OTSI Office of Transport Safety Investigations

TECHNICAL INSPECTION FINDINGS

FIRE INVOLVING TRANSDEV SHORELINK BUS MO1970

MOUNT COLAH

16 DECEMBER 2011

TECHNICAL INSPECTION FINDINGS

FIRE INVOLVING TRANSDEV SHORELINK BUS MO1970

MOUNT COLAH

16 DECEMBER 2011

File Reference: 04533

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

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.

Summary of the Incident

At approximately 8:40pm[1] on Friday 16 December 2011, when pulling out from the kerb and around a parked vehicle on Excelsior Road in Mount Colah, the driver of Transdev Shorelink bus MO1970 looked in his right rear view mirror and saw smoke coming from the rear of the bus. The driver was alone in the bus at the time having just set down his last passenger on his last run for the day.

As soon as he was clear of parked vehicles, the driver pulled over to the kerb and parked the bus, leaving the engine running. The driver immediately called the depot using the bus's radio and then left the bus through the front door, taking a small fire extinguisher with him.

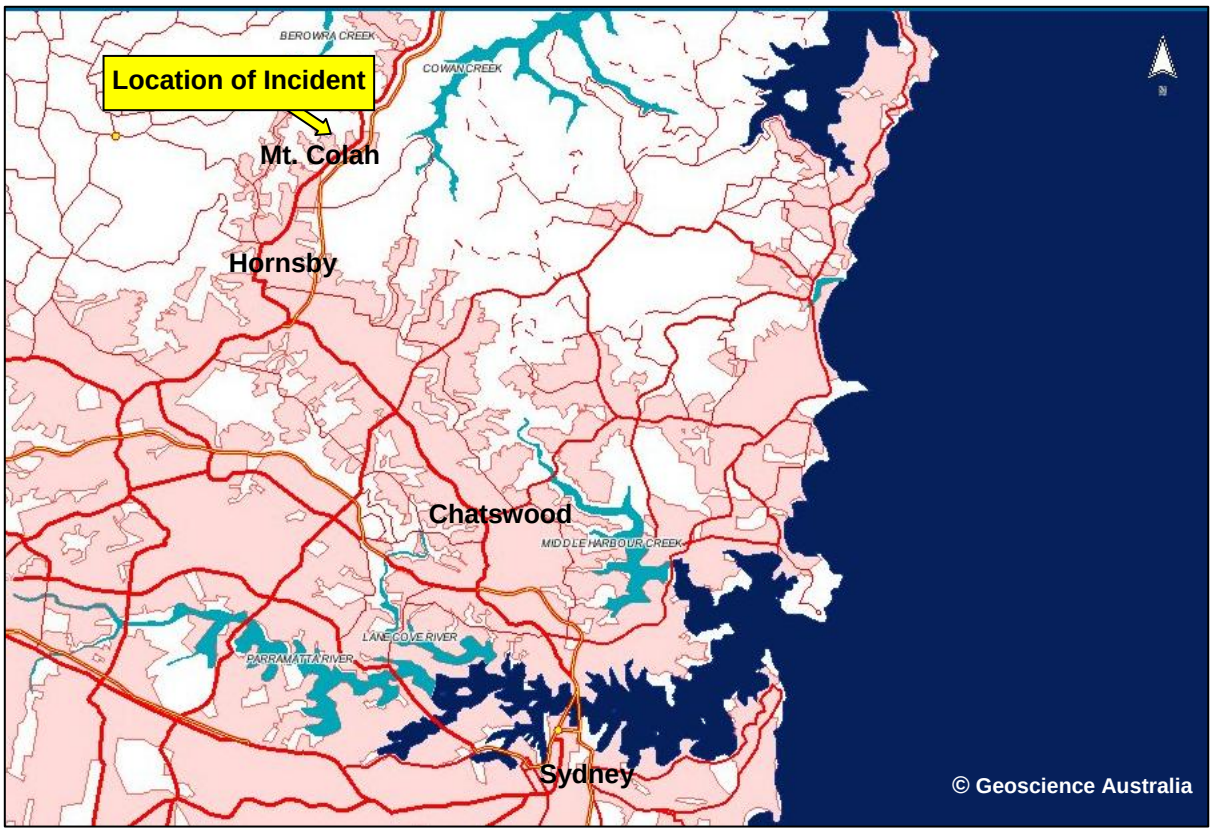


Figure 1: Location of incident

The last passenger to be set down saw the fire and followed the bus, arriving as the driver was attempting to extinguish the fire. Nearby residents also observed the fire and contacted Emergency Services.

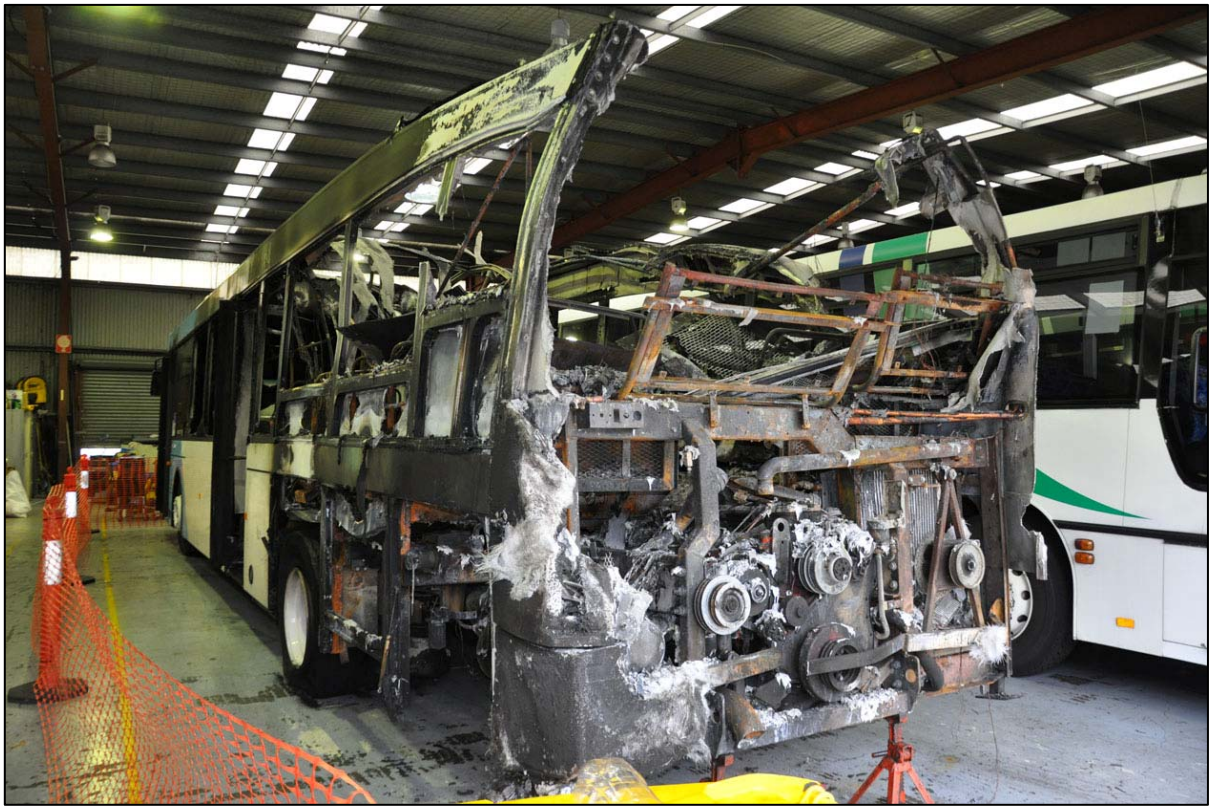
[1] All times given in this report are in Australian Eastern Daylight Time (UTC + 11 hours).

As the driver approached the rear of the bus, the intensity of the fire suddenly increased, and then spread out from under the bus and towards the driver. The driver attempted to extinguish the fire by directing the fire extinguisher towards the apparent seat of the flames, without success. Once the extinguisher was empty, the driver returned to the front of the bus, retrieved the radio handset and called the depot again while standing outside the bus, as the interior had filled with smoke and the rear seating and interior linings were well alight.

Within 10 minutes of the fire being reported, mechanics arrived from the bus depot and also attempted unsuccessfully to extinguish the fire using hand-held extinguishers. The fire was ultimately extinguished by a Fire and Rescue NSW unit from the Hornsby Fire Station.

After the fire was extinguished the bus was towed to Transdev's depot at Mt Kuring-Gai.

OTSI's Duty Officer was notified of the incident at 10:00pm on Friday 16 December 2011 by the Transdev depot. An initial inspection of the bus and the site of the fire took place on Monday 19 December 2011. The extent of damage to the bus can be seen in *Photograph 1*.



Photograph 1: Post-fire condition of bus

On the basis of the information obtained from the initial inspection of the bus and at the site, the Chief Investigator initiated a technical inspection.

Incident Timeline

The bus was equipped with closed circuit television, with four cameras in the following locations:

- Overhead at the front centre, looking at the driver and rearwards.
- Overhead at the centre of the right hand side, looking at the centre door and rearwards.
- Overhead on the right side behind the driver, looking at the left side and rearwards.
- Overhead on the right side forward of the driver, looking at the front door and rearwards.

All cameras were operating at the time of the incident, and recordings were obtained showing the operation of the bus leading up to the fire, continuing through the early stages of the fire and stopping 2 minutes and 35 seconds after the bus departed from setting down the last passenger. The cameras immediately re-started and recorded for a further 66 seconds. There was then a two-minute break in the recording after which a further 55 seconds of recording was made, showing only smoke.

Analysis of the CCTV records established the following timeline:

20:39:08 Bus stops, driver opens door, passenger alights.
20:39:21 Driver closes door, bus moves off.
20:39:49 Bus stops, driver opens door.
20:39:52 Passenger alights.
20:39:57 Driver closes door.
29:40:02 Bus moves off.
29:40:10 Smoke seen coming from rear floor hatch.
29:40:13 Driver reacts, appearing to have seen smoke.
29:40:25 Bus stops.
29:40:26 Bright glow at rear window, smoke increasing in rear of bus.
29:40:30 Driver picks up radio microphone.
29:40:35 Driver opens door.
20:40:44 Smoke visible through left rear window.
20:40:46 Driver reaches for fire extinguisher.
20:40:58 Driver exits bus with fire extinguisher.

20:41:01 Sudden escalation of fire at left rear.

20:41:03 Fire escalates further with flames appearing to come from beside the bus.

20:41:08 Flames diminish.

20:41:12 Dash lights go off (one red light remains flashing).

20:41:39 Driver returns.

20:41:42 Driver turns off ignition (bus interior lights go off).

20:41:47 Driver restores power to cabin lighting.

20:41:53 Driver picks up microphone again and exits bus.

20:42:14 Bystander comes to front door of bus, talks to driver.

20:42:24 Bystander starts to enter bus, then retreats.

20:42:36 Recording stops.

20:42:36 Recording re-starts

20:43:40 Recording stops

20:45:42 Recording re-starts

20:46:37 Recording stops

Evidence at the Fire Location

OTSI investigators attended the fire location on Excelsior Road, Mount Colah, on Monday 19 December 2011.

Excelsior Road runs along a ridge, with an upward slope to the location of the bus's last passenger stop. The route the bus travelled to reach Excelsior Road from Mount Colah Railway Station involved approximately 14 minutes of driving through hilly terrain along winding suburban roads, with the last kilometre being predominantly uphill.

The location at which the bus stopped after the fire was detected was readily identifiable by a large scorched area of grass beside the roadway and a discoloured area on the road surface that had been covered with sawdust to soak up residual fluid, as seen in *Photograph 2*.

Photograph 2: Scorching on road surface and grass

The substance causing the discolouration had soaked into and softened the surface of the roadway to such a degree that a tyre mark passing through it left a distinct impression, as visible in *Photograph 3*.

Photograph 3: Tyre mark in softened surface

Leading up to the discolouration on the road surface was a trail following the path of the vehicle. This trail, which can be seen in *Photograph 4*, was approximately 100 metres long and started around 1 metre from the kerb, at the location at which the bus had stopped to set down the last passenger.

Photograph 4: Trail left by bus

There was no trail leading up to this point, and the greater width of the discolouration at its start suggests that it commenced while the bus was either stationary or moving at a low speed. The fact that the trail can be seen to initially track closer to the kerb suggests that it originated from a source substantially behind the rear axle, thus having been affected by the tendency of the rear of the bus to swing in as the front moved away from the kerb.

The substance causing the discolouration had been thoroughly washed from the road by the attending Fire and Rescue officers and had then been covered with sawdust to soak up any residue, but had nonetheless caused softening of the bitumen road surface.

Examination of the Bus

The bus, built and entering service in March 2011 and identified by Vehicle Identification Number 6F2BARB00ADT00582, comprised a Volgren CR228 body with seating for 46, on an Iveco Metro chassis. It was fitted with an 8.9 litre Cummins ISLe Euro 5[2] diesel engine coupled to an Allison T375R six-speed automatic transmission.

Structurally, the bus was predominantly aluminium and fibreglass on a bolted and riveted aluminium frame, with a plywood floor. It was not equipped with fire detection or suppression systems.

The bus was examined by OTSI investigators on 19 December 2011, and again on 29 December 2011 by OTSI investigators together with a representative of Iveco and a fire investigator representing the insurer.

Bus Maintenance

Since it commenced service in early 2011, the bus had travelled 46,426 kilometres and had been regularly serviced at 10,000 kilometre intervals. The most recent service was on 16 November 2011 when the bus had travelled 40,603 kilometres.

An examination of the vehicle's Defect Log Book showed no entries of significance.

Electronic control module

During the second inspection the engine control module (ECM) was removed for examination. ECMs store engine operating data to aid in service operations but, due to the extreme damage as seen in *Photographs 5 and 6*, it was impossible to obtain any data from it.

[2] Euro 5 refers to a European exhaust emission standard not yet in force in Australia.

Photograph 5: Damaged engine control module

Photograph 6: Damaged engine control module after removal

Turbocharger

At the first inspection of the bus, it was noted that the turbocharger shaft carrying the turbine and compressor wheels could be easily rotated by hand. When the bus was inspected a second time ten days later, the shaft could no longer be rotated.

The turbocharger, seen in *Photograph 7*, was removed and sent for examination by a consulting metallurgist.

Photograph 7: Turbocharger before and after removal

The consultant advised the following:

a. Once the compressor housing had been removed the turbine and compressor wheels were free to rotate.

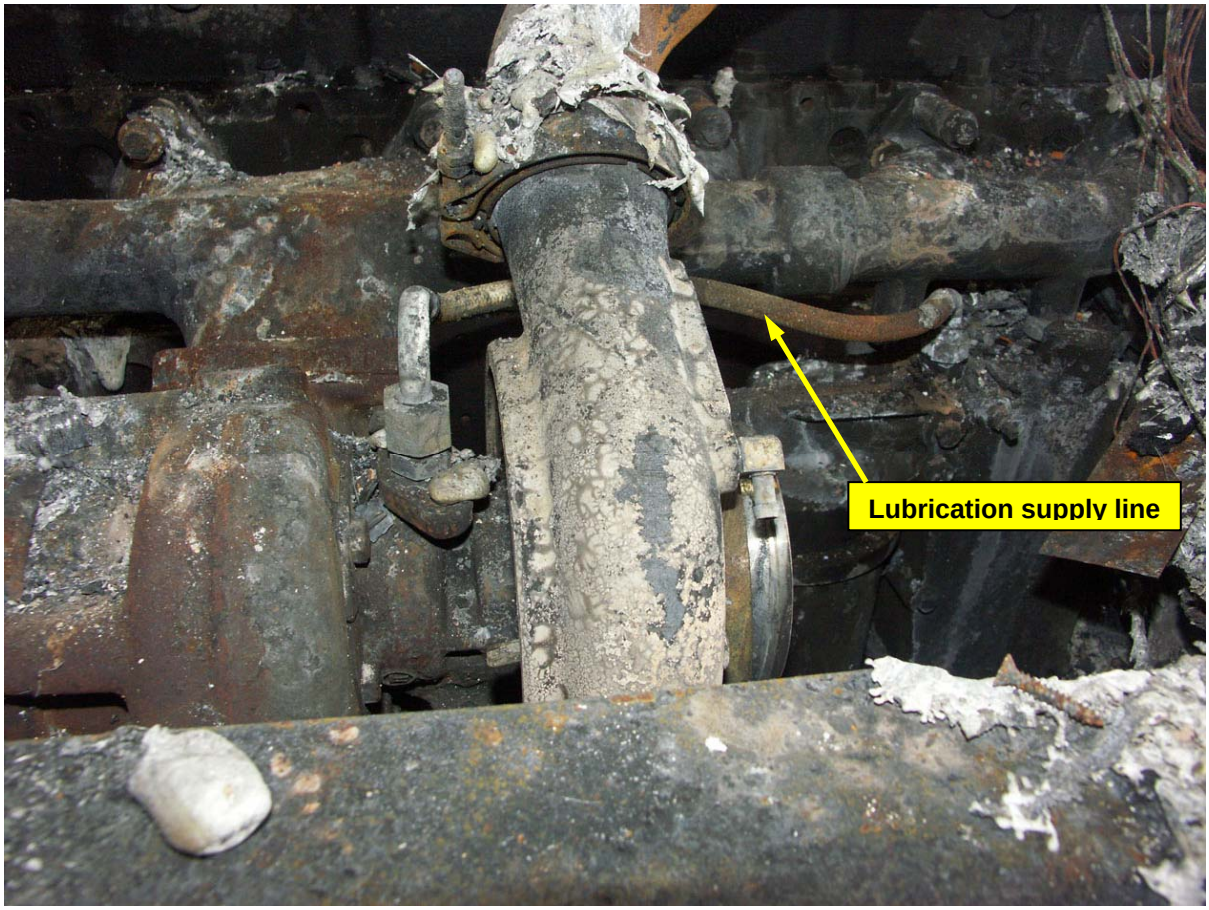
b. The turbocharger shaft exhibited some evidence of heat discolouration but no significant mechanical damage.

c. The two floating bearings exhibited some heat/burnt oil discolouration but no evidence of any significant mechanical damage.

The consultant's opinion in conclusion was that there was no evidence to indicate that the fire was caused by overheating of the turbocharger in association with a lubrication failure.

Turbocharger lubrication oil supply line

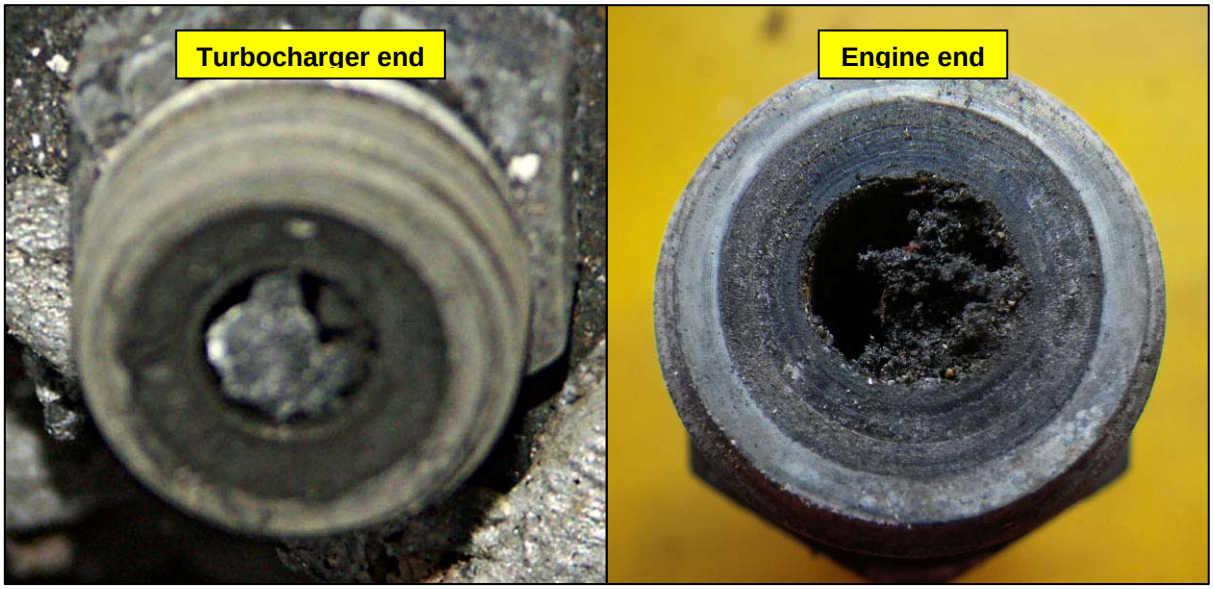
The turbocharger lubrication oil supply line, seen in *Photograph 8*, was removed and examined.



Photograph 8: Turbocharger lubrication oil supply line

The line was intact, and the union securing it to the turbocharger housing was tight. However, the union at the oil filter end was only a little more than finger tight.

The engine end of the line and the union at the turbocharger end of the line were found to contain hard deposits partially blocking the bore, as shown in *Photograph 9*.

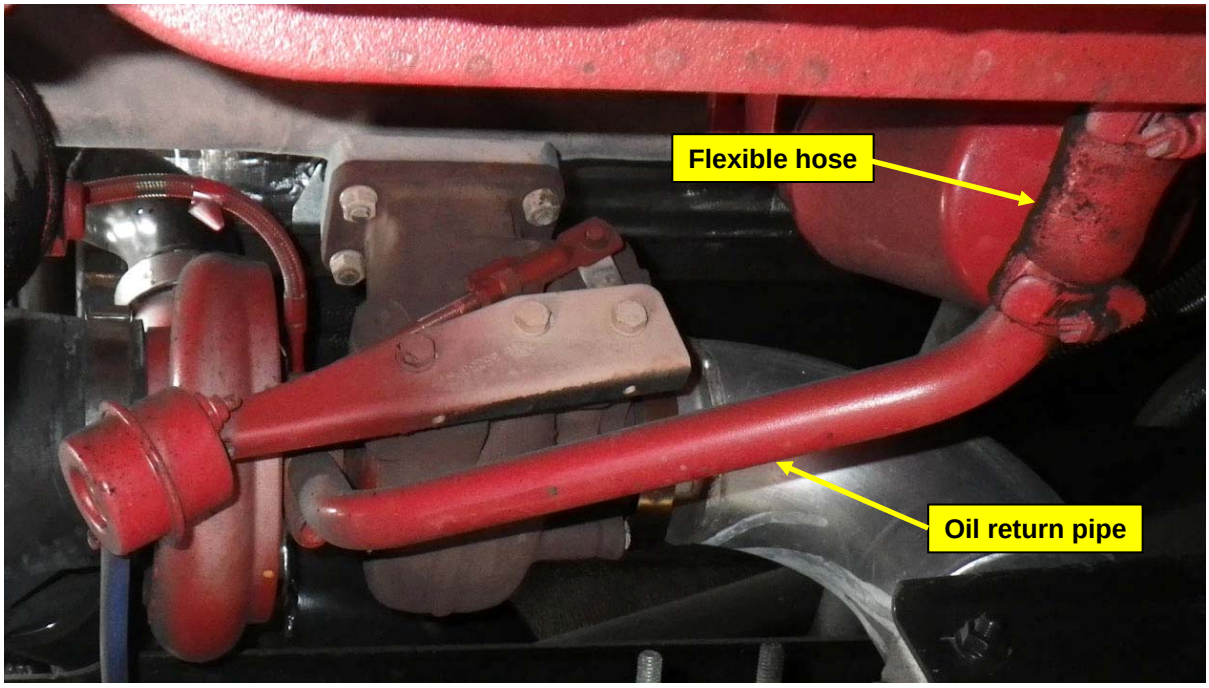


Photograph 9: Deposits in union and line

It is likely that these deposits formed during the fire after the engine stopped, as otherwise they would most likely have been carried into the turbocharger by the flow of lubricant, resulting in failure of the turbocharger bearings.

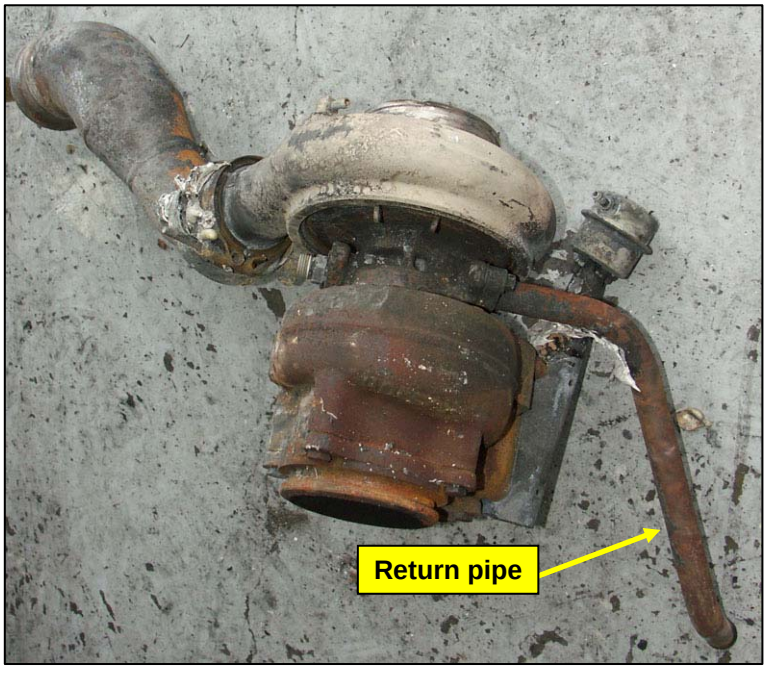
Turbocharger lubrication oil return line

Lubrication oil supplied to the turbocharger is returned to the engine's sump through a large bore steel pipe with a bolted flange connection to the turbocharger and a flexible hose connection to the engine. The configuration on a similar vehicle is shown in *Photograph 10*.



Photograph 10: Turbocharger oil return viewed from below

The flexible hose between the return pipe and the engine had been completely burned away, and the hose clamps were no longer in place. The condition of the return pipe can be seen in Photograph 11.



Photograph 11: Turbocharger lubricant return line

If the flexible hose had been burned away while the engine was running oil would have been pumped out at the delivery rate of the oil pump, until the oil supply was exhausted or the engine stopped.

Engine oil and oil filter

The remaining engine oil was drained from the vehicle's sump into a 20 litre container, and its volume estimated at approximately 13 litres. As the normal oil capacity is 26 litres and the vehicle was relatively new with no history of excessive oil consumption, it is probable that approximately 13 litres of oil had been expelled, leaving the trail found on the roadway and fuelling the fire.[3] The remaining oil had an unusually strong, unpleasant odour

The oil filter, seen in *Photograph 12*, was removed for examination. It was found to be full of oil, with the oil having the same appearance and odour as that from the sump.

Photograph 12: Oil filter

The oil filter was drained and on examination was found to have an irregularly shaped black mass firmly adhered to the bottom, as can be seen in *Photograph 13*.

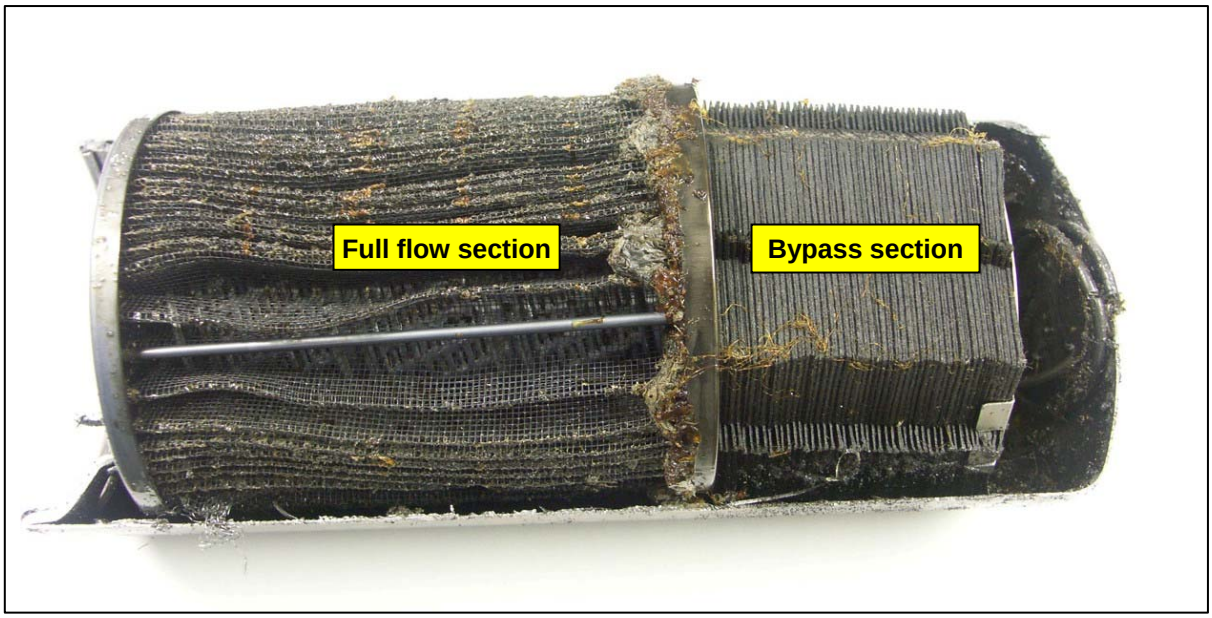
[3] Information obtained from Cummins South Pacific indicated that the oil pump delivery rate was consistent with an ability to expel 13 litres of oil in the 83 seconds from when the bus stopped to allow the last passenger to alight, to the time the instrument lights went off, the latter being the probable time that the engine stopped.

Photograph 13: View inside oil filter

A filter was then removed from a nominally identical bus, and found to contain a black insert as seen in *Photograph 14*. Cummins documentation indicated that the filter was of a combined full-flow and bypass type, and that the insert was a venturi used to control the flow of oil as it re-combined after leaving the two filter sections.

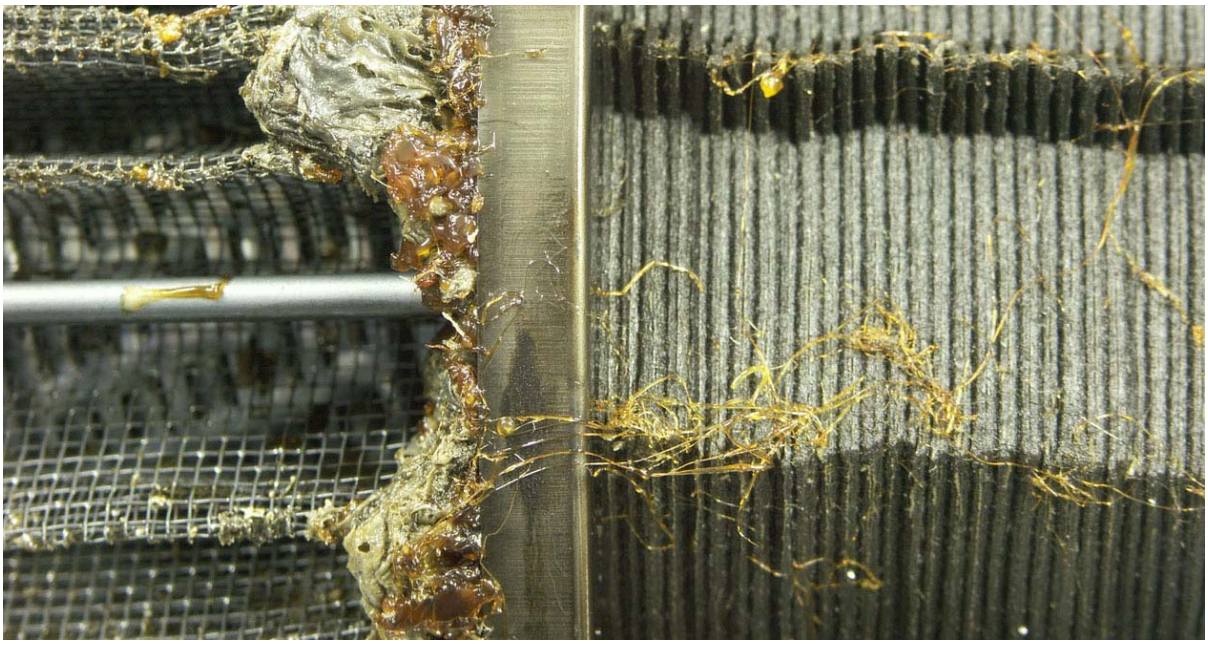
Photograph 14: View inside undamaged filter (Photograph courtesy of Transdev Shorelink)

The filter from the burnt bus was then sectioned longitudinally, as seen in *Photograph 15*. The two sections of the filter can be seen, with the full-flow section being of conventional folded paper construction while the bypass section used stacked cards to provide a finer level of filtration.



Photograph 15: Longitudinally sectioned filter

A variety of substances as seen in *Photograph 16* had been trapped by the filter. However, the quantities were small and there was no evidence that the filter had been blocked to such a degree that oil flow would have been significantly impeded.



Photograph 16: Deposits in filter

The mass seen at the bottom of the filter in *Photograph 13* was removed and is shown in *Photograph 17*. Its shape confirmed that it was a grossly distorted plastic venturi, indicating that it had been subjected to a temperature well beyond normal.

Photograph 17: Heat distorted oil filter venturi

General damage to engine

Although the fire damage to the engine was widespread, there were two areas where the damage appeared greater than elsewhere. These were in the vicinity of the turbocharger as can be seen in *Photograph 18*, and the engine's cam cover as seen in *Photograph 19*.

Photograph 18: Damage near turbocharger

Photograph 19: Heat damage to the cam cover

Consideration was given to the possible sources of fuel for the fire in these areas. The main potential source of fuel in the vicinity of the turbocharger was the lubrication system, and in particular the supply and return lines connected to the turbocharger. In the case of the cam cover, the nearest potential fuel source was the diesel fuel supply associated with the engine's fuel injection system.

Development of the Fire

In order for a fire to develop and be sustained for a significant time, four elements are necessary:

- An initiator
- Combustible material
- An oxidising agent, in this case oxygen in air
- A path by which the fire can spread

The initiator

Due to the extent of damage to the bus it was not possible to determine the initiator of the fire with absolute certainty. The most severe damage to the engine appeared to be around the turbocharger and near the fuel supply to the fuel injection system, and the possibility of initiation in one of these areas was considered.

Initiation in the fuel supply was eliminated due to the fact that the engine operated normally for a considerable time (over a minute) from the time the fire was first detected.

Initiation in the vicinity of the turbocharger was considered the more probable. The most common possible initiators in this area were the turbocharger itself, which would have been hot as the bus had been operating uphill at relatively low road speeds in hilly terrain, or a short circuit in electrical wiring. The latter was considered less likely, as the driver had seen no indication of an electrical malfunction either by means of abnormal operation of the bus or dashboard warnings.

It is considered most likely that the fire was initiated when flammable material came in contact with the hot turbocharger.

Combustible material

The turbocharger was supplied with lubricating oil under pressure from the top of the oil filter housing and, after lubricating the turbocharger bearings, the oil returned to the engine via a pipe into the sump. The line from the top of the oil filter to the turbocharger was removed for examination, and it was found that the union securing it to the filter housing was much looser than that securing it to the turbocharger.

It is possible that oil leaked from this union and contaminated the area around the turbocharger, ultimately igniting when the bus's operating conditions resulted in an elevated turbocharger temperature.

Once the fire had started, it is likely that it burned through the flexible connection from the oil return to the sump, thus providing a high volume supply of oil to feed the fire. As an oil trail was found leading from the bus's last passenger stop but no trail was found leading up to this stop, it is probable that the fire commenced before this stop and burned through the return pipe's flexible connection while the bus was at the stop.

Propagation path

Once established, the fire was in all probability provided with a copious supply of oil from the turbocharger lubricant return line, until the engine stopped. When the driver stopped the bus and left the engine running, the oil would have continued to flow, pooling under the bus until the pool of oil also ignited, probably at the time (20:41:01) when a sudden escalation of the fire was seen in the CCTV and noted in the timeline.

Once the fire was well established in the engine bay, the CCTV record indicates that it entered the interior of the bus through the rear panel and then involved the rear seat. The fire then travelled forward in the roof linings which were burned right to the front of the bus. The seats were also destroyed, except for the driver's seat and the foremost passenger seats. The plywood floor appears to have been an effective barrier until the fire was well established in the interior of the bus.

The time between the initial detection of the fire by the driver and re-entry of the bus becoming impractical was 1 minute 40 seconds. The time between when the driver was able to stop the bus and re-entry of the bus becoming impractical was 1 minute 28 seconds. This is the time that would have been available to evacuate passengers.

Conclusions

Although the cause of the fire could not be determined with certainty, it is considered probable that it started when oil contamination from a leaking turbocharger oil supply line was ignited by the hot surface of the turbocharger. The resulting fire then probably burned through a flexible section on the oil return from the turbocharger to the engine sump, allowing oil to be pumped out at a high rate to fuel the fire.

The fire, fuelled by engine oil, spread rapidly from the engine bay to the interior of the bus by burning through the rear panel. It then travelled forward through the bus. The fire was of such intensity that the use of hand-held fire extinguishers had little effect, and it continued to burn until extinguished by Fire and Rescue NSW.

Should there have been passengers on the bus, the time available for evacuation of the bus would have been 1 minute 28 seconds.

If the bus had been equipped with effective fire detection and suppression systems, it is probable that early detection and suppression of the initial fire would have prevented the failure of the turbocharger oil return and further development of the fire.

On the basis of these findings 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 Transdev Shorelink Buses, Iveco Trucks Australia, the Independent Transport Safety Regulator and Transport for NSW.