TECHNICAL INSPECTION FINDINGS

FIRE INVOLVING HUNTER VALLEY BUSES BUS 3595 MO

RAYMOND TERRACE, NSW

22 FEBRUARY 2012
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Section 45C (2) of the Transport Administration Act 1988

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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.

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**The Incident**

At approximately 4:20pm\(^1\) on Wednesday 22 February 2012, the driver of Hunter Valley Buses\(^2\) (HVB) bus 3595 MO pulled over to the kerb while travelling along Adelaide Street through Raymond Terrace on a route 1491/1492 school service.\(^3\) The driver had been alerted to a problem by a student in the rear seat of the bus and, upon checking his rearward view, noticed smoke emanating from the floor area at the rear of the vehicle. The driver then immediately evacuated the four passengers travelling on the bus.

In the company of the driver of a following HVB bus\(^4\) who attended with a portable fire extinguisher, the driver moved to the rear of the bus where they both depleted their bus's medium sized portable fire extinguishers around the rear hatch of the engine compartment. Their efforts were not successful as they were 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 after.

**Result**

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

There were no injuries sustained by the driver or any of the passengers. Police attended the incident but their involvement was limited to traffic management and making a report of the matter, later deeming that, as there were no suspicious circumstances, no further involvement by them was required. The Police remained on scene until the bus was towed away.

Under instructions from the operator, the bus was removed from the scene by a local tow truck operator utilising a flat bed tow truck to convey it to the maintenance compound within HBV’s Thornton Depot.

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1. Times shown throughout are Eastern Daylight Saving Time, 11 hours ahead of Coordinated Universal Time.
2. Hunter Valley Buses (HVB) is a member of the ComfortDelgro Cabcharge (CDC) Group of companies. HVB holds separate and appropriate NSW operator accreditation and is responsible for providing passenger transport services to the Hunter Valley region. The bus was operated from HVB’s Thornton Depot.
3. Route 1491/1492 school service connects Callaghan College Jesmond to Maryland, Wallsend, Shortland and Raymond Terrace.
4. This second bus 1538 MO also operated from HVB’s Thornton Depot.
OTSI Involvement

OTSI’s Duty Officer was notified of the incident at 4:55pm by HVB Thornton Depot’s Assistant Depot Manager. Arrangements were then made for OTSI investigators to undertake an inspection and initial assessment at Thornton Depot the following day.

The Bus

The bus was a Volvo B6R model, fitted with a 6 litre diesel engine and an automatic transmission. It was built in August 1994 and had travelled 1,132,586 kilometres since it was introduced into service. The bodywork of the bus consisted of a two door Custom Coaches Road Cruiser Series 210 body 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 February and again on 5 March 2012, the latter in the presence of Volvo representatives with technical expertise in that model bus, including an Accident Research Manager from Sweden. 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 to 3. The bus was not fitted with CCTV equipment.5

Damage

Examination of the bus established that there was a concentrated pattern of fire damage around a specific area under the rear seat and within the engine compartment near the turbocharger. Damage to the exterior of the bus was confined to the aluminium engine bay hatch cover and the fibreglass body panels above and to the sides of the hatch (visible in Photograph 1). Damage to the interior of the bus was confined to the rear window and flooring around the rear seat (visible in Photograph 2).

Clause 82 of the Passenger Transport Regulation 2007 states: “An operator of a bus service who carries on a regular passenger service partly or wholly within the Metropolitan, Newcastle or Wollongong transport district……..must ensure that each bus in the fleet (emphasis added) is fitted with: (a) an approved security camera system….”. Transport for NSW indicated that this was not enforced on buses that are used solely on school bus runs. However, “from 1 July 2012 under the new standard Fleet Procurement Specifications, all bus services operating when replaced through the aged replacement program will be fitted with CCTV cameras - including school buses”.

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OTSI Technical Inspection Findings

Bus Fire, Raymond Terrace, NSW, 22 February 2012
The fire in the engine compartment was extinguished by Fire and Rescue NSW, but not before it had spread throughout the engine bay and affected most of the engine components and combustible materials (see Photograph 3).

The engine bay damage can be seen in the photographs of the damaged bus (Photographs 3 to 6) and for comparison in the photographs of the engine compartment of similar model buses (see Photographs 7 and 8).

Photograph 1: Fire damage to the rear exterior of the bus
(Photo courtesy of Hunter Valley Buses)
Photograph 2: Fire damage on floor near rear seats

Photograph 3: Overview of fire damage to the engine compartment
Fuel injector lines

Witness observations, corroborated by the location of the greatest concentration of fire damage, indicated the likely source of the fire was on the driver's side of the engine. The turbocharger 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 bay. Other components in that area of the engine bay included several fuel injector delivery lines (‘delivery pipes’) which ran from the fuel pump to the fuel injector near the top of the engine. These were checked for any irregularities.

The delivery pipes on the damaged bus were bent and badly damaged and one had broken away from its connection point at the fuel injector (see Photograph 4). In this instance, it was established that the broken delivery pipe would have allowed the release of fuel over nearby components, particularly the extremely hot turbocharger and associated exhaust components. Once established, the fire could spread quickly throughout the engine bay and thence to the underside of the interior flooring of the bus. The bus was not fitted with an automatic fire suppression system and the spread and intensity of the fire was beyond the capacity of the portable fire extinguishers applied to it.

Further, given that one delivery pipe was bent around an adjacent pipe (see Photograph 5), it was established that this was unlikely to have been as a consequence of the fire, but was more likely to have occurred during a previous repair, maintenance or re-installation activity. In this condition, the fuel delivery pipes were more susceptible to failure from vibration and stresses under normal operation.

Two identical buses were made available by HVB during the examination of 3595 MO on 5 March to allow a ‘before and after’ comparison and to view undamaged components within and around the engine bays. The exterior and interior comparative photographs of the engine bays are shown in Photographs 4 to 7.
Only two of the five supporting clamps remain attached.

Fuel injector delivery pipe twisted around an adjacent pipe.
Three of the five supporting clamps, each attached to two adjacent delivery pipes

Photograph 6: Side view of damaged fuel injector delivery pipes

Two ‘group’ supporting clamps for all fuel injector delivery pipes

Photograph 7: Side view of undamaged fuel injector delivery pipes of bus 3594 MO
The comparison of the fuel injector delivery pipes on the three HVB buses revealed the following:

- **Comparative bus 3594 MO** had undamaged fuel injector delivery pipes and had retained their original pipe fixings (the supporting clamps). The six delivery pipes connected to the fuel pump were supported by two ‘group’ clamps (see Photograph 7). Beyond this point, groups of two adjacent delivery pipes were connected by a total of five smaller supporting clamps, all of which improved rigidity against vibration, prevented chaffing against adjacent pipes and minimised the likelihood of undue stresses at the connection points.

- **Damaged bus 3595 MO** did not have any groups of supporting clamps (see Photograph 5) and only two of the five smaller supporting clamps remained, albeit they had been moved from their set positions and reinstalled incorrectly inverted. It is likely that the unconnected delivery pipe visible in Photograph 4 was bent to fit it around an adjacent delivery pipe. However, this meant that the end of the bent delivery pipe was no longer in natural alignment with its original connection point. When ‘forced’ into its final position, it would have been placed under additional stress at that point and so be more susceptible to failure from vibration, particularly in the absence of any group supporting clamps.

- **Comparative bus 3597 MO** had only one group supporting clamp. Whilst clamps were in place for the sets of two adjacent fuel delivery pipes, the clamps themselves had been moved from their set positions and reinstalled incorrectly inverted. Similar to 3595 MO, some delivery pipes were bent and damaged and were considered to be more at risk of failure.

**Maintenance**

The maintenance records of the damaged bus for the previous year were examined and showed no indication of recent maintenance that may have been related to the causation of the fire. However, the records indicated that the bus underwent a major engine rebuild between 4 and 7 January 2011. This work required removal and refit of the engine, transmission and several other major and minor components including the fuel injector delivery pipes. The bus had travelled approximately 30,000km since the engine rebuild.
On 16 March 2012, ComfortDelgro Cabcharge (CDC) initiated a fleet-wide inspection of Volvo B6R model buses similar to 3595 MO to identify and rectify any problems with the delivery pipes, fittings, supporting clamps and rubber inserts. This inspection uncovered problems on a small number of other buses, including evidence of loose or missing clamps and worn rubber inserts which allowed the pipes to chaff and rub against each other, contributing to wear and cracking in some cases.

CDC provided three internal Technical Bulletins/Work Instructions which addressed concerns with various aspects of the delivery pipes, clamps and fittings. The earliest, titled 23724-2 Delivery pipes, replace (all), was dated 21 February 2006 and included service literature from Volvo. In its description of the problem, this bulletin states at the beginning:

“\textit{The delivery pipes are supplied in multipacks. All the delivery pipes in the set must be replaced. This will make the pipes less sensitive to geometric differences in comparison with earlier (sic) when delivery pipes were supplied individually. By replacing all the delivery pipes in the set, the risk of burst pipes due to bending that was performed for previous service and repair purposes on injector and/or injection pump will be eliminated.}”

On page 4 is a clearly illustrated note warning:

“\textit{Do not bend the pressurised fuel delivery pipes when fitting}!”

The damage to the fuel delivery pipes and absence of the required number of correctly installed supporting clamps could not be explained. However, given the vehicle’s maintenance history, some or all of the defects should have been readily identifiable at the time of the engine rebuild in January 2011, if they pre-existed this major work. No servicing since then should have interfered with the components. In any case, the cumulative effect of damage to the delivery pipes and the absence of properly installed supporting clamps would make the fuel delivery pipes more vulnerable to failure and likely to be less effective in meeting their intended purpose.
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. Due to personal safety concerns, he did not attempt to open the rear engine bay hatch.

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 2.1kg 1A:20B:E dry powder type extinguisher was fitted to the bus, attached to a recessed panel next to the driver’s seat. Whilst the type and location of this extinguisher did satisfy the minimum requirements of the Standard, a rating of 1A did not. In accordance with Table 5.1 of the Standard, a passenger-carrying vehicle is required to have an extinguisher with a minimum rating and classification of 2A:20B (fitted with hose).

It is clear from the Standard that the dry powder 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, this extinguisher could not be expected to extinguish a fire that was well established and spreading.

The available fire extinguisher was ineffective in fighting the fire on bus 3595 MO. It did not meet the Standard, was not designed for use against established and spreading fuel fires, and was not used to attack the seat of the fire due to concerns with opening the engine bay hatch. The bus was not fitted with an automated fire suppression system.

Table 1 shows the comparison between the fire extinguishers from four similar HVB buses in relation to the parameters of the Standard. This comparison revealed that all four buses had different extinguishers installed; however, all but the extinguisher on the damaged bus 3595 MO complied with the Standard.
Table 1: Fire extinguisher ratings and classifications

CDC provided a Service Record confirming checks on fire extinguishers for a number of their buses in their Thornton Depot, including bus 3595 MO. This record dated 19 December 2011 indicates that bus 3595 MO had an extinguisher installed which complied with the Standard, however, it is not clear when this extinguisher was changed out.

Fire warning sensor system

The inspection of the bus revealed there was a fire/heat warning sensor system installed. This system consisted of three fire warning sensors and was fitted to all CDC/HVB Volvo B6R model buses. The sensors are strategically placed throughout the engine bay as follows:

- one sensor rated to 110°C located in proximity to the starter motor;
- one sensor rated to 110°C located in proximity to the alternator; and
- one sensor rated to 150°C located in proximity to the turbocharger and fuel pump (see Photograph 8 which shows the engine bay of bus 3597 MO depicting the typical position of this detector probe.)
The system is designed to activate when it detects a significant heat source in the engine compartment and then provides an audible and visual warning alert to the driver. In this instance, the driver could not recall any general warning lights, or the specific fire warning alarm being activated before he evacuated the bus.

Volvo commenced fitting an updated system of four warning sensors to its buses from 2010. The comparison between the warning sensors fitted to the early Volvo models and those sensors fitted to later models can be seen from Photographs 9 and 10.
Detection of the fire and activation of the alarm system takes place automatically. In the event of a fire (or when ambient temperature exceeds the sensor rating), the plastic coating around the detector probe melts and the internal wires contact, creating an open circuit which energises a relay. Once energised, the relay activates two red warning light indicators on the driver’s dashboard, as well as an audible ‘bell’ like alarm to alert the bus driver. The system does not have its own independent power supply.

The results of a check of the presence and electrical continuity of the warning sensor system in three similar HVB buses are shown in Table 2.
<table>
<thead>
<tr>
<th>Bus No</th>
<th>Fire warning sensors installed</th>
<th>Check of warning sensor system</th>
</tr>
</thead>
<tbody>
<tr>
<td>3594</td>
<td>Yes</td>
<td>Unable to be tested as power supply disconnected but appeared complete.</td>
</tr>
<tr>
<td>3595</td>
<td>Yes</td>
<td>Unable to be tested as power supply disconnected but appeared complete.</td>
</tr>
<tr>
<td>3597</td>
<td>Yes</td>
<td>Was able to be tested and was inactive as wiring had disconnected from its connection at the back of the Drivers test switch.</td>
</tr>
</tbody>
</table>

Table 2: Check of warning sensor systems

It could not be established whether or not the sensors activated on bus 3595 MO. The driver was alerted to the fire by a passenger; if the sensors did activate then he missed the cues. There may be benefit in reviewing the function of the alerts to ensure they are optimised for gaining the attention and correct interpretation by vehicle drivers.

Conclusions

It is considered most likely that the heat source which initiated the fire was failure of a damaged fuel injector delivery pipe which broke away from its original connection point and allowed the release of fuel onto nearby hot engine components, such as the turbocharger and associated exhaust components. This is consistent with Volvo’s findings from its technical inspection.

CDC and its depots worked with Volvo Australia to better understand the issues identified with the fuel injector delivery pipes, clamps and fittings highlighted as a result of this incident.

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 ComfortDelgro Cabcharge, Hunter Valley Buses, Volvo Australia, the Independent Transport Safety Regulator and Transport for NSW.
Post Script

On 1 March 2012, another Volvo B6R model bus 3594 MO operated by Hunter Valley Buses (HVB) was severely damaged by a fire in the engine bay when travelling empty along Luskintyre Road, Lambs Valley, near Lochinvar. The driver was alerted to a potential problem by a hot engine warning alarm. When the driver stopped the bus to investigate, he found smoke then flames emanating from the engine, but was able to extinguish the fire using the onboard fire extinguisher. Fire and Rescue NSW attended but were not required to assist.

Bus 3594 MO was one of two identical buses made available by HVB during the examination of 3595 MO on 5 March.\(^6\)

The cause of the vehicle fire on bus 3594 MO could not be established despite thorough examination of the bus by OTSI investigators, CDC staff and Volvo representatives. However, it is considered most likely that the fire started in the cable harness behind the upper alternator and close to the rear electrical centre.

As a result of this incident, Volvo Australia recommended CDC/HVB carry out a general inspection of cable harnesses and review of earlier repairs done on cable harnesses in the engine compartment.

\(^6\) Though 3594 MO had suffered damage from the engine fire on 1 March 2012, the area around the fuel injector, fuel injector delivery pipes and fuel injector pump were intact and had only suffered superficial damage.