BUS SAFETY INVESTIGATION REPORT

FIRE INVOLVING STA BUS MO 3936
ASHFIELD, SYDNEY
19 MAY 2015
BUS SAFETY INVESTIGATION REPORT

FIRE INVOLVING STA BUS MO 3936

ASHFIELD, SYDNEY

19 MAY 2015

Released under the provisions of
Section 45C (2) of the Transport Administration Act 1988 and
Section 46BA (2) of the Passenger Transport Act 1990

Investigation Reference: 04693
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, 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.

Once OTSI has completed an investigation, its report is provided to the NSW Minister for Transport and Infrastructure for tabling in Parliament. The Minister is required to table the report in both Houses of the NSW Parliament within seven days of receiving it. Following tabling, the report is published on OTSI’s website at www.otsi.nsw.gov.au.
TABLE OF CONTENTS

TABLE OF PHOTOGRAPHS ii
TABLE OF FIGURES AND GRAPHS ii
EXECUTIVE SUMMARY iii
PART 1 CIRCUMSTANCES OF THE INCIDENT 1
   Incident Synopsis 1
   The Bus 2
   The Bus’s Electrical System 2
   The Driver 4
   Driver’s Actions 5
   Injuries 5
   Emergency Response 5
PART 2 ANALYSIS 6
   Inspection 6
   Damage 6
   Ignition Source 9
   Faults, Warnings and Alarms 10
   Repairs and Maintenance 11
   Driver’s Instructions 12
   Fire Extinguishers 12
   Bus Fires 13
PART 3 FINDINGS 15
   Causation 15
   Contributory Factors 15
   Remedial Action 15
APPENDIX 1 SEQUENCE OF EVENTS 17
APPENDIX 2 SOURCES AND SUBMISSIONS 18
### TABLE OF PHOTOGRAPHS

<table>
<thead>
<tr>
<th>Photograph</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bus MO 3936 route</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Ignition and main battery connector switches on dashboard</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Rear electrical centre</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Damage comparison on top of engine, viewed from floor hatch</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Undamaged turbocharger and engine</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>Damage to rear of bus comparison</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>Fire damage and delamination of rear floor hatch</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>Short circuit on high amperage cable</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>Alternator cable short occurred 20.1.15</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>Wear on protective covering on cable</td>
<td>14</td>
</tr>
</tbody>
</table>

### TABLE OF FIGURES AND GRAPHS

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Starter and alternator circuits</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Indicator lamp display</td>
<td>11</td>
</tr>
<tr>
<td>1</td>
<td>Bus fires reported to OTSI May 2014 to May 2015</td>
<td>13</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

On 19 May 2015, State Transit Authority bus MO 3936 experienced a fire which caused extensive damage in the engine bay and flooring area. The bus was in service travelling along Parramatta Road in Ashfield with 24 passengers on board.

The driver stopped the bus and immediately evacuated the passengers to a safe place on being alerted to a strong burning odour by a passenger sitting at the rear of the bus. During the evacuation a passenger fell and suffered a minor injury to her back and received treatment at Royal Prince Alfred Hospital. Two other passengers and the driver suffered from smoke inhalation and were treated at the scene.

NSW Fire and Rescue units attended promptly and extinguished the fire.

A short circuit of the main alternator cable caused the fire. The cable was part of the high current circuit and was unfused. The driver did not switch off the electrical supply after he stopped the bus. Therefore, a continuous supply of power, generating heat at the short circuit site continued until the cable was severed.

The State Transit Authority initiated an immediate inspection of its fleet of the same model bus, concentrating on the condition and securing of all main electrical cables in the engine bay. A review of Driver training in relation to critical actions in the event of fire was undertaken.

The State Transit Authority also initiated and funded a program to retrofit fire suppression systems to the remainder of its fleet which did not already have such systems installed.

OTSİ notes the Government recently announced that all buses providing contracted Metropolitan and Outer Metropolitan bus services will be retrofitted with fire suppression systems. Also, the fitting of engine bay fire suppression systems is now a standard feature of the specification for all new buses procured to provide the services.
PART 1  CIRCUMSTANCES OF THE INCIDENT

Incident Synopsis

1.1 At approximately 14:02 on Tuesday 19 May 2015,¹ State Transit Authority (STA) Volvo B10BLE bus MO 3936 caught fire while travelling along Parramatta Road, Ashfield. The bus at the time conveyed 24 passengers on board. A passenger seated at the rear of the bus alerted the driver to a strong burning odour emitting from the floor of the bus. The driver stopped the bus on Parramatta Road near Bland Street, evacuated all the passengers to a safe location approximately 50 metres ahead of the bus. (See Photograph 1).

1.2 Concurrently, the driver contacted the STA Network Control Centre (NCC) and informed them of the possibility of a fire. The NCC contacted Fire and Rescue NSW who deployed promptly to the scene, arriving at 14:11. Prompt action by Fire and Rescue saved the bus from being destroyed, as they extinguished the fire before it breached the interior. Police arrived at 14:13 to control traffic, closing all three lanes of Parramatta Road as a precautionary measure and to allow access for emergency crews.

¹ All times referred to in this report are in Australian Eastern Standard Time (UTC+10 hours).
1.3 During the evacuation of the bus, a passenger fell injuring her back when her bag strap caught on a seat. Ambulances conveyed the injured woman to the Royal Prince Alfred Hospital. Two passengers and the driver suffered smoke inhalation and were treated at the scene.

1.4 STA towed the bus to the their Leichhardt Depot where OTSI investigators conducted a preliminary examination on 20 May 2015.

The Bus

1.5 The bus was an 11/1999 model Volvo B10BLE diesel powered bus owned by STA and operated out of its Burwood Depot. Bus MO 3936 was one of 124 of this model in the STA fleet. They were authorised to carry 78 passengers.

1.6 On 19 May 2015, after conducting pre-departure checks, the driver departed the depot at 11:29 on the first run for the day. The bus operated continuously on designated routes and, at 13:20, departed The Domain on a Route 461 service destined for Burwood Station. The fire occurred at 14:01 on Parramatta Road near Bland Street, Ashfield. The sequence of main events recorded on CCTV between The Domain and 14:24 when recording stopped. (See Appendix 1.)

The Bus’s Electrical System

1.7 The bus operated with a 24 volt electrical system using two 12 volt batteries connected in series and located at the offside front of the bus. These batteries distributed electrical power through two main electrical centres to the numerous systems required for the bus’s operation. The main electrical centre was located behind the driver’s console. The other electrical centre was mounted above the engine in the engine bay at the rear.

1.8 Two batteries supplied power connecting the main contractor to the starter solenoid (see Figure 1). When the ignition key/switch was activated and the engine started, two alternators then supplied power to the rear mounted electrical centre and through it, to charge the batteries. The circuit was completed through the bus’s chassis acting as the ground return. Located on the dashboard was an emergency electrical cut-out switch which would, if
activated, immediately cut the electrical supply, de-energising the system by removing electrical supply from the continual power distribution rail.

Figure 1: Starter and alternator circuits

Photograph 2: Ignition and main battery connector switches on dashboard

1.9 The rear electrical centre contained an array of fuses including a 150 amp fuse protecting the alternator polarity, a 16 amp fuse protecting the starter solenoid and an 80 amp fuse protecting the continuous power main line. Other electrical supply circuits also received power from this centre including
various sensors located around the engine. This electrical centre also provided an auxiliary engine start/stop switch that enabled mechanics to switch the engine on and off while conducting servicing and maintenance, without having to go to the driving position.

Photograph 3: Rear electrical centre

1.10 The main electrical centre distributed power to a wide range of electrically operated systems within the bus, including interior lighting, radio, CCTV, passenger overhead lighting, turn indicators, headlights, dashboard lighting, alarms and warning lamps.

The Driver

1.11 The bus driver had been employed by the STA since 2010. He had a current heavy vehicle licence\(^2\) and held a current Driver Authority to drive a public passenger vehicle as required by the *Passenger Transport Act 1990*. The driver was trained in handling emergency procedures as part of induction training on joining the STA. The training included the use of the portable fire extinguishers and safe evacuation of passengers.

---

\(^2\) Heavy Combination licence permits the holder to drive any articulated vehicle or truck trailer combination.
1.12 The driver was rostered within STA guidelines and had worked one day after having two rostered days off duty. He indicated he was not fatigued.

**Driver’s Actions**

1.13 A passenger seated at the rear of the bus alerted the driver to a strong burning odour emitting from the floor of the bus. The driver immediately stopped the bus, turned off the ignition, and evacuated his 24 passengers to a safe location, approximately 50 metres away from the bus. Concurrently, he contacted the STA NCC and informed the operator of the burning odour indicating the possibly of a fire.

1.14 After ensuring the passengers were safe, the driver returned to the bus but did not attempt to open the rear engine hatch or to use the bus’s 2.5 kg dry powder extinguisher. Further, he did not isolate the batteries, which therefore continued to provide electrical power throughout the bus’s internal circuitry.

**Injuries**

1.15 During the rapid evacuation of the bus, one passenger received a minor back injury when she slipped down a set of stairs and caught her handbag on a seat. Ambulance conveyed the injured woman to the Royal Prince Alfred Hospital as a precautionary measure. Two other passengers and the driver suffered the effects of smoke inhalation and were treated at the scene.

**Emergency Response**

1.16 Fire and Rescue NSW were notified of the fire at 14:05 by the STA NCC and arrived on site at 14:11. With the prompt response, they were able to extinguish the fire before it entered the interior of the bus. Police also attended to control traffic to allow emergency vehicle access to the bus.
PART 2   ANALYSIS

Inspection

2.1 OTSI investigators conducted a preliminary inspection of the bus at the STA Leichardt Depot on 20 May 2015 followed by a detailed inspection on 25 May 2015. Investigators examined maintenance, service records and obtained a capture of the bus’s internal CCTV recordings.

Damage

2.2 The engine bay suffered considerable fire and heat damage with significant damage to the engine bay wiring between the rearmost section of the engine bay and the automatic transmission bell housing (see Photograph 4). Fire consumed the insulating material on most of the low current wiring looms.

Photograph 4: Damage comparison on top of engine, viewed from floor hatch

2.3 The turbocharger, exhaust manifold and discharge pipe from the turbocharger turbine housing, displayed no evidence of ignition of fluids or other combustibles (see Photograph 5). These areas, apart from falling debris, were unaffected by heat or fire.
2.4 Fuel had leaked from fire damaged fuel feed lines to the lift pump and return line to the fuel tank. The leak was attributed to the existing level of the tank being higher in relation to the open ends of the damaged fuel lines, which were destroyed in the fire. The hydraulic fan drive oil was leaking from fire-damaged lines in the area directly behind the oil reservoir. In addition, the polycarbonate constructed oil level sight glass and housing had been melted in the fire.

2.5 Both the alternators, hydraulic fan drive reservoir, hydraulic fan drive pump, associated components and rear engine hatch panels were extensively
damaged. The fire had severely damaged, but not penetrated, the external surface of the rear fibreglass canopy. The rear window had shattered and some minor damage to the upper internal roof panel was evident. Additionally, there was damage to the internal rear floor over the engine bay. The floor comprised of a multi-layer of rubber flooring material and plywood with heat insulation on the underside surface.

2.6 The floor hatch above the engine showed considerable degradation from prolonged exposure to flames, with penetration through three layers of the plywood surface in some areas (see Photograph 7). The fire pattern on the underside of the hatch indicated that the area immediately below the hatch was the initial seat of the fire.

2.7 The CCTV footage confirmed that the main battery switch remained active in the on position. The CCTV showed the driver switching off the ignition but not the electrical supply to the batteries via the main battery connector switch. The saloon lights were still lit when the CCTV recording ceased. A check of a similar model bus confirmed that the saloon lights receive power
through the main battery contactor. While the contactor is closed, constant and unfused power continues to be supplied to the B+ terminal of the starter motor.

Ignition Source

2.8 The fire was caused by a short circuit of a cable which connects electrical power fed from the alternators at the rear electrical centre to the B positive terminal on the starter motor. Adjacent to the cable on top of the engine were two other cables running to the main earth point. It is most likely the short circuit occurred in this vicinity when wiring exposed due to loss of insulation came into contact with other wiring or metal components (see Photograph 8).

Photograph 8: Short circuit on high amperage supply cable

2.9 As the alternator circuit was unfused, and the power from the main batteries was not switched off, the continuous supply of power to the site of the short circuit generated significant heat until the cable was severed. Insulation material near the short circuit caught fire. The fire would then have spread to other materials.
2.10 Apart from the flammable fittings and fixtures, the underside of the bus’s floor directly above the engine, the rear engine panelling and the rear window suffered the most damage as the fire spread. Fortunately, the fire was extinguished before it could progress into the interior of the bus.

2.11 Another STA 1999 Volvo B10BLE bus, MO 3938, was used for comparison purposes to assist in identifying wiring harnesses. Its main circuit cable connecting the rear electrical centre distribution rail to the starter motor was found to be inadequately secured. This allowed movement of the cable while the bus was in operation.

2.12 STA examiners also found the cable inadequately secured on three other buses of the same model they inspected. In response, STA immediately arranged the inspection of all their fleet of Volvo B10BLE buses to identify and rectify any wiring harnesses not secured correctly.

Faults, Warnings and Alarms

2.13 Volvo B10BLE buses have 20 warning lights activated by sensors throughout the bus, these are displayed on the dashboard panel. These lights are designed and positioned to attract the driver’s attention. There are lights for a variety of parameters; in particular one warning of an engine fire and another warning of excessive engine temperature (see Figure 2).

2.14 The driver assured investigators that there had definitely been no alarms activated or fault light indicators illuminated prior to or at the time of the fire. Further, he stated that all dashboard instrumentation was operating normally at the time of initial start-up at the depot.
2.15 Maintenance records showed that the bus had been regularly maintained throughout its service in accordance with both the manufacturer's and STA's servicing regime.

2.16 The vehicle underwent a routine preventative maintenance on 13 May 2015 in preparation for a Roads and Maritime Services Heavy Vehicle Inspection Scheme (HVIS) inspection due at the beginning of June 2015. The previous HVIS inspection had occurred on 2 December 2014.

2.17 Examination of maintenance records revealed that, on 20 January 2015, the bus required towing to the Fleet Operations yard following an “on road” incident involving smoke emanating from the engine bay. On this occasion, a short in the main alternator circuit between the rear electrical centre distribution rails and the B+ terminal of the starter motor was identified. (See Photograph 9). The alternator cable severed at the point where the short circuit occurred. Removal and repair of the main alternator loom was necessary.

![Figure 2: Indicator lamp display](image)

### Repairs and Maintenance

- **Component**
  - No.
  - Parking brake pressure switch
  - Indicator lamp, direction indicators
  - Warning lamp, engine oil pressure low
  - Indicator lamp, high beam
  - Charging warning lamp, alternator 1
  - Charging warning lamp, alternator 2
  - Warning lamp, service brakes pressure low
  - Warning lamp, parking brake off
  - Indicator lamp, retarder
  - Indicator lamp, starting heater
  - Indicator lamp, rear fog lights
  - Warning lamp, engine oil level low
  - Warning lamp, tran. temp. high/EGS diag. and safety system
  - Warning lamp, door brake
  - Warning lamp, engine comp./luggage doors open
  - Warning lamp, engine compartment temp./high
  - Indicator lamp, next stop
  - Warning lamp, doors open
  - Warning lamp, engine coolant temperature high
  - Warning lamp, engine coolant level low
  - Warning lamp, engine compartment fire
  - Warning lamp, perambulator
  - Warning lamp, air suspension pressure low
  - Engine oil level low contact
  - Fire warning lamp and buzzer relay
  - Indicator lamp, ABS
  - Air suspension pressure low contact
  - Lamp check relay
  - Oil pressure low buzzer activating relay

**Warning and indicator lamps panel**

542 508 559 558 507
505 503 544 555 540
546 543 541 554 506
5009 528 536 561 562

![Photograph 9](image)
2.18 Another maintenance record indicated an intermittent fault for “Temperature Alarm and Fire Alarm on dash” on 22 October 2014. Repairs requiring the replacement of two fire sensors was repaired at the STA Burwood Depot on 23 October 2014, the work order signed off as tested and completed.

Driver’s Instructions

2.19 As a result of this fire, and a fire at Mosman on 1 April 2015, STA instructed all drivers that, in the event of a fire and where possible, they were to activate the electric cut out switch on the dashboard as well as switching off the ignition and fuel supply.

Fire Extinguishers

2.20 The Australian Design Rules require buses and coaches to be equipped with fire extinguishers in accordance with Australian Standard (AS) 2444-2001 Portable fire extinguishers and fire blankets – Selection and location. The bus carried one 2.5kg ABE powder type extinguisher which satisfied the minimum rating and location requirements of the Standard. However, the driver did not use it on this occasion.
2.21 It is clear from the Australian Standard that the extinguishers were chosen as suitable for initial ‘suppression’ of a developing fire in the passenger compartment or engine bay area of the bus, but could not be expected to extinguish a well-established fuel or oil fed fire.

2.22 MO 3936 was not fitted with an automatic fire suppression system (AFSS). An AFSS offers the potential for rapid activation of fire protection measures to reduce the consequences of a fire within its sphere of influence.

**Bus Fires**

2.23 In the 12 months prior to the MO 3936 fire, OTSI received 37 reports of fires on buses from accredited operators (May 2014 to May 2015). Analysis of these incidents determined the highest causes were brakes 43% and electrical 30% (see Chart 1). Other causes identified were mechanical failure and fluids leaking onto surfaces in the engine bay.

![Bus Fires Chart]

**Graph 1: Bus fires reported to OTSI May 2014 to May 2015**

2.24 As in the case of MO 3936, a common cause in a number of the fires was short circuiting of high amperage cables (positive +). The short circuits occurred when the outer protective covering was worn or damaged allowing

---

3 A fire suppression system defined in Australian Standard AS 5062-2006 *Fire protection for mobile and transportable equipment* as “An engineered or pre-engineered system designed to suppress or extinguish a fire by either local application or total flood design methodology”.

---
the wires to make contact with other cables (negative -) or fittings. When cables and looms are not adequately secured then vibration while the bus is in operation will promote excessive wear of protective coverings. During the investigation, examples of wear and chafing of protective cable insulation was observed on the bus used for a comparison (see Photograph 10).

Photograph 10: Wear on protective covering on cable

2.25 These observations highlight the importance of checking all wiring harnesses during routine maintenance. Attention is required to identifying and rectifying cables that are not adequately secured or that show signs of chaffing or abrasion of the protective wiring covering.
PART 3  FINDINGS

Causation
3.1 The fire on MO 3936 was initiated by a short circuit of the cable which connects electrical power fed from the alternators at the rear electrical centre to the B positive terminal on the starter motor. The cable had not been adequately secured thus allowing the insulation to wear and so expose the wiring. A short circuit occurred when this wiring contacted other cables or metal components.

Contributory Factors
3.2 The cable was part of the high amperage circuit and was unfused. Therefore, when the driver did not isolate the electrical supply after he stopped the bus, the continuous supply of power to the site of the short circuit generated significant heat until the cable was severed.

3.3 Maintenance inspections of the securing of electrical cables on STA’s Volvo B10BLE buses had not been adequate during servicing. Cables on three other Volvo B10BLE buses were found to be inadequately secured.

Remedial Action
3.4 STA initiated an immediate inspection of all Volvo B10BLE buses in the fleet, concentrating on the condition and securing of all main electrical cables and looms in the engine bay. STA also initiated and funded a program to retrofit fire suppression systems to the remainder of its fleet which did not already have such systems installed.

3.5 A review of driver training was also undertaken. The review covered the critical actions to be taken by drivers in the event of a fire particularly isolation of the main battery power. OTSI considers the remedial action undertaken to be an appropriate and satisfactory response to the incident. Consequently, no recommendations are made.

3.6 Further, OTSI notes the recent Government announcement that all buses providing contracted Metropolitan and Outer Metropolitan bus services will be retrofitted with fire suppression systems. Also, the fitting of engine bay fire
suppression systems is now a standard feature of the specification for all new buses procured to provide the services.⁴

⁴ A Constance (Minister for Transport and Infrastructure), *Safety Boost for Bus Customers*, media release, Sydney, 6 August 2015
APPENDIX 1  SEQUENCE OF EVENTS

The following sequence of events was determined from the bus’s internal CCTV recording:

13:20  Bus departs The Domain to operate a Route 461 service
13:36  Bus passes through Railway Square
14:00  Bus passes Ashfield Park
14:01  two passengers move from the rear of the bus and report to the driver of the presence of smoke in the rear saloon
14:02  all passengers move towards the front of the bus
       Bus driver stops and secures bus, opening both doors
       All passengers evacuated to a safe distance from bus
       The driver re-enters bus and retrieves personal items (cash tray, etc.)
       The driver exits bus and moves passengers further away from bus (40-50 metres)
14:04  CCTV shows flames and smoke visible inside saloon
14:10  Thick smoke begins to fill the saloon of bus
14:11  NSW Fire and Rescue arrive, park appliance adjacent to bus in lane 3 and begin to unload equipment
14:13  Police arrive and begin to direct traffic
14:16  Flames no longer visible, with thick smoke still filling bus saloon
14:17  Fireman enters rear door, assesses the situation and exits
14:23  Fireman enters the rear door with hose, moves towards the rear and applies water to the fire
       Ambulance arrives and parks in Bland Street
14:24  Second ambulance arrives and crews begin to assess passengers
14:24  CCTV footage ends
APPENDIX 2 SOURCES AND SUBMISSIONS

Sources of Information

- Australian Design Rules
- Australian Standards
- State Transit Authority
- Volvo maintenance service manuals

Submissions

The Chief investigator forwarded a copy of the Draft Report to the Directly Involved Parties (DIPs). This provided them with the opportunity to contribute to the compilation of the Final Report, by verifying the information, and to submit recommendations for amendments to the Draft Report if they believed it would enhance the accuracy, logic, integrity and resilience of the Investigation Report. Invitations to make submissions on the Draft Report were sent to the following DIPs:

- Roads and Maritime Services
- State Transit Authority
- Transport for NSW

Responses were received from all three DIPs and their recommended amendments were incorporated in the Final Report.