OTSI Office of Transport Safety Investigations

TECHNICAL INSPECTION FINDINGS

FIRE INVOLVING STATE TRANSIT BUS 2204 ST CREMORNE, SYDNEY

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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.

OTSI's investigations are conducted under powers conferred by the Rail Safety Act 2008 and 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 2:30pm on Tuesday 22 March 2011, the driver of State Transit Authority[1] bus 2204 ST pulled over to the kerb while travelling along Military Road through the Sydney suburb of Cremorne on an M30 route service[2]. The driver had been alerted to a problem by a motorcyclist passer-by and, upon checking his rearward view, noticed smoke emanating from the rear of the vehicle. He went to the rear of the vehicle and saw that a large amount of smoke was coming from the engine compartment. The driver then immediately evacuated the 12 passengers travelling on the bus.

With the assistance of a nearby shopkeeper who attended with a portable fire extinguisher, the driver returned to the rear of the bus where he depleted the bus's medium sized handheld fire extinguisher into the engine compartment. The bus was also fitted with a fire suppression system in the engine compartment which activated and successfully extinguished the fire.

By the time Fire and Rescue NSW arrived the fire had been extinguished; however, they remained on scene until the bus was towed away.

Result

The upper area of the engine bay in the vicinity of a main electrical distribution (fuse) box was damaged, as was the covering hatch of the engine bay and the body panel above the hatch.

There were no injuries sustained by the driver or any of the passengers. Police attended the incident but their involvement was limited to making a report of the matter, deeming that as there were no suspicious circumstances, no further involvement by them was required.

Under instructions from the operator, the bus was initially moved by the Roads and Traffic Authority to a nearby side street, then removed from the scene utilising a State Transit tow truck to convey it to a compound within their old Leichhardt Depot.

[1] 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).

[2] Route M30 connects Mosman, Neutral Bay, the City, Chippendale, Newtown and Enmore.

OTSI Involvement

OTSI's Duty Officer was notified of the incident at 3:00pm by State Transit's Radio Room located in the Transport Management Centre. Arrangements were then made for OTSI investigators to undertake an inspection and initial assessment at Leichhardt the following day.

The Bus

The bus was a Volvo B12BLEA model, three door articulated bus, fitted with a 12 litre diesel engine and an automatic transmission. It was built in October 2010 and had travelled 18,440 kilometres since it was introduced into service in December 2010. The bodywork of the bus consisted of a Volgren CR228L series body type with an aluminium frame supporting a combination of aluminium and composite (fibreglass) panels.

Examination of the Bus

General examinations of the bus were undertaken on 23 March and again on 30 March 2011. The examinations took the form of a visual inspection of the bus to try to establish the origin and likely ignition source of the fire. The condition of the bus following the fire can be seen from *Photographs 1 and 2*.

Damage

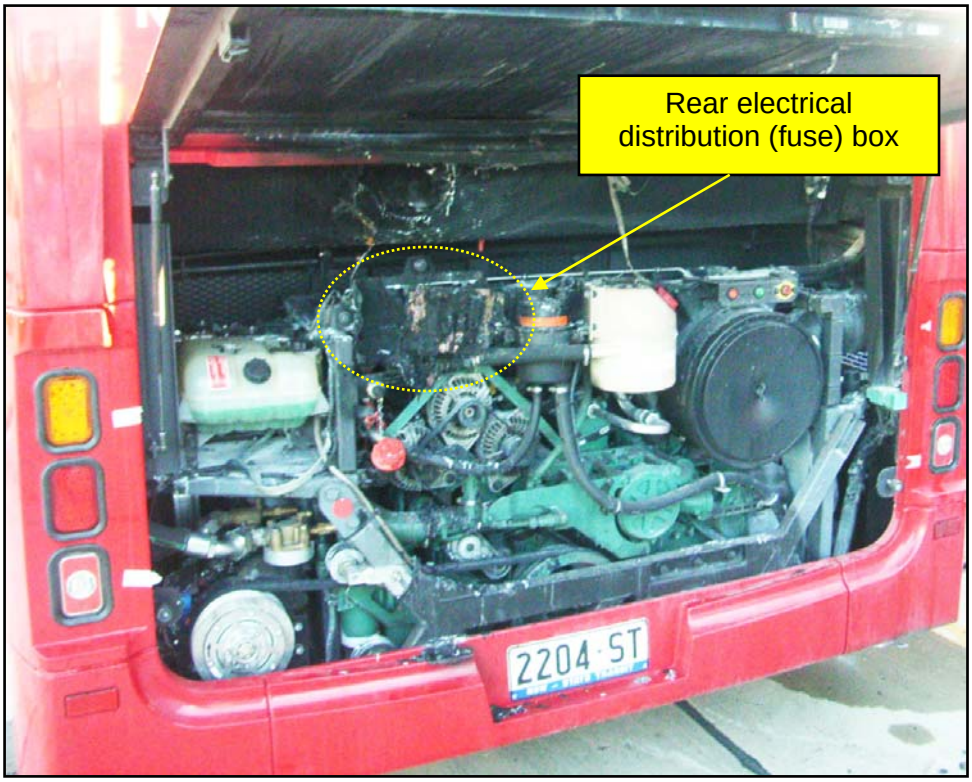
Damage to the exterior of the bus was confined to the aluminium engine bay hatch cover, the fibreglass body panel above the hatch, the reversing camera housing and centre 'wig wag' lights (visible in *Photograph 1*).

Examination of the engine compartment established that the fire had ultimately been extinguished by the onboard fire suppression system in sufficient time to limit the spread of fire to other engine components and combustible materials. This concentrated the pattern of fire damage around a specific area within the engine compartment; that of the rear electrical distribution (fuse) box which contains a range of plastic components.

This fuse box can be seen in the photographs of the damaged bus (*Photographs 2 and 3*) and for comparison in the photographs of the engine compartment of an identical bus (*Photographs 4 and 5)*.

There were no visible signs of smoke or fire damage within the interior of the bus.

Photograph 1: Fire damage to the exterior



Photograph 2: Overview of the fire damage within the engine bay

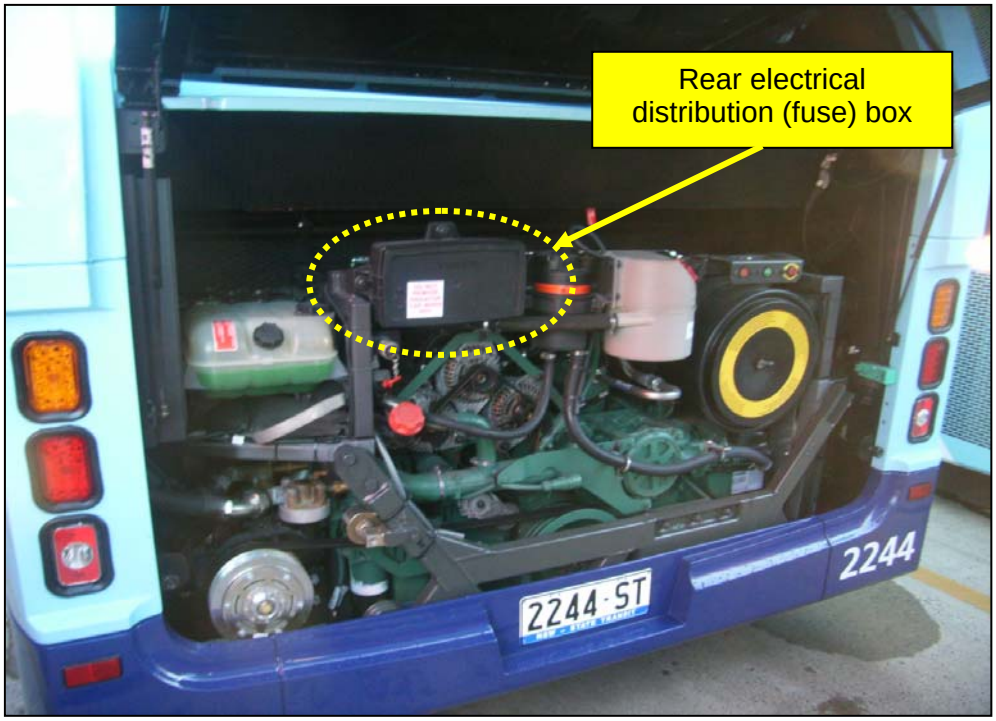
Photograph 3: Fire damage to the fuse box

Wiring looms and fuses

The wiring looms throughout the engine bay were checked for any irregularities, particularly the high amperage wires running to and from the fuse box. All looms were intact and appeared normal.

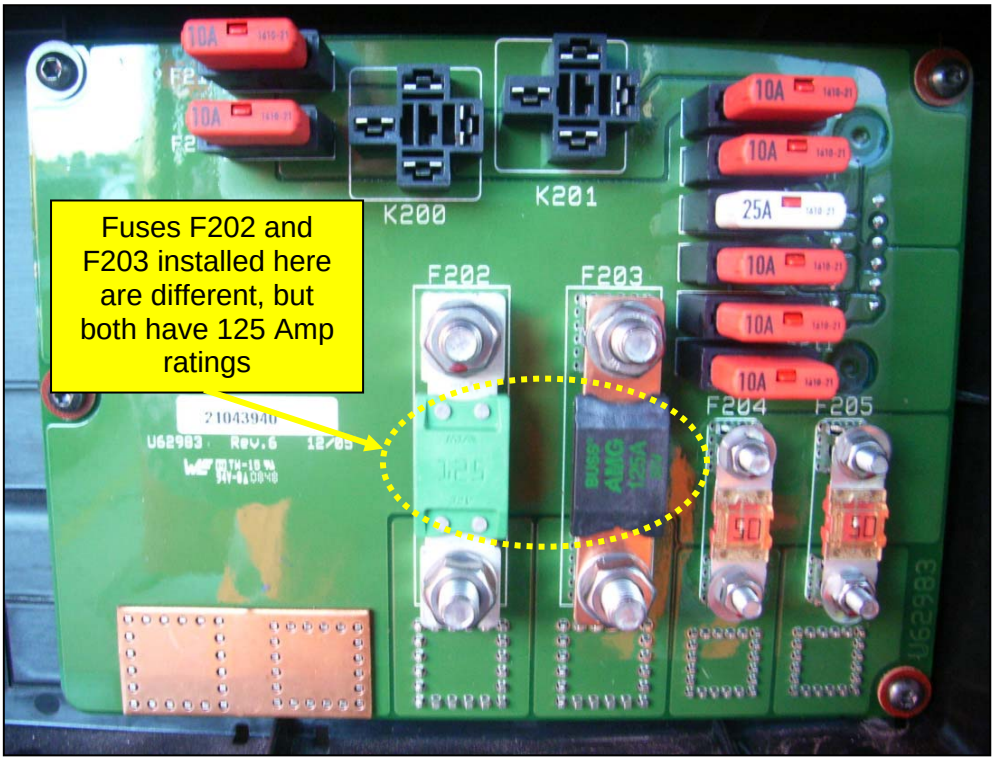
Within the engine compartment, the outer plastic covering of the rear electrical distribution (fuse) box had completely burnt away leaving the circuit board exposed. Despite the heat that would have been generated within the compartment, all other wiring remained intact.

An identical bus was made available by State Transit to allow a “before and after” comparison and to view undamaged components within and around this fuse box. The exterior and interior of the fuse box in the identical bus are shown in *Photographs 4, 5 and 6*.



Photograph 4: Fuse box in the engine compartment of identical bus

Photograph 5: Interior of a fuse box of identical bus



Photograph 6: Fuse ratings of those installed in identical bus

On 23 March 2011, the day after the incident, Volvo provided State Transit with an 'alert' titled *Bus Field Service Tips, Insert 37-200 – Electrical Component and Cable Inspection*.[3] This alert specified concerns with a range of this type of bus (fleet numbers 2001 – 2260) which included the bus with the fire damage (2204 ST) and the identical bus (2244 ST).

In its description of the problem, *Insert 37-200* states: "*There is a possibility of overheating cabling in the event that "P" clamps are not properly secured/positioned, electrical terminals are not tightened to the correct torque and if the incorrect fuses are fitted to the rear electrical distribution box.".*

Insert 37-200 specifies the fuse ratings for F202 as 150 Amps and Fuse F203 as 100 Amps.[4] Both the fuses installed in the identical bus (2244 ST) differed from the specified ratings, being rated at 125 Amps (see *Photograph 6*). It was later found that the specifications for fuse amperages in *Insert 37-200* were not consistent with the specifications in Volvo's original *Bodybuilding instruction* (BBI) (see *Table 1*).

[3] This document was updated and reissued by Volvo on 1 April 2011.
[4] Fuses F202 and F203 feed the air conditioning roof pod units to the front and rear of the bus. All other fuses are not in use.

Fuse No	Recommended rating according to 37-200	Recommended rating according to BBI	Actual rating installed on bus 2244 ST
F202	150	125	125
F203	100	100	125

Table 1: Fuse ratings - recommended and actual

Upon receipt of the alert, State Transit advised that they immediately commenced a check of the other 96 buses in their fleet with the identical fuse box and wiring arrangement and found a small number of buses had problems similar to those described in the alert. They also found inconsistencies in the routing of the wiring looms. All faults and anomalies were fixed during this inspection and the repairs were certified by both Volvo and State Transit before the buses returned to service. On 6 April 2011 Sydney Buses issued an internal 'maintenance alert' detailing the known combination of faults surrounding the fuses, wiring and associated connections.

State Transit's Technical Investigation into the fire on 2204 ST stated:

> "*The heat damage evident at the lower terminals for the air-conditioning circuit fuses located in the engine bay electrical fuse panel fitted to 2204ST was consistent with arcing damage resulting from a poor connectivity of either the terminal lug to the terminal post (loose terminal lug fastener) or poor crimping of the cable in the terminal lug…….. This heat damage from this arcing would be sufficient to propagate heat to the surrounding polypropylene housing of the fuse enclosure to induce ignition of the housing…… As this fuse panel is fed from a direct feed from the alternator bank, the heat build up from this arcing would have continued until the engine had stopped, adding to the heat load of the fire*".

Maintenance

Maintenance records showed that bus 2204 ST had been returned to the depot at Tempe on 22 February 2011 for a scheduled service and that this service identified a damaged alternator drive belt. Remedial work included the removal and

replacement of the alternator drive belt and removal and refit of the air conditioning belt.[5]

Fire Protection

Fire Extinguisher

The driver of the bus advised that once he was alerted to the presence of a fire, he immediately evacuated the bus and attempted to extinguish it using the dry powder-type extinguisher that was mounted next to the driver's seat.

Australian Design Rules require buses to be equipped with fire extinguishers selected and located in accordance with *Australian Standard 2444 - 2001: Portable fire extinguishers and fire blankets - Selection and location*. One 4.5kg ABE powder-type extinguisher was fitted to the bus, attached to 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 the Standard.

It is clear from the Standard that the extinguisher was chosen as suitable for initial 'knock-down' of a developing fire in the passenger compartment or engine of the bus and is considered most effective when aimed at the base of a fire. However, the extinguisher could not be expected to extinguish a fire that was well established in the structure or engine compartment of the bus.

Fire Suppression System (FSS)

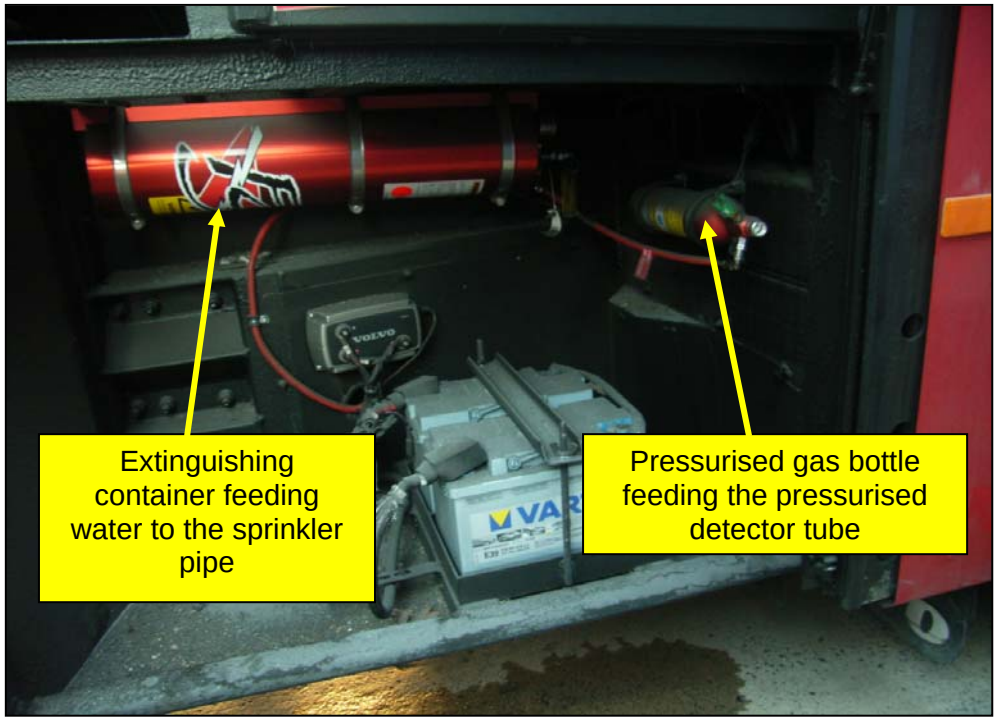
The inspection of the bus revealed there was a 'Fogmaker' fire suppression system (FSS) installed in the bus. This system is now fitted to all new State Transit buses and has also been retrofitted to some buses in their Newcastle fleet.[6] The system is designed to activate when it detects a significant heat source in the engine compartment or transmission area, and was successful in extinguishing the fire and limiting the spread of fire damage in this instance.

The FSS consists of two cylinders located towards the rear of the bus. One of these contains compressed nitrogen gas which is distributed in two plastic pressurised detector tubes to the engine bay and transmission, and the other contains water with

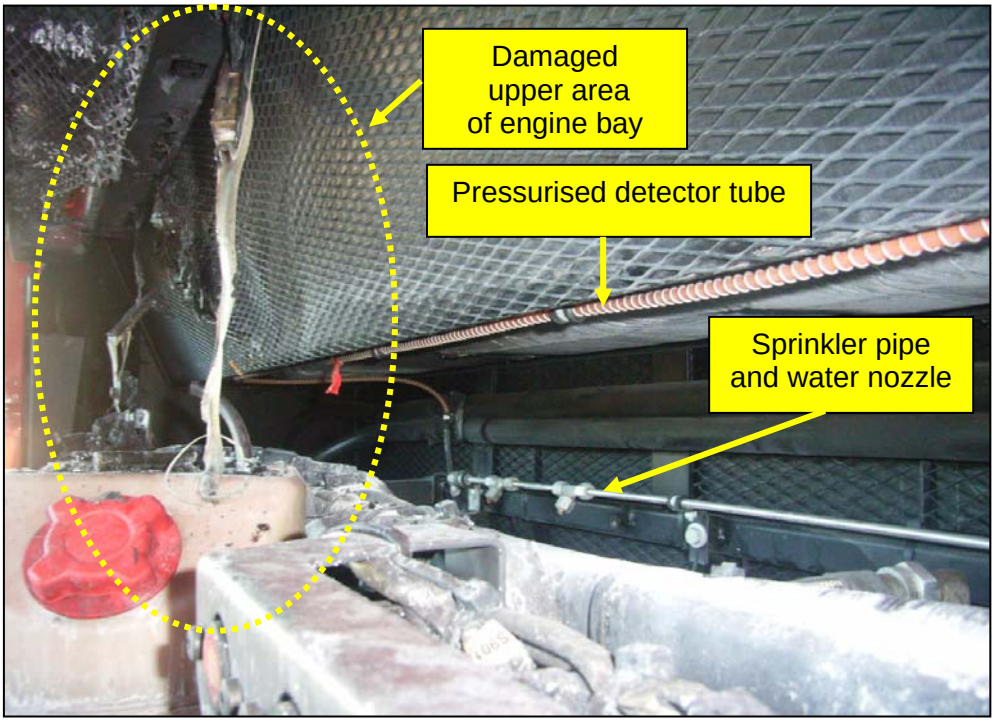
[5] The removal and refit of the air conditioning belt was necessary to gain access to the alternator belt.

[6] At the time of the incident, State Transit was in the process of receiving the last deliveries of two contracts dating from 2006, where fire suppression was not fitted.

a foaming additive which is distributed along two metal sprinkler pipes, also to the engine bay and transmission (see *Photographs 7* and *8*).



Photograph 7: The holding containers for the fire suppression system



Photograph 8: Relative positions of the fire damage, detector tube and sprinkler pipe in the engine bay

Detection and activation of the system takes place pneumatically. In the event of a fire, the pressurised detector tube bursts and the resultant drop in pressure activates a valve on the extinguishing container. A pressure switch on the detection gas bottle indicator gives an audible and visual alarm to the bus operator, via a display panel installed above the driver's side 'A' pillar. The system operates independently of a power supply.

When the system is activated, the water in the metal piping is discharged under pressure as a mist from small nozzles along the sprinkler pipe throughout the engine bay and over the transmission.

The water mist increases the water content of the air and prevents the supply of oxygen to the fire. The vaporization process cools the fire-affected area, contributing to the rapid extinction of the fire and reducing the risk of re-ignition. The water mist also deposits a layer of foam over inflammable oil products that tend to collect in depressions around the engine.

Photograph 8 also depicts the position of the detector tube relative to the concentration of fire damage to the fuse box and the mesh and insulation adjacent to the air vents above it. While the FSS ultimately extinguished the fire, there may be a case for reviewing the positioning of the detector tube to optimise earlier detection of a fire.

Conclusions

It is considered most likely that the heat source which initiated the fire was electrical in origin and was caused by loose wiring connectors on the fuse box. The heat caused the main electrical box, which sits above and to the left of the alternators and is made predominately of plastic, to catch fire. The fire then gained sufficient intensity to burst a pressurised detector tube of the fire suppression system. This in turn activated a valve that released water mist under high pressure from a sprinkler pipe which extinguished the fire before it spread to other engine components.

The State Transit Authority is continuing to work with the prime contractor, body builder and air conditioning suppliers to better understand the issues identified with

the electrical system of the Volvo B12BLEA and so be alert to similar issues arising with buses delivered in the future.

OTSI has concluded its examination of the circumstances of this incident and has determined that it does not require further investigation by this Office 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, the Independent Transport Safety Regulator and Transport for NSW.