OTSI Office of Transport Safety Investigations

TECHNICAL INSPECTION FINDINGS

FIRE INVOLVING STATE TRANSIT BUS MO 3422

DARLINGHURST, NSW

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Published by: The Office of Transport Safety Investigations
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THE OFFICE OF TRANSPORT SAFETY INVESTIGATIONS

The Office of Transport Safety Investigations (OTSI) is an independent NSW agency whose purpose is to improve transport safety through the investigation of accidents and incidents in the rail, bus and ferry industries. OTSI investigations are independent of regulatory, operator or other external entities.

Established on 1 January 2004 by the Transport Administration Act 1988, and confirmed by amending legislation as an independent statutory office on 1 July 2005, OTSI is responsible for determining the causes and contributing factors of accidents and to make recommendations for the implementation of remedial safety action to prevent recurrence. Importantly, however, OTSI does not confine itself to the consideration of just those matters that caused or contributed to a particular accident; it also seeks to identify any transport safety matters which, if left unaddressed, might contribute to other accidents.

This OTSI investigation was conducted under powers conferred by the Passenger Transport Act 1990. OTSI investigators normally seek to obtain information cooperatively when conducting an accident investigation. However, where it is necessary to do so, OTSI investigators may exercise statutory powers to interview persons, enter premises and examine and retain physical and documentary evidence.

It is not within OTSI's jurisdiction, nor an object of its investigations, to apportion blame or determine liability. At all times, OTSI's investigation reports strive to reflect a "Just Culture" approach to the investigative process by balancing the presentation of potentially judgemental material in a manner that properly explains what happened, and why, in a fair and unbiased manner.

The Incident

At approximately 0926 hours[1] on Thursday 16 October 2012, the driver of State Transit Authority[2] (State Transit) bus MO 3422 pulled over to the kerb while travelling through Darlinghurst on Oxford Street on an L94 route service.[3] The driver had been alerted to a problem by warning alarms on his dashboard and, upon checking his rearward view, noticed smoke emanating from the rear of the vehicle. The driver immediately evacuated his 44 passengers.

In the company of a nearby shopkeeper who attended with a portable fire extinguisher, the driver moved to the rear of the bus where they observed a hotel employee deplete his medium sized portable fire extinguisher around the rear hatch of the engine compartment. The hotel employee's efforts were not successful as he was unable to attack the seat of the fire with the hatch closed. However, the fire was extinguished by a unit from the local Fire and Rescue NSW station which arrived shortly afterwards.

Result

All components in the engine compartment, particularly in the vicinity of the near side of the engine, were damaged, as was the engine compartment hatch and the body panels above and to the sides of the hatch. The rear window shattered from the effects of heat.

No one who had been on or near the bus was injured. Police attended the incident but their involvement was confined to traffic management and making a report of the matter. As there were no suspicious circumstances, no further involvement by the Police was required but they remained on scene until the bus was towed away.

Under instructions from the operator, the bus was removed and towed to the maintenance compound within State Transit's Leichhardt Depot.

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1 Eastern Daylight-saving Time.

2 The State Transit Authority of New South Wales is the government owned entity responsible for the operations of Sydney Buses, Newcastle Buses & Ferries and Western Sydney Buses (Liverpool Parramatta Transitway).

3 The L94 route service connects La Perouse, Little Bay, Malabar, Maroubra Junction, Kingsford, Moore Park, Darlinghurst and the City (Circular Quay).

OTSI Involvement

OTSI's Duty Officer was notified of the incident at 0935 hours by State Transit's Radio Room located in the Transport Management Centre. Arrangements were then made for OTSI investigators to deploy to the scene and undertake an inspection and initial assessment at the Leichhardt Depot later that day.

The Bus

The bus was a two door Scania L113TRBL model fitted with a 10.55 litre diesel engine and an automatic transmission. It was built in June 1993 and was one of 49 similar model Scania buses in the State Transit fleet. The odometer was showing 236,837 kilometres at the time of the incident. The bodywork of the bus consisted of an Ansair Roadstar series body type with an aluminium frame supporting a combination of aluminium and composite (fibreglass) panels.

Examination of the Bus

Visual inspections of the bus were undertaken on 16 October 2012 to try to establish the origin and likely fuel and ignition sources of the fire.

Damage

The fire in the engine compartment was extinguished by Fire and Rescue NSW but not before it had spread throughout the compartment and affected most of the engine components and combustible materials.

Examination of the bus established that there was a concentrated pattern of fire damage around a particular area within the engine compartment on the near side between the turbocharger, exhaust manifold and auxiliary alternator. Damage to the exterior of the bus was confined to the aluminium engine compartment hatch, the fibreglass body panels to the side and above the hatch, the rear window, the reversing camera housing and centre 'wig wag' lights (visible in *Photograph 1*). There were signs of minor heat and fire damage within the rear interior of the bus.

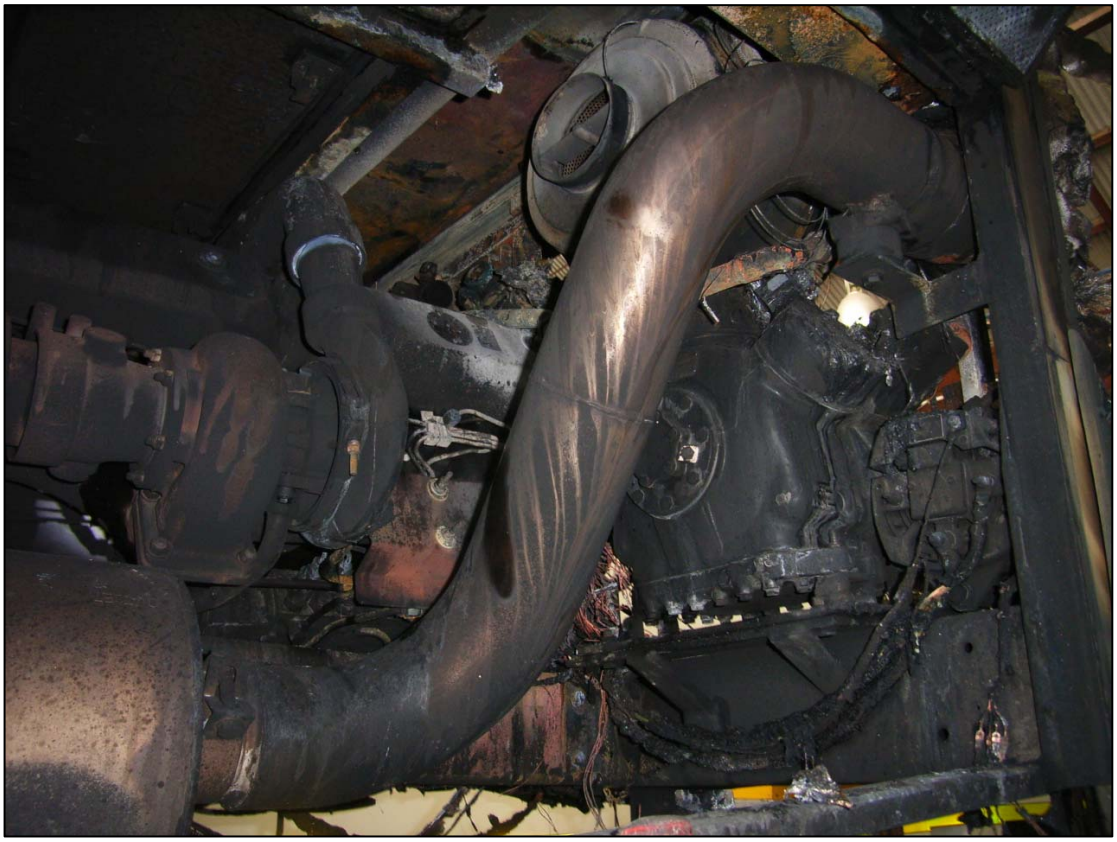
The extent of the damage, including the engine compartment, can be seen in *Photographs 1* to *4*.

Photograph 1: Overview of fire damage to the rear of the bus

(Image courtesy of State Transit)

Fuel injector delivery pipes and fuel return line

Witness observations, corroborated by the location of the greatest concentration of fire damage, indicated the likely source of the fire was on the near side of the engine (see *Photographs 1 to 3*). The turbocharger, air filter, auxiliary alternator and some nearby engine components were removed to allow for more detailed examination of those components, and to allow better access to that general area of the engine compartment. Other components in that area of the engine compartment included the exhaust manifold and several fuel injector delivery lines ('delivery pipes') which ran from the fuel pump to the fuel injector near the top of the engine. Amongst these delivery pipes was a low pressure fuel injector return line ('return line'). All components were checked for irregularities.



Photograph 2: Damage within engine compartment (near side)

Photograph 3: Component damage adjacent to fuel return line

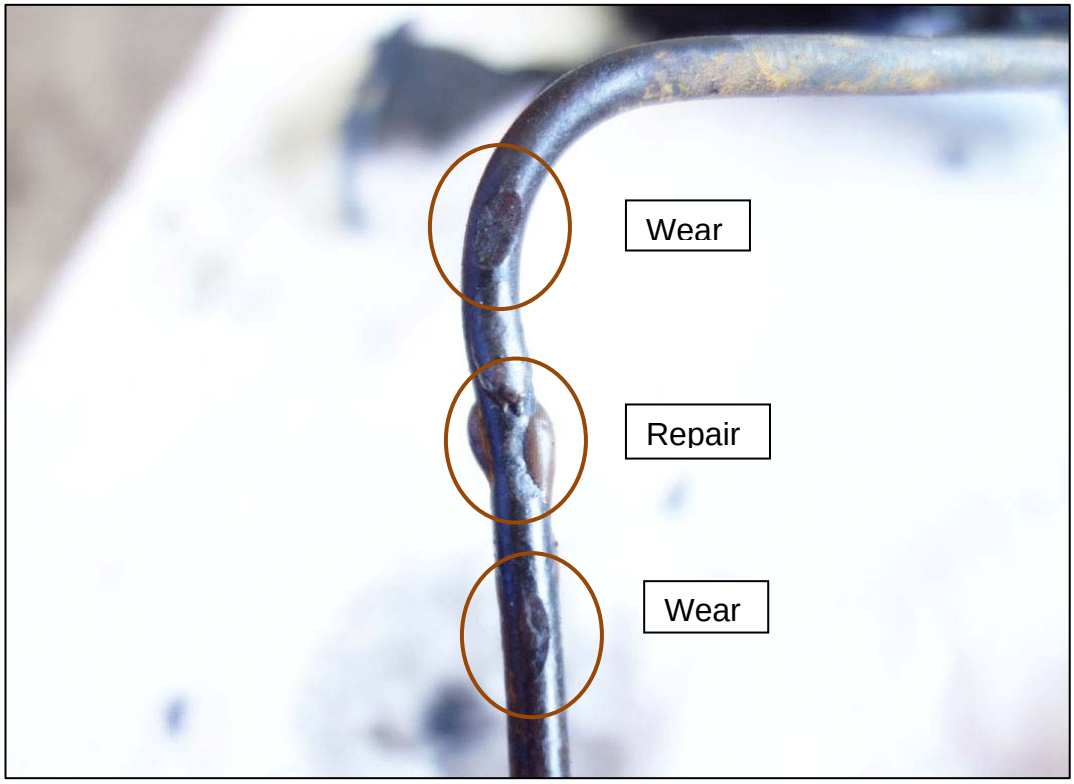
The delivery pipes appeared intact and properly clamped, however the return line was bent, unclamped, loose at one connection point and showed evidence of a previous repair (see *Photographs 4 and 5*). When removed for closer examination, the movement at the connection point was found to be due to a crack near a junction in the return line (see *Photograph 6*).

Photograph 4: Fuel return line in situ, showing previous repair

State Transit's technical investigation report established that the broken return line would have allowed the release of diesel fuel over nearby hot surfaces, such as the extremely hot turbocharger and exhaust manifold, creating a diesel vapour. The report states that it was the presence of this heated diesel vapour that: "… *provided an environment with a potentially high level of flammability within the engine compartment*". Further, it states: "… *the most probable cause of the ignition of the diesel fuel … is the presence of a high temperature electrical spark or arc created by the running surface of the armature slip rings and the brushes within the auxiliary alternator*". These electrical sparks or arcs commonly occur during normal operation of an alternator.

The return line was bent from its normal alignment, had evidence of a previous repair and showed wear marks from rubbing against adjacent pipes (see *Photograph 5*). This damage was unlikely to have been caused by the fire. It was more likely to

have occurred from a combination of normal operation/vibration, maintenance intervention and/or reinstallation activity. In this condition, the return line was more susceptible to failure from vibration and stresses under normal operating conditions.



Photograph 5: Wear damage and previous repair on the return line

Photograph 6: The crack in the return line

Metallurgical Report on the Fuel Injector Return Line

An independent metallurgical investigation commissioned by State Transit found that:

- A fatigue crack had initiated at one end of the return line and grown in size over a period of time prior to the fire. The metallurgical investigation report states: *"A pre-existing crack of this size will have acted as a significant stress concentrator such that further crack propagation would have been likely to develop over a relatively short period of time, even under nominally normal operating conditions".* Further: "*The presence of a crack at one end of the return line … indicate that the return line provided the fuel source for the initiation of the fire in question".*
- There were no witness marks along the length of the return line to indicate the presence of any supporting rubber sleeved "P" clamps. These clamps have an important role in improving rigidity against vibration, preventing chaffing against adjacent pipes and minimising the likelihood of undue stresses at the connection points. Importantly: "*The absence of a supporting "P" clamp will have greatly increased any movement of the return line associated with engine vibration etc. and therefore greatly increased the bending movement on the end of the return line where it fractured*".
- Examination of the return line in the area of the previous repair indicated:
    - *"There was no visible evidence to indicate that this previous repair had leaked."*
    - *"There were two visible areas of mechanical or wear type damage adjacent to the repair."* (See Photograph 5) *"This type of damage is probably the type of damage that had previously been repaired*."

Maintenance

The maintenance records of the damaged bus for the previous year were examined and showed no indication of recent maintenance specifically on the return line. However, there were several separate incidents of fuel leaks, most occurring at or near the fuel injector pump. The last repair of fuel leaks was on 6 September 2012, 40 days prior to the fire, and was in response to a Vehicle Defect Notice issued by

Roads and Maritime Services on 4 September 2012.[4] This repair work included fitting a new seal to the fuel injector pump which was removed and reinstalled, and which required the return line to be separated from the injector pump assembly. It was established that the return line was not separated from its upper union to facilitate the removal and reinstallation of the injector pump and instead was 'moved aside'. It is likely that this action contributed to the fracture in the return line.

The origins of the wear damage and repair work and the absence of the required number of correctly installed supporting clamps on the return line could not be explained. Given the recent fuel leaks experienced with the vehicle, the absence of the supporting clamps should have been readily identifiable at the time of the repair work to the leak at the injector pump in September, if it pre-existed this work. However, State Transit is of the view that it is not likely that the leak in the pipe was present at the time of this repair. Rather, "…*the failure of the pipe is likely to have originated from material defects initially as a result of the pipe being 'moved aside' when the fuel pump was fitted. The fracture and leak in the pipe being a fatigue failure resulting from insufficient pipe clamping.*" Regardless, the cumulative effect of damage to the return line and the absence of properly installed supporting clamps would make the return line more vulnerable to failure and less effective in meeting its intended purpose.

Fire Protection

Fire detection

This model bus is fitted with a fire/heat warning sensor system. It consists of two sensors placed in the engine compartment – one above the rear of the engine and the other on the under side of the off side rear passenger floor. The system is designed to activate and provide audible and visual alarms on the dashboard when it detects a significant heat source in the engine compartment. The driver indicated that it was these alarms that alerted him to the presence of a fire.

Fire extinguisher

The driver of the bus advised that once he was alerted to the presence of a fire, he immediately evacuated the bus. However, by the time this was completed, he

[4] Vehicle Defect Notice AHV0867080 dated 4 September 2012 identified four defects requiring rectification, only the "*Fuel system leak at injector pump*" was located in the engine. STA's records indicate that rectification work was carried out and all the defects cleared by 7 September 2012.

considered it unwise to attempt to extinguish the fire using the available portable fire extinguisher. Further, due to personal safety concerns, he did not attempt to open the rear engine compartment hatch.

One 4.3kg ABE powder-type extinguisher was fitted to the bus, mounted in a recessed panel next to the driver's seat. The type, size and location of this extinguisher satisfied the minimum rating and location requirements of *Australian Standard 2444—2001: Portable fire extinguishers and fire blankets - Selection and location*.

Once established, the fire spread quickly throughout the engine compartment and thence to the outside and exterior panelling of the bus. The bus was not fitted with a fire suppression system and the spread and intensity of the fire was beyond the capacity of the portable fire extinguisher used by the hotel employee.

Remedial Action

As a result of this incident, State Transit immediately inspected the remaining 48 buses of the same model in the fleet. They subsequently issued a maintenance alert covering vehicles of a similar configuration in the fleet (totalling 204 Scania buses). The alert focuses on the correct removal, repair and installation procedures relating to fuel lines.

Further, they are evaluating the viability of installing a manual emergency engine shut-off device.

Conclusions

It is most likely that, due to the absence of supporting clamps, the fuel injector return line suffered a fatigue failure which created a fuel leak. On coming into contact with nearby hot engine components, such as the turbocharger and exhaust manifold, the diesel fuel vaporised and was then ignited by an electrical spark or arc from the auxiliary alternator.

Appropriate remedial action is in hand to mitigate the risk of similar fires in State Transit's Scania fleet.

It is noted that this has been the second occasion where damaged metal fuel lines have been the cause of a bus fire; the previous incident involved a 1994 Volvo B6R model bus operated by Hunter Valley Buses.[5]

OTSI has concluded its examination of the circumstances of this incident and has determined that it does not require further investigation under the provisions of Section 46BA (1) of the *Passenger Transport Act 1990*.

A copy of these Findings has been provided to the State Transit Authority and the Roads and Maritime Services (as the NSW Bus Regulator).

[5] Refer to OTSI Technical Inspection Findings, *Fire Involving Hunter Valley Buses Bus 3595 MO, Raymond Terrace NSW, 22 February 2012*. A copy of this report can be found on the OTSI website at: http://www.otsi.nsw.gov.au/bus/120222_HVB_Fire_Raymond_Terrace_Final.pdf