



Office of Transport Safety Investigations

BUS SAFETY INVESTIGATION REPORT

FIRE INVOLVING STA BUS MO 1695

MOSMAN

1 APRIL 2015



BUS SAFETY INVESTIGATION REPORT

FIRE INVOLVING STA BUS MO 1695

MOSMAN

1 APRIL 2015

Released under the provisions of
Section 45C (2) of the *Transport Administration Act 1988* and
Section 46BBA (1) of the *Passenger Transport Act 1990*

Investigation Reference: 04689

Published by: The Office of Transport Safety Investigations
Postal address: PO Box A2616, Sydney South, NSW 1235
Office location: Level 17, 201 Elizabeth Street, Sydney NSW 2000
Telephone: 02 9322 9200
Accident and incident notification: 1800 677 766
Facsimile: 02 9322 9299
E-mail: info@otsi.nsw.gov.au
Internet: www.otsi.nsw.gov.au

This Report is Copyright. In the interests of enhancing the value of the information contained in this Report, its contents may be copied, downloaded, displayed, printed, reproduced and distributed, but only in unaltered form (and retaining this notice). However, copyright in material contained in this Report which has been obtained by the Office of Transport Safety Investigations from other agencies, private individuals or organisations, belongs to those agencies, individuals or organisations. Where use of their material is sought, a direct approach will need to be made to the owning agencies, individuals or organisations.

Subject to the provisions of the *Copyright Act 1968*, no other use may be made of the material in this Report unless permission of the Office of Transport Safety Investigations has been obtained.

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 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.

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.

OTSI cannot compel any party to implement its recommendations and its investigative responsibilities do not extend to overseeing the implementation of recommendations it makes in its investigation reports. However, OTSI takes a close interest in the extent to which its recommendations have been accepted and acted upon.

TABLE OF CONTENTS

TABLE OF PHOTOGRAPHS	II
TABLE OF FIGURES AND DIAGRAMS	II
EXECUTIVE SUMMARY	III
PART 1 FACTUAL INFORMATION	1
Incident Synopsis	1
Incident Narrative	2
Emergency Services Response	3
Initial Inspection	4
The Bus	4
The Driver	5
Environmental Information	5
PART 2: ANALYSIS	6
Inspection	6
Independent Metallurgist Report	10
Servicing and Maintenance	11
PART 3 FINDINGS	12
Causation	12
PART 4 RECOMMENDATION	13
APPENDIX 1 SOURCES AND SUBMISSIONS	14

TABLE OF PHOTOGRAPHS

Photograph 1: Damage to trailer section	1
Photograph 2: Daily Telegraph Photograph of bus at incident scene	3
Photograph 3: Seat of initial fire at exhaust pipe exit at roof canopy	6
Photograph 4: Mufflers removed showing oil residue	7
Photograph 5: Oil in exhaust line from turbocharger	7
Photograph 6: Compressor impeller split in housing	8
Photograph 7: Compressor impeller removed for examination	9
Photographs 8 & 9: Internal electrical wires shorted	10

TABLE OF FIGURES AND DIAGRAMS

Figure 1:	Google Map - Incident location	2
Diagram 1:	Exploded view of turbocharger	11

EXECUTIVE SUMMARY

On 1 April 2015 State Transit Authority articulated Volvo bus MO 1695 experienced a fire which caused extensive damage to the trailer section. The bus with 18 passengers on board was travelling along Spit Road in Mosman en route to the Sydney CBD.

On being alerted to the fire by the driver of a following bus, the driver stopped at the first available safe place and evacuated his passengers. He then attempted to extinguish the fire but was unsuccessful. NSW Fire and Rescue units attended promptly and extinguished the blaze.

No passengers suffered any ill effects from the fire. However, as a precaution, the driver was treated at Mona Vale Hospital for minor smoke inhalation. Though the rear of the bus and internal fittings and fixtures suffered significant damage, the engine was unaffected.

The fire was caused by catastrophic failure of the bus's turbocharger compressor impeller which allowed lubricating oil to enter the exhaust system and ignite. The fire ignited the fibreglass canopy and the interior lining at the back of the bus then quickly spread through the interior of the bus.

A secondary source of fire resulted from the bus's electrical system not being switched off. The heat from the fire melted the electrical system wiring insulation and their plastic securing ties resulting in live wires shorting against each other and other metal objects.

A recommendation is made to the State Transit Authority to upgrade instructions for all drivers to include the requirement, in the event of a fire, to switch off the electrical supply to all systems, if possible without subjecting themselves to risk, to reduce the risk of a fire spreading to the interior of a bus.

PART 1 FACTUAL INFORMATION

Incident Synopsis

- 1.1 At 15:00 on 1 April 2015 State Transit Authority (STA) articulated Volvo bus MO 1695 experienced a fire which caused extensive damage to the trailer section. The bus with 18 passengers on board was travelling along Spit Road in Mosman en route to the Sydney CBD.
- 1.2 The driver was alerted to the fire by the driver of a following bus. The driver stopped the bus just north of the intersection with Awaba Road, evacuated the passengers, and then attempted to put out the fire with the on board portable fire extinguisher. He was not successful. The fire was eventually extinguished by NSW Fire and Rescue units who attended in response to the driver's radio call to the STA Radio Room. Damage to the trailer section of the articulated bus was extensive (see *Photograph 1*).



Photograph 1: Damage to trailer section

- 1.3 No passengers suffered any ill effects from the fire. However, as a precaution, the driver was treated at Mona Vale Hospital for minor smoke inhalation.

Incident Narrative

- 1.4 The fire occurred on Spit Road, a section of a busy arterial road connecting the Northern Beaches with the Sydney CBD. The road has three lanes in each direction. At the time of the incident traffic was heavy in both directions on Spit Road as the peak was building.
- 1.5 The driver noticed the bus engine experience a loss of power just as he reached Medusa Street at the top of the winding road up the steep hill up from The Spit (see *Figure 1*). He cycled through the gears and noticed that the turbocharger boost gauge was reading zero although there was no audio or visual alarm activated.

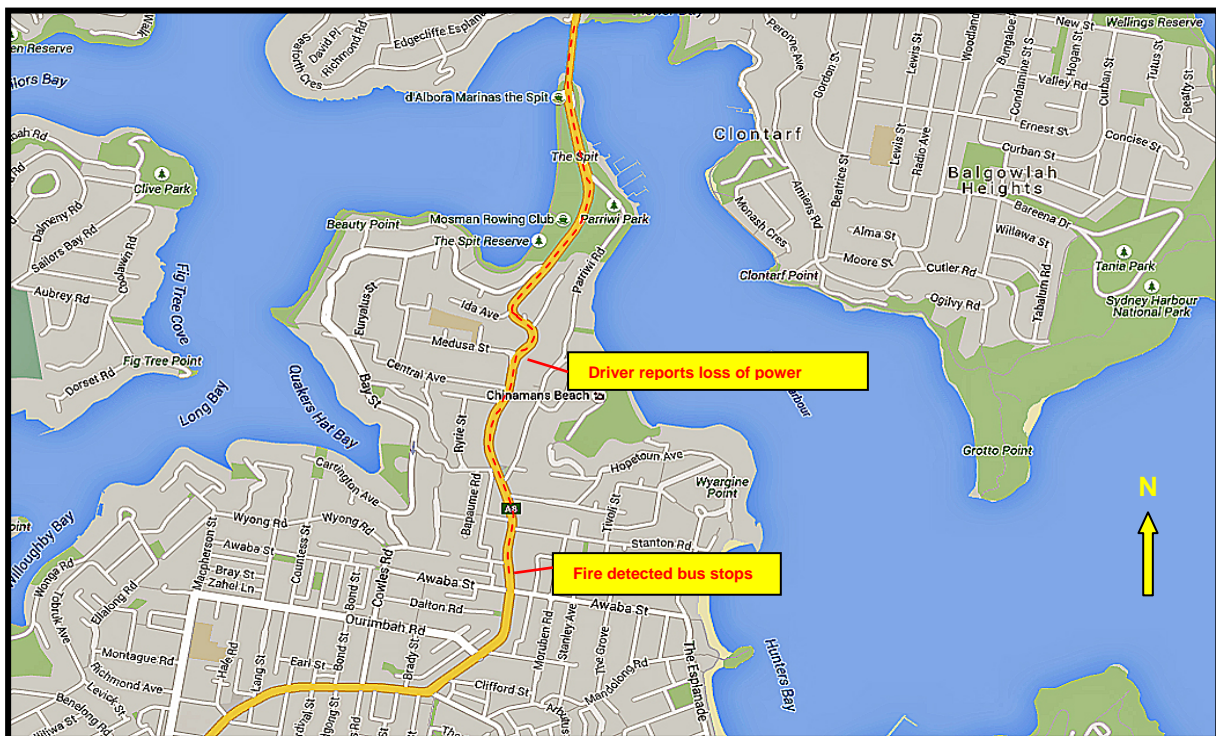


Figure 1: Google Map - Incident location

- 1.6 The driver continued on for a short distance before he received a call from the driver of a following bus alerting him to a fire at the rear of the bus. The driver pulled over at the first available safe place just north of the intersection with Awaba Street. On observing the smoke emanating from the rear of the bus in the rear vision mirrors, he switched off the ignition. However, he did not switch off the electrical supply from the batteries. The driver then evacuated his passengers while, at the same time, alerting the STA Radio Room to the

situation. The Radio Room then notified the Transport Management Centre (TMC).

- 1.7 Once the passengers were safe, the driver inspected the rear of the bus and observed flames coming from the exhaust area. He re-entered the bus and retrieved the portable 2.5kg dry powder extinguisher from the driver's console, He then returned to the back of the bus and discharged the contents of the extinguisher into the rear engine bay. This had no effect on the fire.
- 1.8 The driver noted with concern that, when he discharged the extinguisher up towards the roof area, powder blew across the adjacent lane. This created a hazard as overtaking vehicles tended to react by swerving to avoid it.

Emergency Services Response

- 1.9 The TMC notified NSW Fire and Rescue who responded quickly and were on the scene seven minutes after the driver had reported the fire. When they arrived the rear trailer section and the roof of the bus were well alight (see *Photograph 2*). However, the fire was quickly extinguished.



Photograph 2: Daily Telegraph Photograph of bus at incident scene

- 1.10 Police attended, arriving at 15:08 to control the heavy traffic congestion. They initially closed off Spit Road to all north and south bound traffic. After the fire

was extinguished, all northbound lanes were opened to traffic. Only one lane was opened to southbound traffic until the bus was removed.

Initial Inspection

- 1.11 OTSI deployed an investigator to the scene arriving 30 minutes after notification of the incident by the TMC. A preliminary inspection only was made at the scene as the fire had impacted on the heavy early peak traffic flow. The bus was towed by STA to their North Sydney depot initially. After the end of the afternoon/evening peak hour traffic, it was towed to the Leichhardt depot where it was quarantined awaiting detailed examination.

The Bus

- 1.12 The bus was a Volvo B12BLEA model diesel powered turbocharged articulated bus owned and operated by the STA. The bus was in current registration as MO 1695 and was attached to the Mona Vale Depot. The bus was licensed to carry 88 passengers comprising of 66 seated and 22 standing. The body was supplied by Custom Coaches, NSW, to contract standards. At the time the bus was on service L90 from Palm Beach into the Sydney CBD.
- 1.13 On 1 April 2015 the bus commenced service on the following routes prior to the fire:
- 06:33: Bus departed Mona Vale depot to Careel Head Road to commence the first service.
 - 06:48: Route E88 Careel Head Road to the University of NSW scheduled to arrive at 08:42.
 - 08:52: Running Special, departed the University returning to Mona Vale depot and arriving at 09:58.
 - 10:00: The bus remained at the depot until the next service after the driver's three hour rest and meal break.
 - 13:17: Commenced operating service L88 Mona Vale to Avalon arriving at 13:33.
 - 13:55: Bus departed Avalon on Route L90 to the CBD.

15:00 Bus stops on Spit Road near Awaba Street Mosman when the fire was detected.

The Driver

- 1.14 The driver was attached to the Mona Vale depot and held a current heavy vehicle license issued by the Roads and Maritime Services (RMS). He was also an accredited bus operator with Transport for NSW (TfNSW). He had eight years' experience driving buses within the metropolitan area and had been employed by the STA since 2008.
- 1.15 The driver commenced his shift at 06:23 at the Mona Vale depot with the initial pre-start checks of MO 1695. He was the sole driver of the bus for the day and had not experienced loss of engine power at any other time.
- 1.16 The driver had worked the two previous days but his roster indicated that he had not performed excessive driving duties in the days prior to the incident. He stated that he was in good health and not fatigued.
- 1.17 The driver had been trained by STA in emergency procedures and the use of the on board portable fire extinguisher. .

Environmental Information

- 1.18 The weather was fine and sunny with a temperature of 24⁰ C and was normal for that time of the year. The weather was not considered a factor contributing to the fire.

PART 2: ANALYSIS

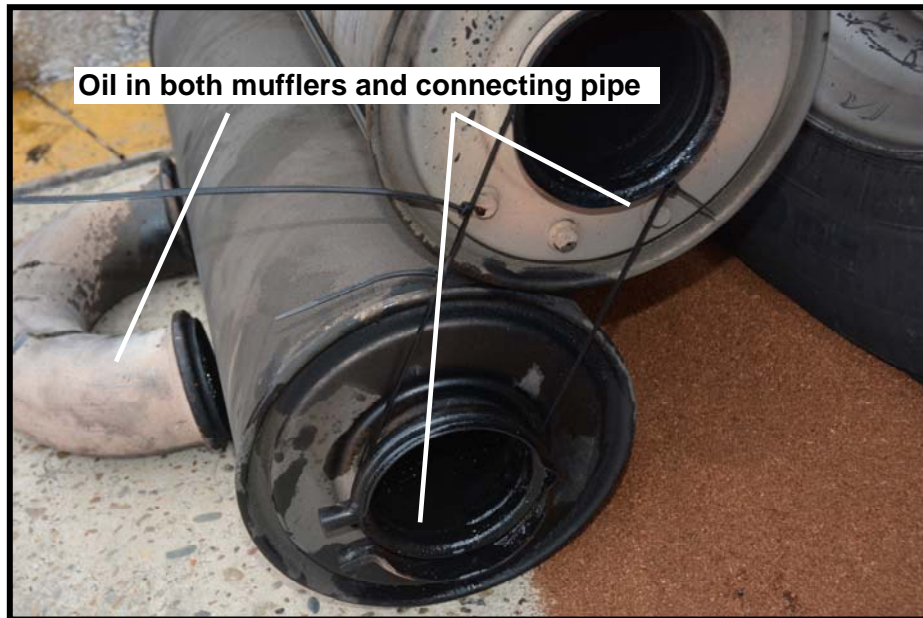
Inspection

- 2.1 On 2 April 2015 OTSI investigators attended the STA Leichhardt depot to undertake a detailed examination of the bus. The interior furnishings and seating throughout the bus were destroyed. All other damage was restricted to the rear trailer section. The rear side windows on both sides were broken as a result of the heat from the fire. There was significant damage to the roof in the immediate area of the vertically mounted exhaust pipe at the rear offside of the bus and around the roof escape hatch. There was no fire damage to the engine. However, there was some residual melted plastic on top of the engine which had dripped down from the vicinity of the vertical exhaust pipe.
- 2.2 The fibreglass panelling encasing the exhaust pipe was removed. This revealed the initial seat of the fire as having been in the top of the exhaust pipe where it exited from the roof exterior canopy. The fibreglass roof in this area had ignited and the heat had distorted the stainless steel bracket supporting the exhaust pipe (see *Photograph 3*).



Photograph 3: Seat of initial fire at exhaust pipe exit at roof canopy

- 2.3 When the top section of the exhaust pipe was removed, carbon deposits were found in greater quantity than expected. In the lower section of the pipe there was oil present. The exhaust line was traced backwards to the twin mufflers which displayed signs of oil seepage around the clamps joining the mufflers and their connecting pipe (see *Photograph 4*).



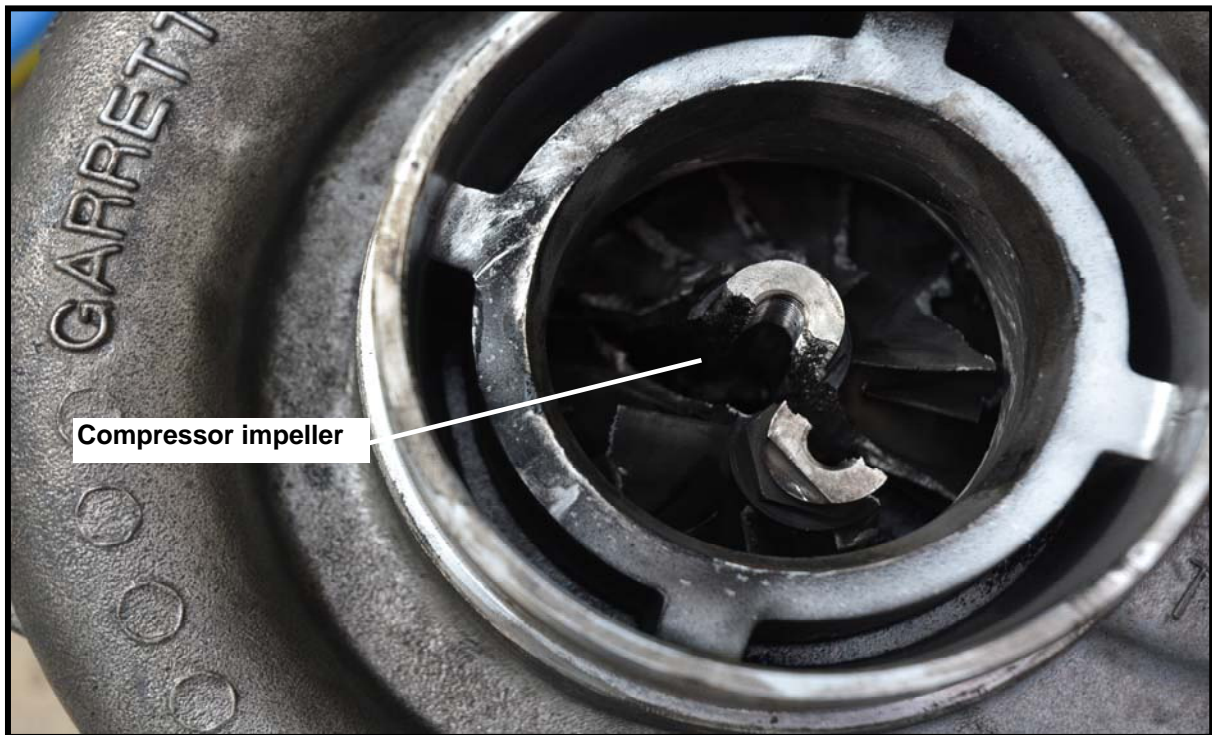
Photograph 4: Mufflers removed showing oil residue

- 2.4 The exhaust mufflers were removed and a large quantity of oil was discovered in both mufflers. The exhaust line between the mufflers and the turbocharger also contained a large amount of engine oil (see *Photograph 5*).



Photograph 5: Oil in exhaust line from turbocharger

- 2.5 The turbocharger was removed and dismantled for examination. The compressor impeller was found to have split longitudinally into approximately equal halves and seized in its casing (see *Photographs 6 and 7*). The turbine wheel was intact although there was some damage to the blades resulting from them striking the housing after the impeller had failed.



Photograph 6: Compressor impeller split in housing

- 2.6 The failure of the compressor impeller would have allowed the turbocharger lubricating oil to enter the hot exhaust system and be carried along the full length of the system. The oil ignited within the exhaust pipe near the discharge point at the roof canopy where a generous air supply was available to feed the fire. The heat generated was so intense that it ignited the fibreglass canopy.



Photograph 7: Compressor impeller removed for examination

- 2.7 Examination of the interior of the trailer identified where the heat from the fire in the exhaust near the roof had ignited combustible material such as interior linings and plastics. Once the fire was inside, it quickly spread towards the roof emergency hatch, which was destroyed. This provided additional access to air which further intensified the fire.
- 2.8 Secondary fires were caused when heat melted the plastic sheathing on house service electrical wiring for interior lighting, CCTV, stop bus buttons and air conditioning. This wiring ran in harnesses on either side of the bus along the interior roofline, and was retained by plastic cable ties. When the heat melted these ties along with wiring protective coverings the wires dropped. Shorting then occurred between wires and with metal objects as the circuits were live because the driver had not switched off the bus's electrical system (see *Photographs 8 and 9*). This served to further promote the fire.



Photographs 8 and 9: Internal electrical wires shorted

Independent Metallurgist Report

2.9 The STA commissioned an independent metallurgist to carry out a macro examination of the failed impeller and form a preliminary opinion about the likely/possible cause of failure. The metallurgist's report concluded:

1. *At this stage of the investigation it appears that the impeller has failed as a result of the formation of two diametrically opposite fatigue cracks which initiated in the bore.*
2. *There was no visible evidence to indicate that the impeller had failed as a result of the presence of any material defects.*

Note:

- a) *Material defects are often not visible at low magnifications and or require other testing procedures to determine their presence.*

These type of defects include:

- i. *Out of specification microstructure associated with incorrect heat treatment.*
 - ii. *Out of specification material composition.*
 - iii. *Out of specification hardness.*
3. *Radiography revealed no visible material defects.*
 4. *Because the impeller had failed as a result of the formation of what appear to be two diametrically opposite fatigue cracks, it is more likely than not that the failure was associated with abnormal loads in the bore of the impeller.*

The more likely cause of abnormal loads in the bore of the impeller would be material contamination in the bore of the impeller when it was fitted to the shaft.

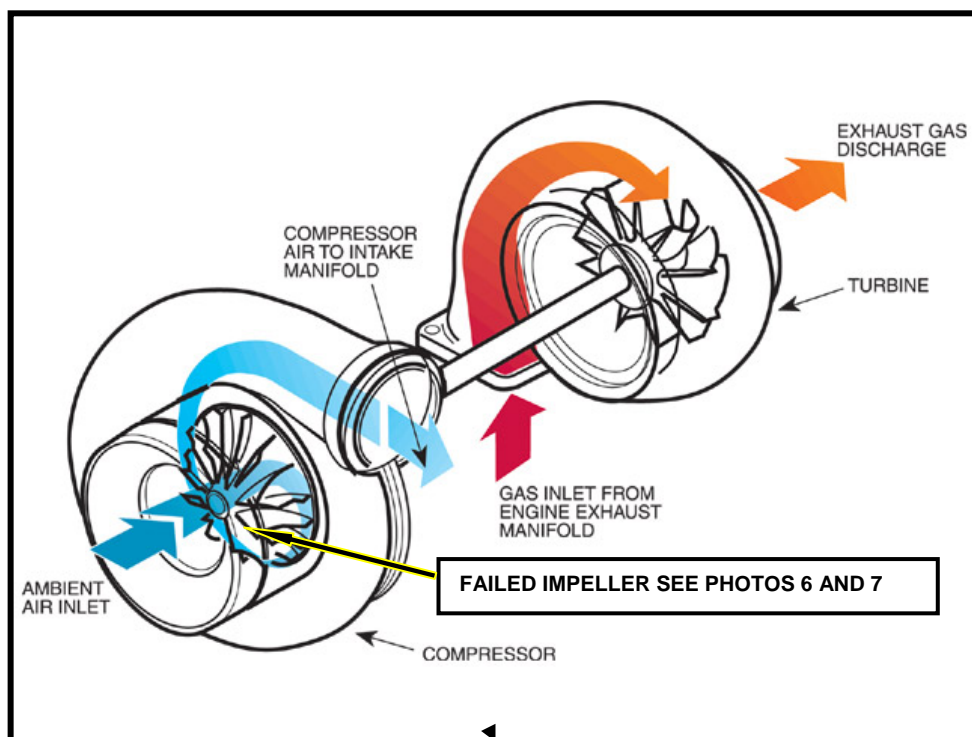


Diagram 1: Exploded view of turbocharger

Servicing and Maintenance

- 2.10 Servicing and maintenance records from April 2014 to 1 April 2015 were examined. The records showed that regular servicing and maintenance had been conducted. Additionally, there was no evidence of any issues attended to involving the turbocharger or its operation in the twelve month period.
- 2.11 The bus passed routine road worthiness inspections by Roads and Maritime Services (RMS) on 26 August 2014 and 3 March 2015.

PART 3 FINDINGS

Causation

- 3.1 The fire on STA Bus MO 1695 was caused by failure of the bus's turbocharger compressor impeller which allowed lubricating oil to enter the exhaust system and ignite. The fire in the top section of the exhaust pipe near the roof resulted in the radiated heat from the fire igniting the fibreglass canopy and the interior lining at the back of the bus closest to the exhaust pipe. Once the fire had started inside the trailer of the bus it quickly spread toward the front and the roof mounted emergency hatch where more air was available to promote the fire.
- 3.2 A secondary source of fire occurred once the fire had reached the internal rear area of the bus. The heat from the fire melted the electrical system wiring insulation and their plastic securing ties resulting in live wires shorting against each other and other metal objects, as the bus's electrical system had not been switched off.
- 3.3 As is common in such fires, the predominant propagation issue is the flammability of the interior materials once the fire enters inside the bus.

PART 4 RECOMMENDATION

- 4.1 To prevent a secondary source of fire contributing to further damage in this type of incident, it is recommended that the State Transit Authority upgrades instructions for all drivers to include the requirement to switch off the electrical supply to all systems, if possible without subjecting themselves to risk, to prevent the spread of a fire to the interior of a bus.

APPENDIX 1 SOURCES AND SUBMISSIONS

Sources of Information

- John L Gray Pty Ltd, Metallurgical Investigation Report, June 2015
- State Transit Authority
- Volvo Australia/Pacific Pty Ltd

Submissions

The Chief Investigator forwarded a copy of the Draft Report to the Directly Interested Parties (DIPs) to provide them with the opportunity to contribute to the compilation of the Final Report by verifying the factual information, scrutinising the analysis, findings and recommendations, and to submit recommendations for amendments to the Draft Report that they believed would enhance the accuracy, logic, integrity and resilience of the Investigation Report. The following DIPs were invited to make submissions on the Draft Report:

- Roads and Maritime Services
- State Transit Authority
- Transport for New South Wales

Responses were received from all three DIPs and were taken into consideration when finalising the report.