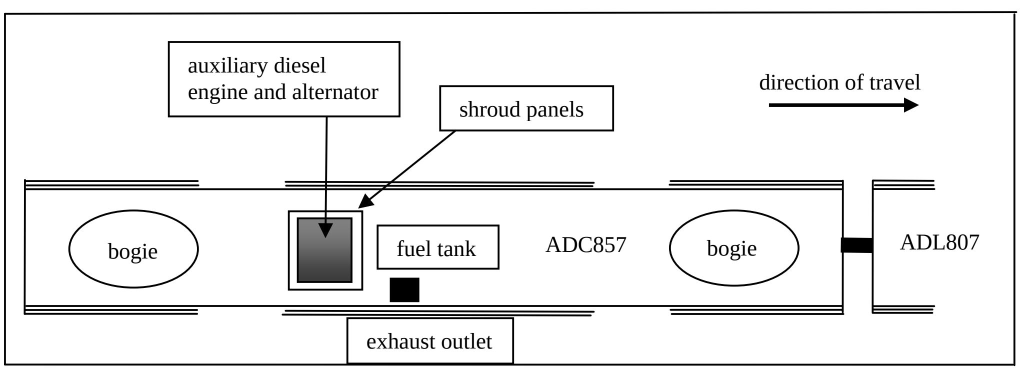

Figure 2
Under-floor plan of ADC857 showing location of auxiliary engine
(not to scale)

1.9.2 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[6]. The engines were supplied by Detroit Australia as standby generators and had been fitted to the ADC fleet during construction. The exhaust was expelled through a vent in the roof of the carriage (see Figure 2).

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[6] Detroit Diesel advised that there were turbochargers from at least 6 different manufacturers that were compatible with the model 471T engine.

1.10 The turbocharger

1.10.1 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 reached temperatures of 450°C, which was at about the same temperature as the exhaust.

1.10.2 Turbocharger 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 sump and the turbocharger. The lubricating oil entered the top of the turbocharger casing between the turbine and the air blower and returned to the sump through another flexible stainless steel braided hose. The braided steel was to protect and reinforce the polymer tube through which the oil flowed.

1.10.3 The hose was manufactured by Parflex Fluid Connections of the United States of America and had been fitted by United Group Rail[7] staff on 17 January 2006 following repairs to a burnt valve on the auxiliary engine on ADC857.

1.10.4 The first model 471T engine was 22 years old. Some spares were still available on the Australian and New Zealand markets but no more were being manufactured by Detroit Diesel. Detroit Diesel specified local supply and maintenance of the oil inlet hoses and fittings on these engines, regardless of the type of turbocharger fitted.

1.10.5 Toll Rail had no documented procedures in place for fitting the oil inlet hoses. The hoses were replaced and fitted by external contractors during refurbishment or repairs to the auxiliary engines or by Toll Rail's own staff during routine maintenance. Toll Rail did not specify polymer thread tape or any jointing compound to be used on the oil inlet hose connections as the fittings were of a tapered thread and relied on a tight fit with the engine block and turbocharger to provide a leak-proof connection.

1.11 Post incident inspection of the auxiliary engine

Fire damage

1.11.1 Fire damage was generally localised to the area from the auxiliary engine fuel tank to the bogie under the trailing cab. Cables, air pipes, and fuel and oil lubricating lines near to the seat of the fire were either damaged or destroyed.

1.11.2 The unburned insulation on the interior of the shroud panels was soaked in oil.

1.11.3 The fire was contained to an area bounded by the top of the auxiliary engine and the underfloor of the vehicle (see Figure 3). The flames had been fanned by the airflow beneath the moving train and had also melted plastic pipe cleats around the trailing bogie of the rear car (see Figure 4).

[7] United Group Rail took over DMU servicing duties from Alstom New Zealand Transport Services in September 2005.

Figure 3
Damaged underfloor above the auxiliary motor

Figure 4
Looking towards the trailing bogie from near the auxiliary engine

1.11.4 The sound absorbing material within the auxiliary engine shroud was almost completely consumed by the fire.

1.11.5 About 150 mm of the turbocharger air inlet pipe was missing. The remnants were found at the bottom of the shroud casing, heavily contaminated with oil. The rubber boots, one of which connected the air inlet pipe to the turbocharger, were missing. Figure 5 shows the rubber boot which connected the alloy pipe to the turbocharger on the reconditioned auxiliary engine following the fire.

1.11.6 Smoke blackening and heat scorching were evident on the exterior of the DMU (see Figure 6) where the flames had risen from the turbocharger side (the left hand side in the direction of travel). The opposite side had no such markings.

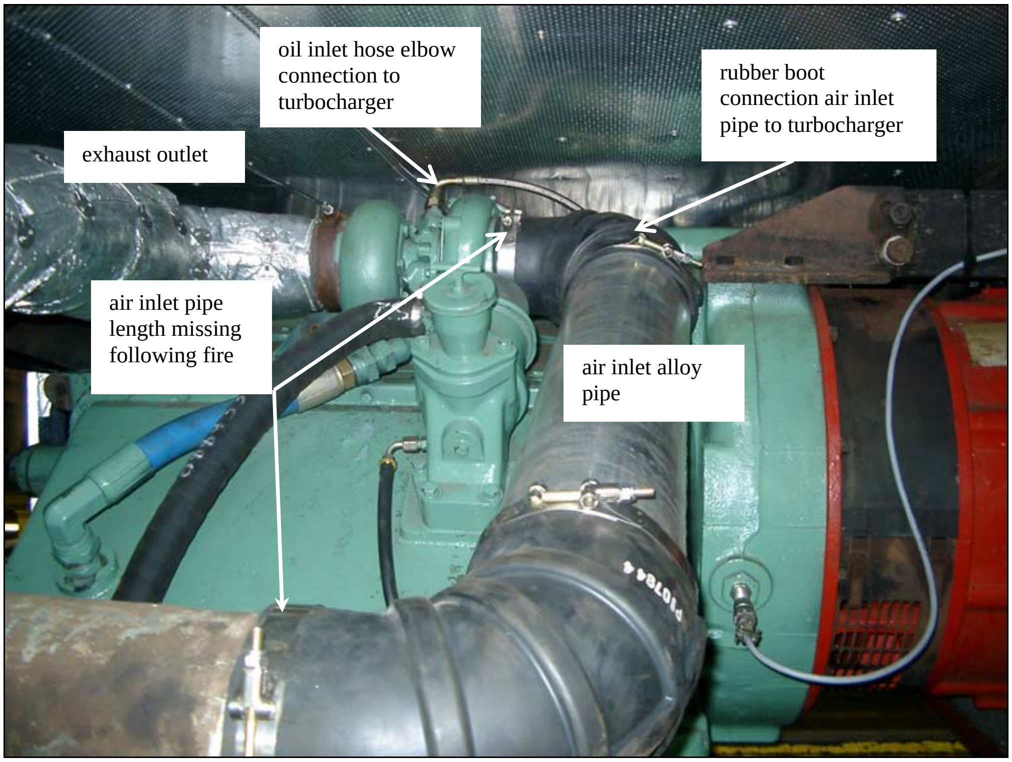

Figure 5
Connections to the turbocharger

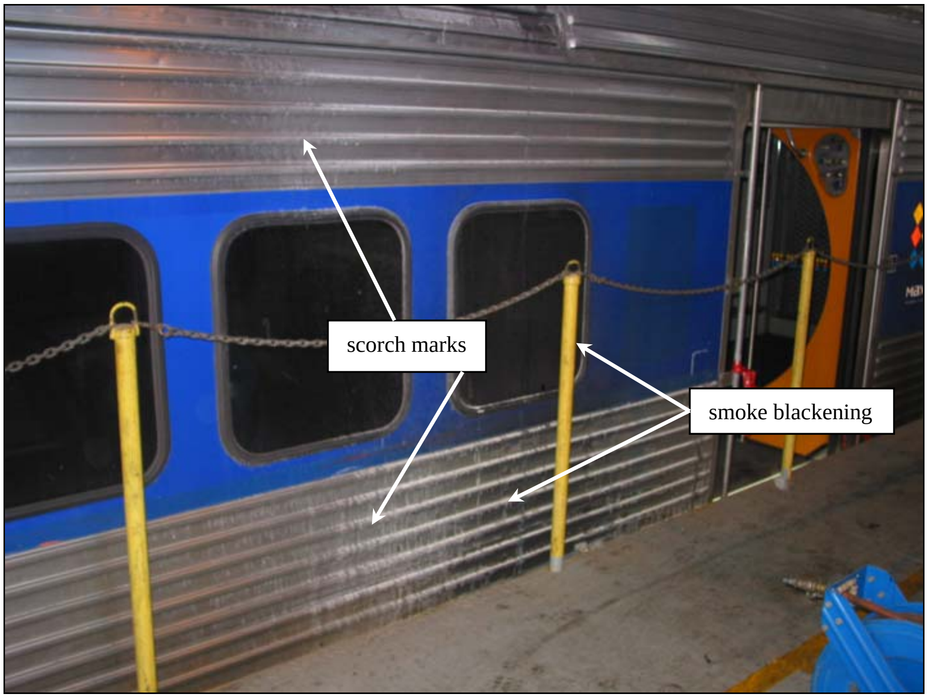

Figure 6
Smoke blackening and scorch marks on the side of ADC857

1.11.7 From the damage, it was clear that the ignition point of the fire was in the vicinity of the turbocharger. This was confirmed by a New Zealand Fire Service inspector.

1.11.8 Inspection of the auxiliary engine showed there had been a mixture of oil, fuel and dirt forming a thick, flammable substance between the top of the auxiliary engine and the passenger saloon floor. Although most of this mixture had been consumed by the fire, the mixture was still present on parts of the motor which had not been affected by the fire

Examination of the turbocharger

1.11.9 The turbocharger, together with its oil supply hose and return pipes, was removed from the auxiliary engine and taken for independent testing and analysis. The turbocharger was stripped down to its constituent parts for examination.

1.11.10 The main bearing was in good condition, and the shaft moved freely in it once the damaged air intake propeller had been removed from the shaft end.

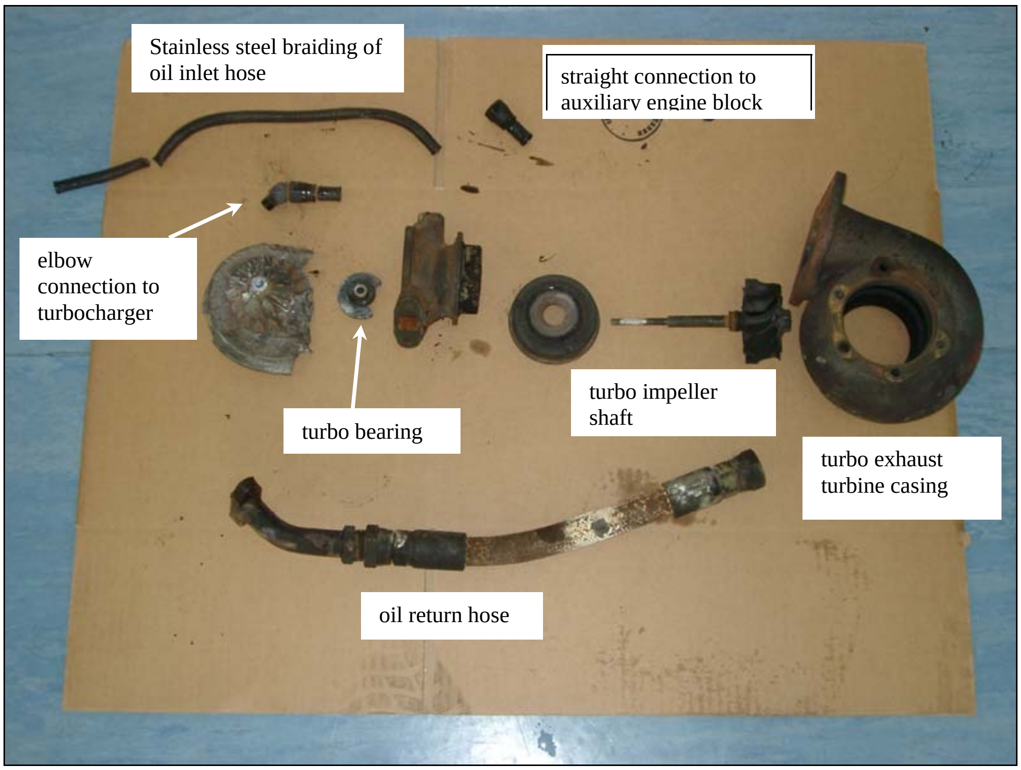

Figure 7
Dismantled turbocharger and associated parts

The oil inlet hose and fittings

1.11.11 The remains of the braided steel hose and its fittings were inspected before disassembly. One end of the hose was fitted to a straight coupling at the auxiliary engine. The connection was tight but, although contaminated with oil, did not exhibit any fire damage.

1.11.12 The other end of the oil inlet hose was connected to the turbocharger through a ferrule to a 45º angled nipple. The nipple threaded into the turbocharger housing and the straight ferrule connected onto the nipple. Both the ferrule and the nipple were found loose and able to be turned by hand.

The connections and the stainless steel braiding covering the polymer oil inlet hose was light brown in colour, consistent with exposure to extreme heat.

1.11.13 The fire-damaged oil inlet hose (see Figure 8) was examined by an independent expert.

a) Braided steel hose with straight ferrule connection. The angled ferrule was removed at the cut end.

b) Straight ferrule attached to braided hose.

c) Angled ferrule detached from braided hose.

Figure 8
Braided oil inlet hose and fittings

1.11.14 The oil inlet hose had been crimped into threaded brass ferrules to allow free rotation of the hose so that the threaded parts could be tightened without imposing torsional stress on the hose. Figures 8(a) and (b) show the straight ferrule still attached to the braided hose. The angled ferrule (see Figure 8(c)) was also attached initially but became detached during handling.

1.11.15 Figure 3(a) also shows the cut end of the braided hose and the bend where the hose was deformed by an unsuccessful attempt to cut through the braiding during the examination.

1.11.16 The fire had deposited substantial amounts of soot on the outside of the metal surfaces. Visual assessment revealed no remnants of the original internal polymer tube. The braided tube was also probed to check for remaining fragments of polymer but none were found.

1.11.17 The steel braiding showed no evidence of melting and, apart from the soot deposit and mechanical damage caused when the tube was cut during testing, there was no evidence of damage to, or distortion of the steel braiding.

Electron microscopy of the connection

1.11.18 The threads on the brass fitting were examined for remnants of polymer tape but no evidence of either tape or charred remnants was found.

1.11.19 Many of the fluorine-rich products that are released by polymer tape as it degrades at elevated temperature are reactive and could be expected to form fluorine compounds. Random spot checks of elemental composition were made inside the grooves of the threads using energy dispersive X-ray analysis but no fluorine was detected.

The shroud panels

1.11.20 The auxiliary engine was enclosed by shroud panels. These had been fitted to ADC857 in 2002 as part of its refurbishment as a test for noise suppression. When the vehicles were in the underground station at Britomart, the auxiliary engine ran continuously.

1.11.21 Tranz Rail contracted fire consulting engineers 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. Once in place, the shrouds could not be removed by hand, rather a spanner was required.

1.11.22 The shroud panel on the turbocharger side of the auxiliary engine contained ports for the exhaust pipe to exit and the air inlet pipe to enter but there were no removable panels to allow maintenance staff to access that side of the engine. For servicing, repairs or cleaning the complete side of the shroud had to be removed.

Figure 9
Side shroud on the turbocharger side of ADC857 (courtesy Toll Rail)

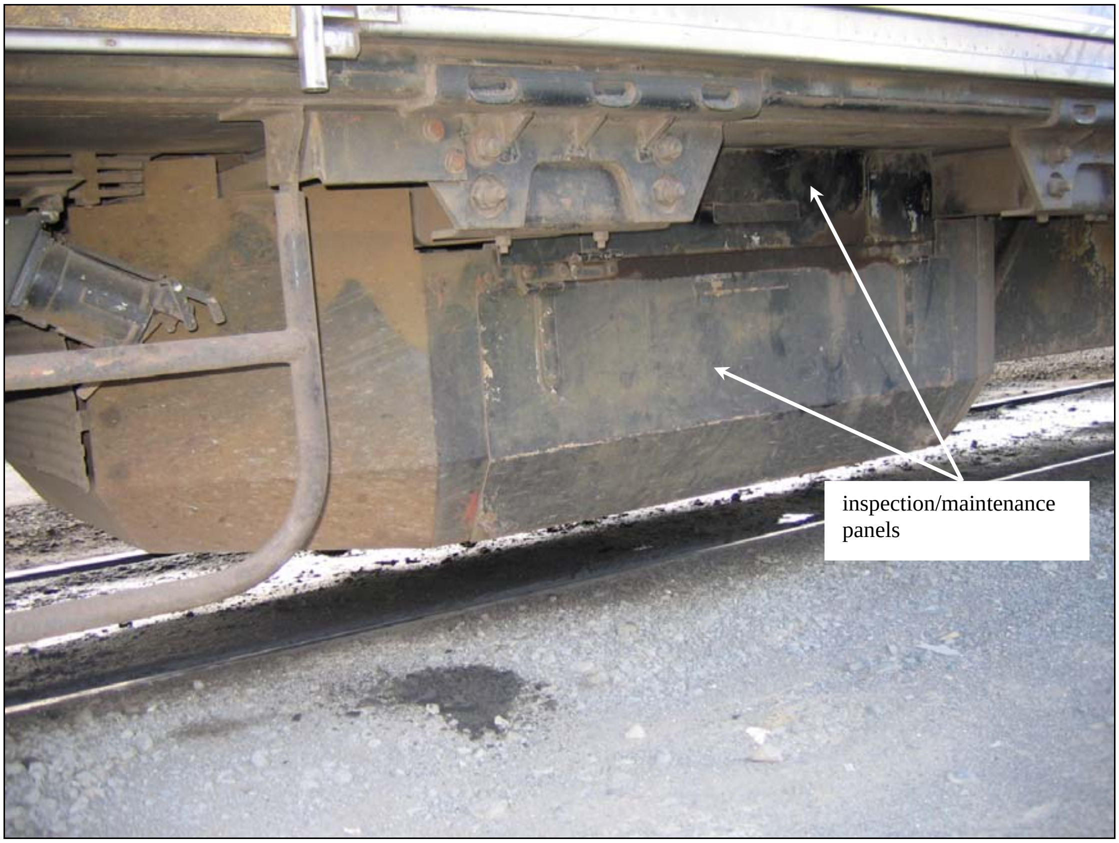

Figure 10
Side shroud on the non turbocharger side of the engine (courtesy Toll Rail)

1.12 History of fires under DMUs

1.12.1 In 2003, the Land Transport Safety Authority commissioned a report into several fire incidents that had occurred on the Auckland suburban DMU fleet. There were 6 incidents of fire reported between 1995 and 2002 and a further 6 similar occurrences between May and August 2003. Debris catching fire or oil coming into contact with hot exhaust fumes caused or contributed to 3 of the occurrences in 2003.

1.12.2 As a result, Tranz Rail took the following action:

> The undersides of the DMUs have previously been cleaned with hot water/steam at twelve-week intervals to remove the build up of oil and debris. This has now been changed to six weeks. (Some engines leak oil more than others, and particularly dirty engines may be cleaned more frequently still).

Occurrence report 04-112 Diesel multiple unit passenger train 2146, fire auxiliary engine, Boston Road, 16 April 2004

1.12.3 On 16 April 2004, as Train 2146 departed from Newmarket, the crew of a passing train advised the LES of smoke coming from beneath his train. The LES stopped at the next station, Boston Road and the passengers were evacuated.

1.12.4 The fire was extinguished with the assistance of the New Zealand Fire Service. The noise suppression shrouds around the auxiliary engine could not be easily removed, which hindered the efforts of the train crew and the fire service to extinguish the fire.

1.12.5 The findings of this investigation included:

- the fire was most probably caused by the loose connection 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

- 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

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

- 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.

1.12.6 This investigation resulted in a safety recommendation to the Chief Executive of ARTA on 4 May 2005 that he:

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

1.12.7 On 20 May 2005 the Chief Executive of ARTA responded in part:

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

1.12.8 On 17 March 2006 the Service Delivery Manager at ARTA advised in part:

> ARTA is working with our operational and maintenance providers, Connex (now Veolia Transport Auckland (VTA)) and Toll Rail respectively, to discuss options to address TAIC's safety recommendation 008/05. Also, in recent months VTA has been attempting to secure commitment from the New Zealand Fire Service to provide input into the recommended solution.
>
> A meeting has been arranged between the parties (VTA, Toll Rail, NZ Fire Service) early next week to agree on a final recommendation to ARTA for implementation.
>
> We will provide you with a progress update in one month's time.

1.12.9 On 11 April 2006 the Service Delivery Manager at ARTA advised in part:

> A detail design for an improved engine shroud has been developed and reviewed by the Fire Service and Veolia Transport (formerly Connex Auckland). A prototype engine shroud is being built and will be inspected by the Fire Service and Veolia to confirm improved access to the auxiliary engine, prior to fitting them across ARTA's ADL fleet.
>
> I will advise you when the prototype engine shroud is completed and the program to fit shrouds across the ADL fleet has been finalised.

Rail Occurrence 05-108 Diesel multiple unit passenger Train 3334, Traction motor fire, Auckland, 23 February 2005

1.12.10 On Wednesday 23 February 2005 Train 3334, a Papakura to Britomart DMU passenger train, sustained a traction engine fire while it was stopped at Signal 125, Auckland.

1.12.11 This fire was caused by hot lubricating oil being ejected from the engine through a deformed and dislodged gasket and onto the non-insulated hot exhaust manifold. The oil was ejected because of excessive blow-by into the sump caused by worn pistons and broken piston rings.

1.12.12 Although the cause of this fire differed from that under investigation in this report, the recurring issues of the cleanliness of the engine surround and the lack of a fire detection and suppression system were raised.

1.12.13 On 27 June 2005 ARTA wrote to Toll Rail expressing its concern at the considerable build-up of oil and attached dirt on the underframe of the DMUs, and requested that:

1. Confirm that steam cleaning of vehicle underframe is currently being carried out at a minimum of 6-weekly frequency in accordance with the requirements of the “A” maintenance check and that the cleaning removes all oil, dirt and other debris that could potentially catch fire or effect the correct performance of any other train system.

2. Confirm that all underframe equipment is inspected at sufficient frequency to identify potential faults that could lead to a fire (e.g. leaking pipe work, broken and/or damaged seals, damaged electrical wiring etc.) and that any identified defects are remedied before there is a significant risk of them leading to a fire.

3. Confirm that robust procedures are in place and are being followed to determine the cause of leaks and/or defects on vehicles which show excessive or abnormal build-up of oil and debris between scheduled steam cleans and to ensure that any such defects are remedied before the vehicles are returned to service.

4. Review whether the frequency and scope of underframe steam cleaning is adequate to ensure that the fire risk is minimised as far as reasonably practicable.

1.12.14 On 18 July 2005, Toll Rail replied to ARTA in part:

1. The 6-weekly cleaning happened most of the time, but sometimes was skipped due to logistical reasons. Staff has been sensitised to the dangers inherent in a dirty underframe and have been asked to attend to this duty with renewed diligence. This is specifically being monitored to ensure the quality level.

2. All vehicles are inspected daily as part of the Servicing Function. Checking for oil or fuel leaks form part of this inspection. At present the quality of the Servicing Section’s output is receiving specific attention. We believe all abnormal leaks would be identified and corrected through this process.

3. The cleaning process itself is difficult and it is easy to miss certain areas. The process is being investigated and various options are evaluated to make the cleaning process more effective.

4. As a short-term measure, temporary staff is being employed to get the fleet back to the required standard of cleanliness.

1.12.15 On 15 June 2006, as a result of this incident, the Commission recommended to the General Manager, Infrastructure and Rail, ARTA that she:

> confirm with Toll Rail, that the underframe equipment on the DMU fleet is currently at an acceptable standard of cleanliness and that the established inspection and maintenance procedures are appropriate to maintain those standards. (033/06)
>
> and
>
> fit an appropriate fire detection and suppression system to the diesel engines on the ADL and ADK class passenger cars. (035/06).

1.12.16 On 26 June 2006, in response to safety recommendation 035/06, ARTA advised in part:

> ARTA is reluctant to consider fitting full fire detection and suppression systems given the age of the ADL vehicles and their likely future use. The marginal increase in safety over and above the proposed steps does not appear to ARTA to warrant the cost. ARTA's preference for the ADL and ADK class passenger cars is to reduce the fuel source around the diesel engines through increasing accessibility around the engines and increasing focus on cleanliness through existing maintenance systems.
>
> Both the ADL and ADK passenger carriages are currently fitted with a warning system that alerts the driver if excessive engine temperature occurs. This system responds automatically to overheating by reducing the engine speed to idle.
>
> Notwithstanding, we are specifying detection and suppression systems in new refurbished rolling stock. The diesel-alternator compartments in the remanufactured SD carriages are fitted with a fire detection and suppression system. Similarly the ADK fleet is now cycling through a major refurbishment program that includes fitting a new diesel-alternator set in a separate compartment which includes a fire suppression system. It is anticipated this program will be completed by June 2007.
>
> If the ADL class vehicles are refurbished with a design that provides an enclosed compartment for the diesel-alternator set, fire suppression will be incorporated. However, there are no plans to do this at present.

2 Analysis

2.1 When the driver of the passing train reported the excessive smoke to the LES of Train 3163, it was likely that the rubber boot that connected the air inlet pipe to the turbocharger was already burning and the smoke was ingested through the turbocharger into the combustion chamber of the auxiliary engine and expelled through the exhaust system.

2.2 The smoke the LES saw being emitted from the exhaust when he checked the train at Homai had not unduly concerned him, or caused him to think the smoke was anything out of the ordinary. Although he had commented on the thick oily nature of the smoke and brought that to the attention of the train manager, the LES thought it was due to a dirty oil filter.

2.3 When the train was at Homai there was no smoke at ground level, nor was there any evidence of smoke or a burning smell in the rear passenger car. The LES probably would not have seen any sign of fire underneath if he had looked because the fire was on the other side of the auxiliary engine at that time and was contained by the shroud. If the fire had been advanced beyond the confines of the shroud panel at the time the passing LES reported the smoke, the airflow beneath the moving DMU would have blown smoke out behind the moving train. However, once the train departed Homai the fire quickly spread beyond the confines of the shroud panels and when the train stopped at Manurewa the flames had spread sufficiently to be escaping from beneath the rear car and climb the sides, causing scorch marks and smoke blackening. It was possible that had the LES inspected the off side of the train while at Homai he may have sighted the fire earlier.

2.4 The sequence of events suggests the initial onset of the fire was slow, caused by an event such as a seeping joint or crack in the lubricating oil inlet hose. Once the fire had begun to consume the polymer section of the braided hose, the fire would have been fed by lubricating oil under pressure and spread rapidly.

2.5 Although the noise suppression shrouds were designed to fire safety standards, they became too hot to handle in a fire situation and could not be removed easily.. This prevented the train crew and fire service crew from gaining immediate access to the seat of the fire. As with the previous incident at Boston Road incident this delay did not have a significant impact on the situation or endanger the safety of the passengers, but again the potential existed for more serious consequences. Safety recommendation 035/06, arising from Rail Occurrence Report 04-112 regarding the noise suppression shrouds, was made to the General Manager, Infrastructure and Rail, ARTA on 4 May 2005 (see 1.18.4). As a result of ARTAs response no further safety recommendation covering this issue has been made at this time.

2.6 The deformed appearance of the turbocharger following the fire suggested initially that it may have become defective during operation and contributed to the ignition of the fire. However, independent testing and analysis confirmed that it had been operating correctly at the time the auxiliary motor was shut down by the LES and was therefore not a causal factor.

2.7 It had not been possible to establish the history of the oil inlet hose. Records did not show whether the hose had been replaced with a new one during service checks or unscheduled maintenance or whether the same one, or another pre-used one, had been fitted. It is possible that a pre-used hose had been fitted that may have previously been subjected to some degree of torsional stress or had another pre-existing fault such as a crack or defective crimping. However, any oil leaking from such defects would probably have seeped out and dripped on to the cold side of the turbocharger where ignition was less likely.

2.8 It is not unknown for fittings such as threaded nipples to come loose under intense heat and give the appearance of having been loose prior to the fire. If the nipple and ferrule had not been tight any leaking oil would have gone to the hot side of the turbocharger, where as oil from a split in the polymer section of the hose would have initially leaked towards the cool side of the turbocharger. Although it could not be established categorically which failure had initiated the fire, evidence suggested it was caused by oil from a loose nipple or ferrule. The reasons for this were:

- it would be unusual for both the threaded nipple and the threaded ferrule to back off due to intense heat

- there was a history of inlet hoses loosening off, and the operator did not provide instruction to fitters to prevent a recurrence

- there was no evidence of the steel braiding on the hose having been subjected to severe torsional stress

- improper fitting of the oil inlet hose could result in residual minor torsional force biased toward loosening the fittings under vibration.

2.9 The oil inlet pipe had been replaced about 3 weeks before the fire, when repairs to a burnt engine-valve were carried out. As the connection to the turbocharger was tightened down, the likelihood of the crimped head rotating was increased, necessitating the use of an additional spanner to keep it from moving. At the time of fitting this was probably either not done, or not done correctly, resulting in residual torsional stress in a counter clockwise direction (loosening). Following this incident, Toll Rail have developed and distributed procedures for the fitting of the oil inlet hose to the turbo-charger so no safety recommendation covering this issue has been made.

2.10 Oil would have been sprayed under pressure on to the surface of the turbocharger, the casing of which reached temperatures of around 450° C. The heat would have eventually ignited the sprayed oil and the resulting flames then spread to the oil-covered air inlet rubber boot, another source of combustible material. It was likely that the fire had consumed the rubber boot, and the alloy pipe connecting the boot to the air filter system, before it dropped to the bottom of the shroud as the fire melted the alloy material. The unclean state of the engine top and shrouds would have provided ready fuel for a fire.

2.11 An attempt was made to analyse the oil consumption of ADC857 to ascertain whether there was any increase following the fitting of the replacement oil inlet hose in January 2006, and to understand how the oil consumption of this particular engine compared to others in the ADC fleet. However, much of the information needed to draw any meaningful conclusions was either unavailable or of questionable accuracy. This suggested that the consumables used by the Auckland suburban rail fleet were not being appropriately managed at that time. The system for monitoring oil useage that Toll Rail had introduced in the month before the fire had been used for only a short time and sufficient data had not been collected for accurate trend analysis.

2.12 It had not been possible to accurately determine the quantity of oil in the auxiliary engine sump prior to the fire, although 7 litres had been recovered. Potentially 18 litres of oil could have been pumped onto the fire if the sump had been full, or the engine could have been loosing oil over the 3 weeks prior to the fire. Such information gives early warning of significant leaks or other serious potential threats to the health of the engine, thereby enabling preventative action to be taken before catastrophic failure occurs. However, in view of the proposed changes and actions which Toll Rail has subsequently introduced to the oil usage recording process, no safety recommendation covering this issue has been made.

2.13 The possible use of polymer thread tape or similar jointing compound around the coupling threads was considered. However, there was no evidence that either had been used and their absence was consequently not considered a contributing factor to the loose connections.

2.14 No remnants of the polymer oil inlet hose were found. It was therefore most likely that the tube had been entirely consumed in the fire or that any remaining fragments had been lost during recovery.

2.15 The ADL/ADC class of DMUs were not fitted with on-board fire detection and suppressant equipment, and ARTA had no plan for such equipment to be installed. The planned service life of the ADL/ADC DMUs, and the costs associated with the installation of such systems, meant that priority for such defences was given to DMUs with a longer service life expectancy. However, fire detection and suppression equipment around confined internal combustion engines such as the auxiliary and main engines of DMUs are critical to the safety of the train and its passengers. A safety recommendation covering this issue has been made to the Director of Land Transport New Zealand.

2.16 Despite the difficulties caused by the side shrouds, hot water pressure washing of the auxiliary engine had been reported as carried out during the A-Checks on 6 January and 23 February. However, given the difficult access to the top of the engine, it is likely that this cleaning had not included the top of the auxiliary motor of ADC857 and, as a result, a combination of debris, oil and old grease, had been allowed to accumulate, a ready source of fuel for a fire. On 15 June 2006, safety recommendation 033/06 was made to the General Manager, Infrastructure and Rail, ARTA in Occurrence Report 05-108 to address this issue, so no further safety recommendation covering this issue has been made.

3 Findings

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

3.1 The fire on Train 3163 started in the auxiliary engine in the vicinity of the turbocharger, when oil from the lubricating oil inlet hose escaped and sprayed or gathered on the unprotected hot surfaces of the turbocharger casing.

3.2 The intensity of the ensuing fire was increased by oil residue accumulated on top of the auxiliary engine and impregnated in the surrounding noise suppression shrouds.

3.3 The opportunity to detect and extinguish the fire earlier would have been enhanced if a fire detection and suppression system had been installed.

3.4 The design of the noise suppression shrouds around the auxiliary engine contributed to the outcome of this incident in 2 ways:

- it hindered efficient inspection, and mechanical and cleaning maintenance
- it hindered efficient fire fighting once the fire had started.

3.5 Poor keeping of maintenance records meant the Commission could not determine for how long and at what rate the auxiliary engine had been losing lubricating oil, and could not determine the maintenance history of the oil inlet hose.

3.6 The cleaning maintenance schedule for the auxiliary engines on the fleet of DMUs was not being fully adhered to and was not being carried out effectively in that:

- proper access to the engines for cleaning was difficult
- hot water rather than the prescribed steam cleaning was used

3.7 There were not sufficient standards for the supply and fitting of engine components in the maintenance system for DMU trains in the Auckland operation.

4 Safety Actions

4.1 On 26 May 2006, as part of its submissions to preliminary report 05-108, ARTA advised in part:

> ARTA has formally written to Toll NZ as ARTA's maintenance provider (27 June 2005) and requested specific actions are undertaken to ensure carriage under frames are kept clean. These include steam cleaning and investigation of any oil and fuel leaks. Toll replied on 18 July 2005 detailing the actions they are taking to address our requested actions. Copies of both letters are provided as attachments to this letter.
>
> An improved ADL engine shroud design has been developed by Toll NZ, and reviewed by the NZ Fire Service and Veolia Transport (formerly Connex Auckland). The design objectives are (1) to reduce the temperature inside the shroud, and (2) permit easier access for both ordinary servicing, cleaning of the diesel-alternator and for firefighting. ARTA has authorised the production of a prototype engine shroud which is currently being manufactured. Tests will be undertaken with the prototype to ensure that the design objectives have been met. When ARTA, Veolia, and the Fire Service are satisfied, it is our intention to extend the new design to the whole ADL fleet. Details of this action were previously advised to TAIC in a letter dated 11 April 2006.
>
> On 29 June 2006, Toll Rail advised that written instructions for the fitting of turbo-charger oil inlet hose had been completed.

4.2 On 26 June 2006 Toll Rail advised that a Fitting Instruction for Turbo Oil Feed-Hose had been developed and distributed to relevant staff.

5 Safety Recommendation

5.1 On 19 June 2007 the Commission recommended to the Director of Land Transport New Zealand that, because of prospective anticipated growth in the rail passenger traffic in the Auckland region in the foreseeable future, and the ageing current rail fleet, he require all rail participants to operate a maintenance system where:

> engineering standards consistent with world standard practice are identified and adhered to
>
> manufacturers' inspection, repair and maintenance instructions are documented and followed
>
> safety critical components are identified and documented.
>
> work instructions are issued for maintaining safety-critical equipment and work on safety-critical components is signed off by someone other than the maintainer
>
> all maintenance is recorded. (015/07)

5.2 On 19 June 2007, the Commission recommended to the Director of Land Transport New Zealand that he:

> require all enclosed compartments containing combustion engines on new or modified rail vehicles to be fitted with fire detection and where appropriate a fire suppression system. Existing rail vehicles that fall into this category should be made to comply within a time specified by the Director. (016/07)

5.3 No response to these safety recommendations had been received from the Director of Land Transport at the date of publication of this report.

5.4 On 16 August 2006 the Commission recommended to the General Manager Infrastructure and Rail, Auckland Regional Transport Authority, that she:

> arrange for an independent risk assessment by suitably qualified personnel to evaluate the appropriateness, security and reliability of the current means by which oil is fed to the turbocharger on DMU auxiliary motors. (036/06)

5.5 On 15 September 2006 the General Manager Infrastructure and Rail, Auckland Regional Transport Authority responded in part:

> An independent risk assessment by Halcrow is being arranged to evaluate the appropriateness, security and reliability of the current means by which oil is fed to the turbocharger. This will include an assessment of the operating environment, the current method of fitting the oil feed and whether the specification of the oil feed hose currently fitted is suitable for use in this environment.
>
> It is anticipated the inspection and assessment will be completed by mid-October 2006 with the final report available by the end of November 2006.

5.6 On 7 May 2007 Auckland Regional Transport Authority advised in part:

> I can confirm the risk assessment has been completed by Halcrow and have attached a letter and their report on this matter.

5.7 On 28 May 2007 the Commission wrote to the General Manager Infrastructure and Rail, Auckland Regional Transport Authority in part:

> The Commission is satisfied that the recommendation has been acted upon and the status of the safety recommendation is closed acceptable.

Approved for Publication 21 June 2007

Hon W P Jeffries
Chief Commissioner

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