



**Office of Transport Safety Investigations**

## **BUS SAFETY INVESTIGATION REPORT**

**STA BUS MO 1707 OIL AND COOLANT SPILL  
NORTH SYDNEY TO SPIT JUNCTION, NSW**

**17 MARCH 2016**



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## EXECUTIVE SUMMARY

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On Thursday 17 March 2016 a State Transit Authority (STA) bus, MO 1707, deposited engine oil and coolant for approximately three kilometres along Military Road from North Sydney to Spit Junction.

At approximately 1645 when on the Falcon Street off ramp of the Warringah Expressway, the driver received a high coolant temperature alarm. The driver silenced the audible alarm and continued the journey. The driver halted the bus at Spit Junction and the passengers disembarked without injury. Once stopped, the driver observed vapour emitting from the engine bay at the rear of the bus. The driver then called for the emergency services. The emergency responders did not detect a fire; however, the incident and related road clean up adversely affected peak time traffic density.

OTSI and STA investigators examined the bus at the Brookvale Depot on 18 March 2016. The preliminary investigation determined that the spill on the road was the result of a dislodged inspection cover on the engine's air compressor assembly. Oil escaped from the engine when a portion of the compressor crankshaft impacted and dislodged the inspection cover. Servicing records showed the compressor was replaced on 7 March 2016 with a later model assembly.

An independent metallurgist examined the broken crankshaft and pinion. The examination determined the pinion had a pre-existing fracture and the crankshaft had failed in close proximity to the pinion bearing.

OTSI has made recommendations to State Transit Authority. Full details of the Findings and Recommendations of this bus safety investigation are contained in Parts 3 and 4 respectively.

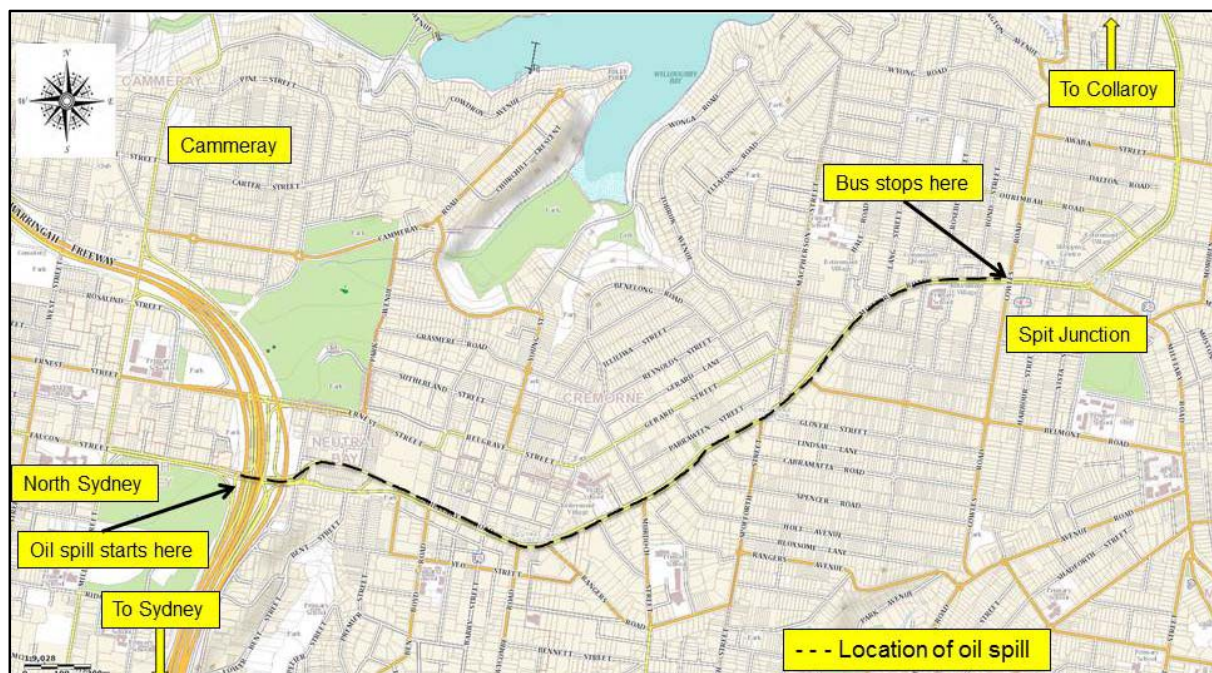
## PART 1 FACTUAL INFORMATION

### Introduction

- 1.1 From approximately 1645 to 1658 on Thursday 17 March 2016, a State Transit Authority (STA) bus, MO 1707, deposited engine oil and coolant along Military Road for approximately three kilometres from North Sydney to Spit Junction (see *Figure 1*).

### Location

- 1.2 Military Road is a six lane arterial route and provides the main road access between Sydney and the Northern Beaches.



Source: Six Maps

Figure 1: Incident location

### The incident

- 1.3 At the time of the incident the bus was operating on a Route L80 service, from Sydney CBD to Collaroy Plateau. As the bus approached the Falcon Street off ramp on the Warringah Expressway the high coolant temperature alarm activated. This produced an audible alarm and displayed a high coolant



temperature symbol on the driver's dashboard. Simultaneously, a red triangle stop bus symbol activated on the driver's dashboard.

- 1.4 When the bus stopped at the traffic signals on the off ramp, the driver silenced the audible alarm which reset the high coolant temperature alarm. However, the stop bus symbol (see *Figure 8*) continued to be displayed on the driver's dashboard. The driver continued the journey to Spit Junction.
- 1.5 Approximately six minutes later, when near the intersection of Macpherson Street and Military Road, the low engine oil and low coolant level alarms activated.
- 1.6 Shortly after, at the intersection of Lang Street and Military Road, a motorist advised the bus driver the bus was leaking oil.
- 1.7 At the intersection of Cowles and Military Roads near Spit Junction, the driver stopped the bus and observed vapour was emitting from the bus's rear engine bay. The driver evacuated the passengers to the footpath then notified the STA control room of the situation.
- 1.8 STA Control notified emergency services. Fire and Rescue NSW dispatched multiple units to clean up the spill. Police also attended to provide traffic control. Peak time traffic was impacted while the clean-up took place.
- 1.9 OTSI received notification and quarantined the bus at the STA Brookvale depot pending examination.

## **The Bus**

- 1.10 The bus, a 2011 Volvo B12BLEA model, was a diesel powered, turbocharged articulated bus owned and operated by the STA. The bus was in current registration MO 1707, and operated from the Brookvale Depot. The bus was approved to carry 88 passengers, 62 seated and 26 standing.

## **The Driver**

- 1.11 The driver held a current motor vehicle licence issued by Roads and Maritime Services (RMS) to drive an articulated bus, and was also accredited by Transport for New South Wales (TfNSW) to operate bus passenger transport

vehicles in NSW. The driver had received initial induction training with STA which included emergency procedures, evacuation of passengers and basic firefighting.

- 1.12 The driver had been inducted to operate a Volvo B12BLE model bus. The induction included the engine management alarm systems.

### **Emergency Service Response**

- 1.13 Fire and Rescue NSW responded to the STA Control Room notification and placed absorbent material on the road from North Sydney to Spit Junction. Police also attended to control the traffic.

## PART 2 ANALYSIS

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### Preliminary Inspection

2.1 On 18 March 2016, OTSI investigators examined the bus at the STA Brookvale Depot. The investigation revealed that an inspection cover from the rear of the engine-mounted air compressor unit had dislodged and was lying on top of the engine. Oil and coolant from the engine were found in proximity to the dislodged inspection cover (see *Figure 2*).

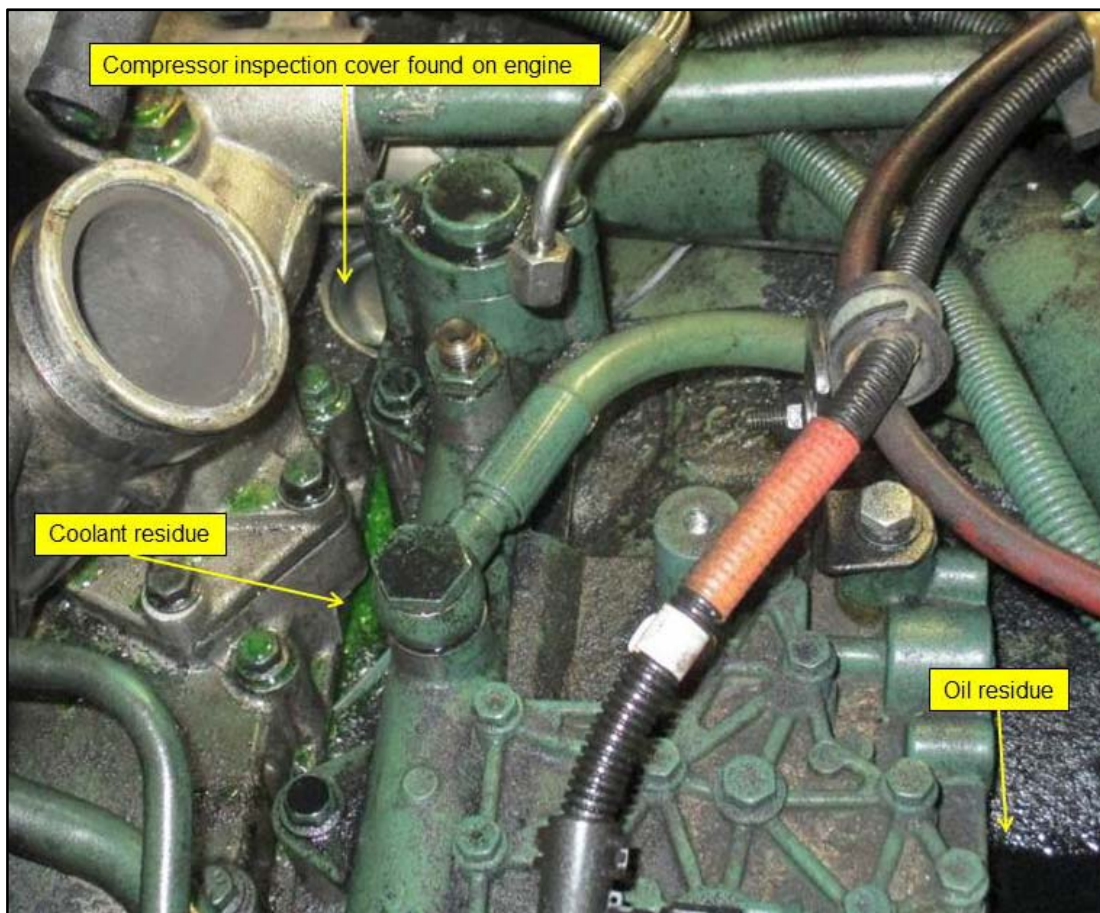


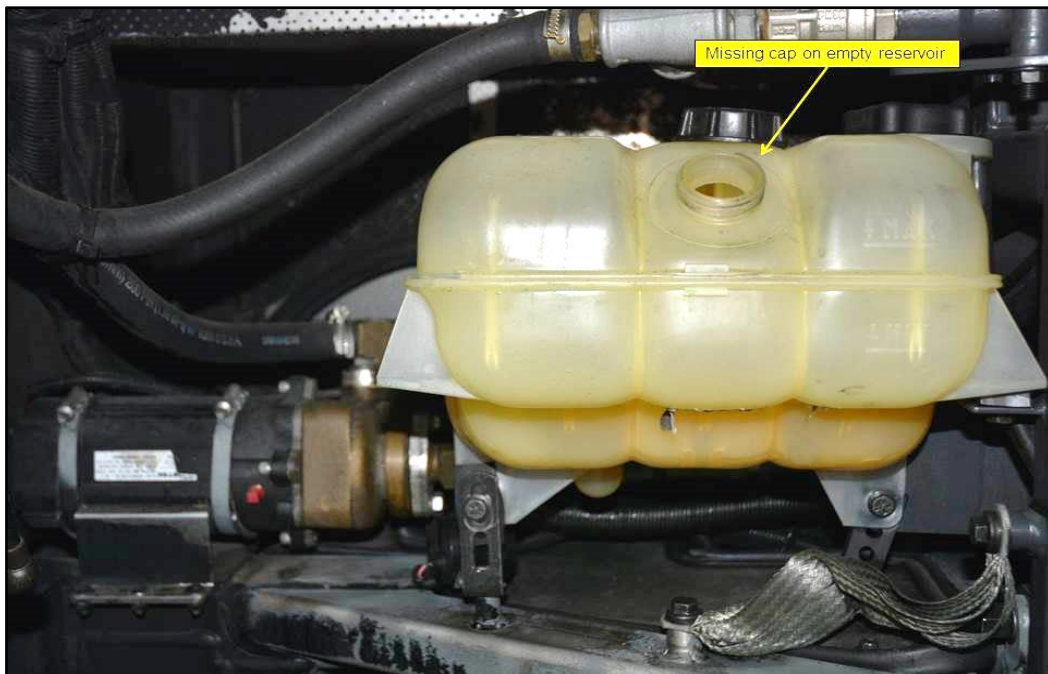
Figure 2: Engine showing oil residue and inspection cover

2.2 Residual oil was also found on the outside of the rear engine hatch. The pattern of the oil residue suggests the oil had been deposited on the hatch by the slipstream of the bus's movement (see *Figure 3*).



**Figure 3: Oil mist on exterior**

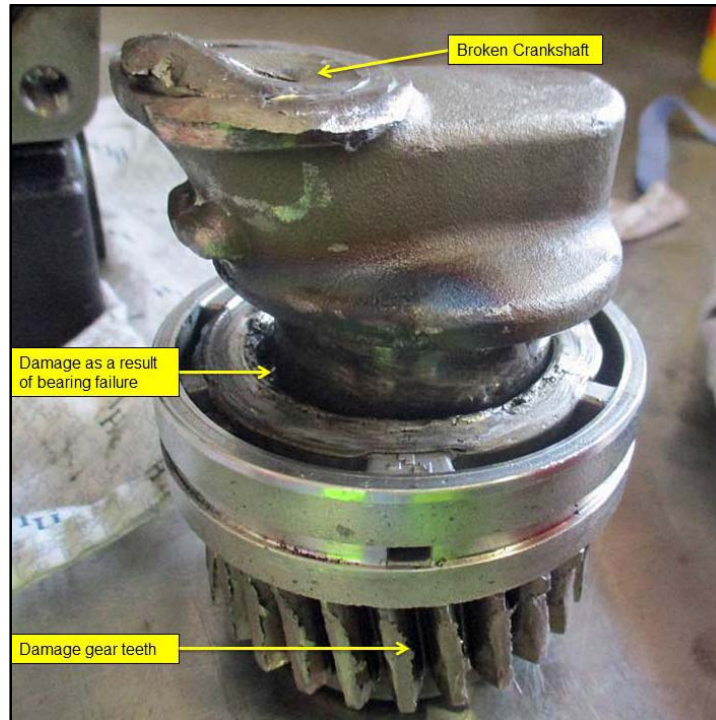
- 2.3 There was evidence of heat-affected oil deposits on the exhaust manifold.
- 2.4 The engine coolant reservoir was empty and the reservoir cap was missing. Coolant residue was deposited over the engine (see *Figure 4*).



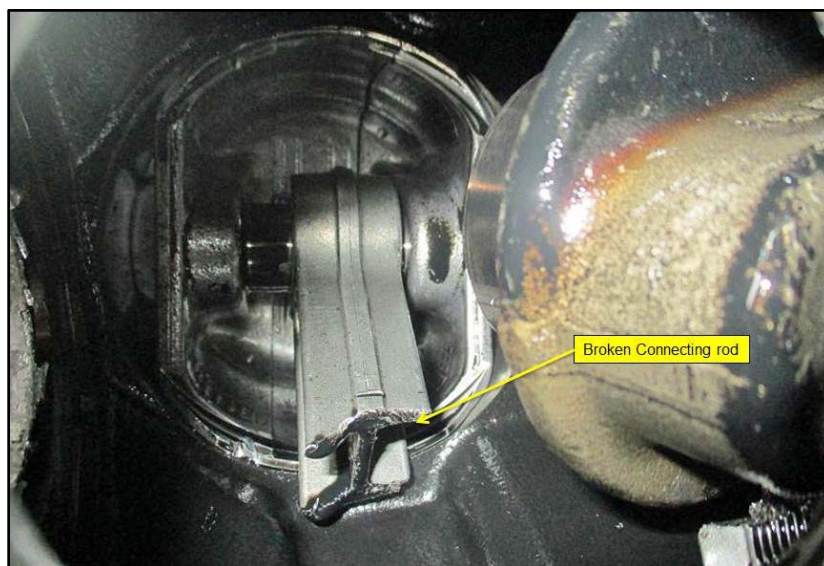
**Figure 4: Empty coolant reservoir and missing cap**



- 2.5 STA mechanics removed the air compressor from the bus for examination. The internal examination of the compressor revealed the air compressor's crankshaft and bearings had failed behind the front gear (see *Figure 5*). Both connecting rods were broken (see *Figure 6*). The compressor pinion was also cracked and the gear teeth damaged. The unsupported rotating pinion gear damaged the front of the housing. A compressor drive bearing retaining circlip was missing.



**Figure 5: Damaged crankshaft**



**Figure 6: Broken connecting rod**

## Review of Bus's CCTV and Data recorder

2.6 The vision and the data showed that:

- At 1645, the bus was on the Warringah Freeway just south of the Falcon Street off ramp when the coolant high temperature alarm activated. When the bus was stopped at the traffic control lights at the intersection, the CCTV showed the driver looking intently at the bus's dashboard. The rear CCTV showed a large volume of oil pooled on the road behind the bus. As the bus moved off, there was evidence of a trail of oil on the road surface behind the bus.
- At 1651 near the intersection of Macpherson Street and Military Road, Cremorne Junction the low coolant and low oil pressure alarms activated.
- At 1652 a motorist's vehicle stopped beside the bus on Military Road near Lang Street and the motorist appeared to talk to the bus driver.
- At 1655 the bus driver stopped the bus just west of the intersection of Cowles Road at Spit Junction. The driver then contacted the STA Control Room by radio advising the engine was overheating and leaking coolant onto the road.

2.7 The investigation determined that it was most likely that the Stop Bus symbol continued to be displayed on the driver's dashboard.

2.8 The CCTV recorded a trail of oil on the road surface from the off ramp at Falcon Street to where the bus stopped at Spit Junction, a distance of approximately three kilometres.

2.9 Examination of the engine fault codes displayed showed the following alarms activated at the following times;

- 1645 a coolant temperature high alarm recorded
- 1651 low oil pressure at fault recorded
- 1651 a fault code for low coolant level recorded. (see *Figure 7*).



Figure 7: Driver's dashboard

## Driver's Interview

- 2.10 The driver said the bus was operating normally when it departed Wynyard. The driver first noted a problem when the bus was getting hot at the Falcon Street off ramp to Military Road.
- 2.11 Near the intersection of Military and Ben Boyd Roads, the driver noted a red engine temperature warning signal displayed on the information panel (see Figure 8). The driver silenced the audible alarm which activated repeatedly until the bus was stopped. The driver was unsure how many times the alarms were reset. The driver remembered the warning light but did not recall hearing any audio alarms. The driver said, "...I had 90 to 100 passengers on board my bus and I was trying to find somewhere safe to pull over..."



Figure 8: Driver's information panel

2.12 The route travelled by the bus after the original alarm at the Falcon Street off ramp had numerous suitable safe locations to stop the bus.

## Service and Maintenance

2.13 The service history of the bus showed that STA mechanics changed the compressor on 7 March 2016 at the Brookvale Depot. The original KNORR model was replaced with a WABCO model. Volvo replaced 150 compressors on STA buses and STA replaced 81 as part of the replacement program.

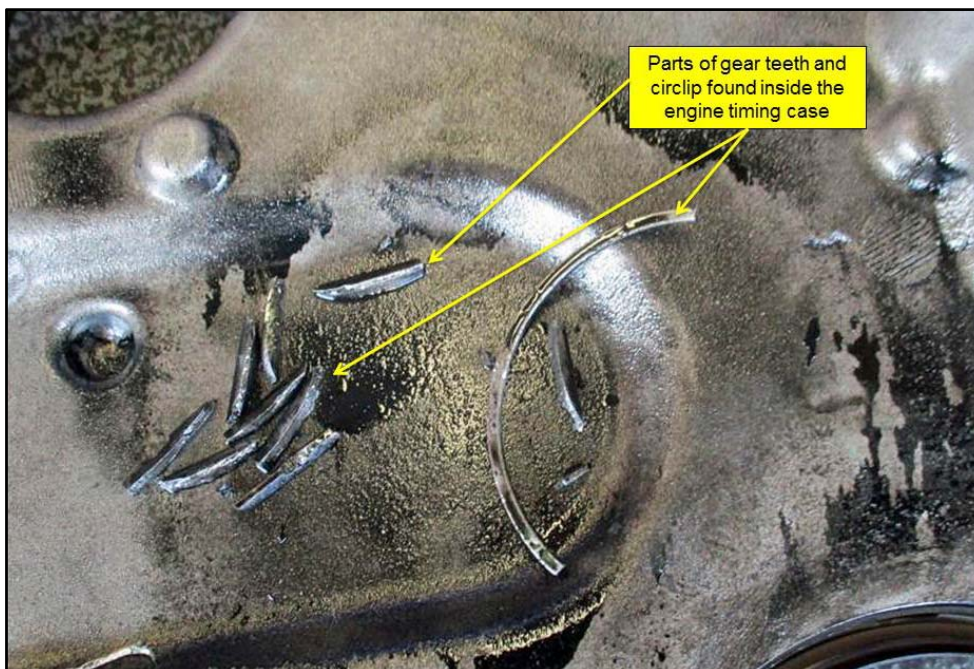
## Further mechanical examination

2.14 The engine was removed from the bus at Volvo Australia's Chullora workshop to evaluate the extent of the damage. The Volvo engineers found;

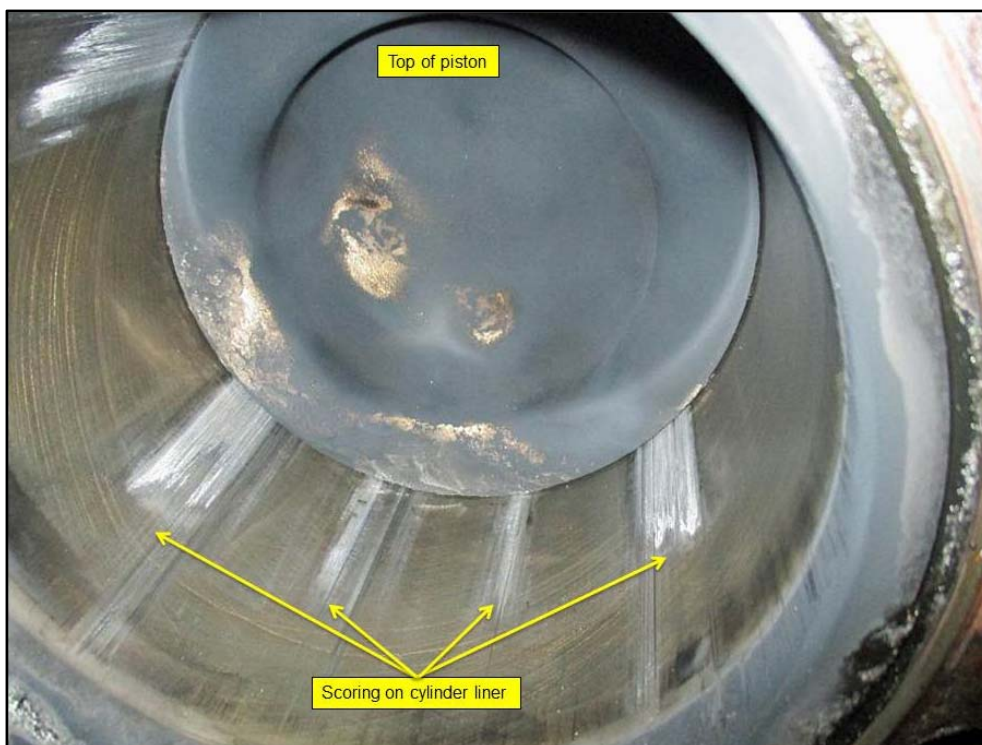
- remnants from the take-off gear and circlip from the compressor had entered the engine timing case (see *Figure 9*).
- the No 1 cylinder and liner showed evidence of a partial seizure caused by overheating (see *Figure 10*)
- the engine timing gear at the front of the engine, which drives the compressor, was severely damaged (see *Figures 11 & 12*)



- metal debris and pieces of bearings from the compressor were deposited on the engine exterior.



**Figure 9: Metal parts found inside the engine**



**Figure 10: Damaged cylinder liner**

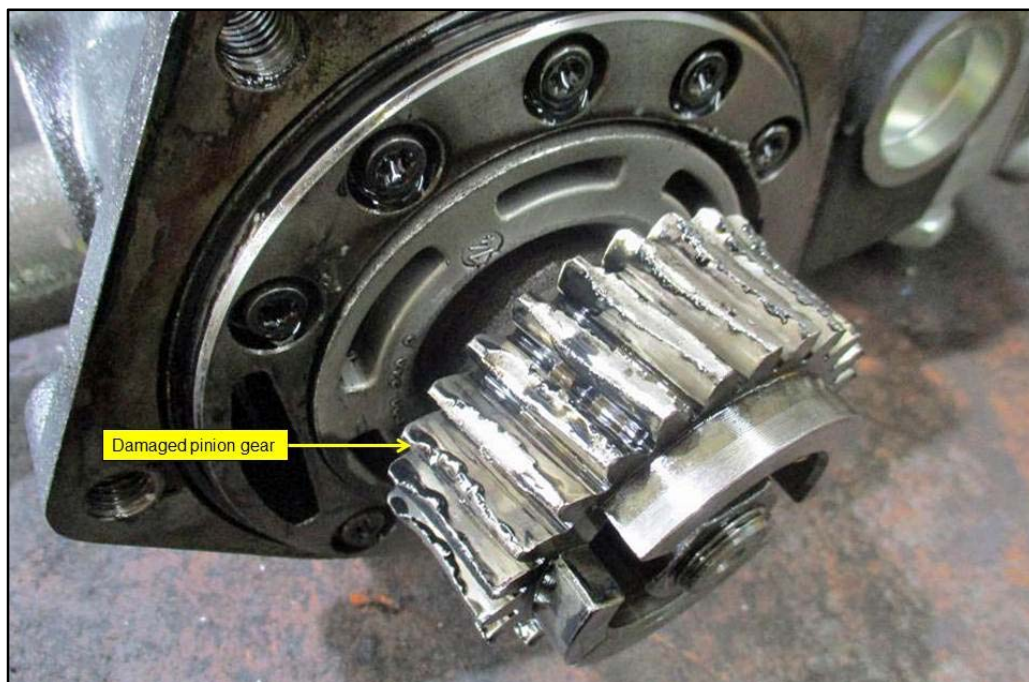


Figure 11: Damaged compressor pinion gear

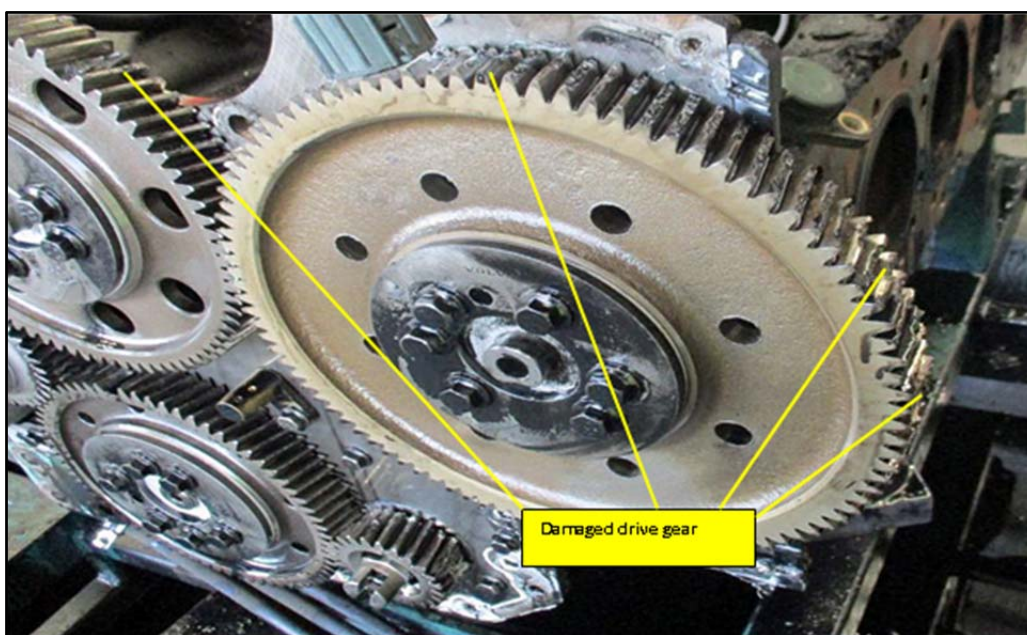


Figure 12: Damage to drive gears

## Sequence of failure

2.15 The following sequence most likely describes the failure of the compressor, resulting in the extensive damage to the engine.

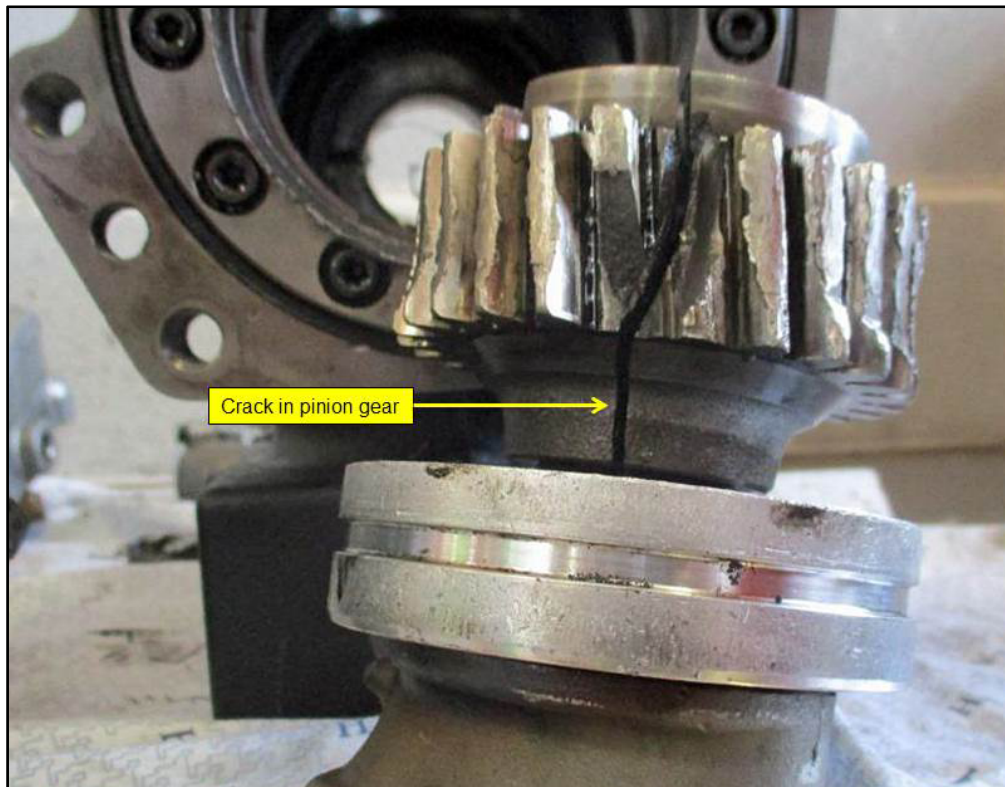
- The failure of the pinion gear from a pre-existing crack which created a misalignment of the pinion.



- The resulting forces created additional stresses in the crankshaft that led to its fracture.
- The fractured crankshaft led to a failure of the compressor connecting rods. The broken components dislodged the inspection cover from the compressor crank housing. This released oil to leak on to the road surface.
- When the compressor failed, the drive gear dislodged and allowed the compressor to disconnect from the water pump drive shaft.
- With the water pump not functioning, engine coolant flow ceased and the engine became overheated. This caused the engine alarm to record a fault code at 1645.
- The temperature rise increased pressure in the system resulting in coolant leaking through the coolant header cap.
- The failure of the air compressor meant that there was no replenishment of compressed air. The continued use of the brakes in normal driving, combined with door operation, progressively depleted the available air in the tanks.

## **Independent Metallurgist Report**

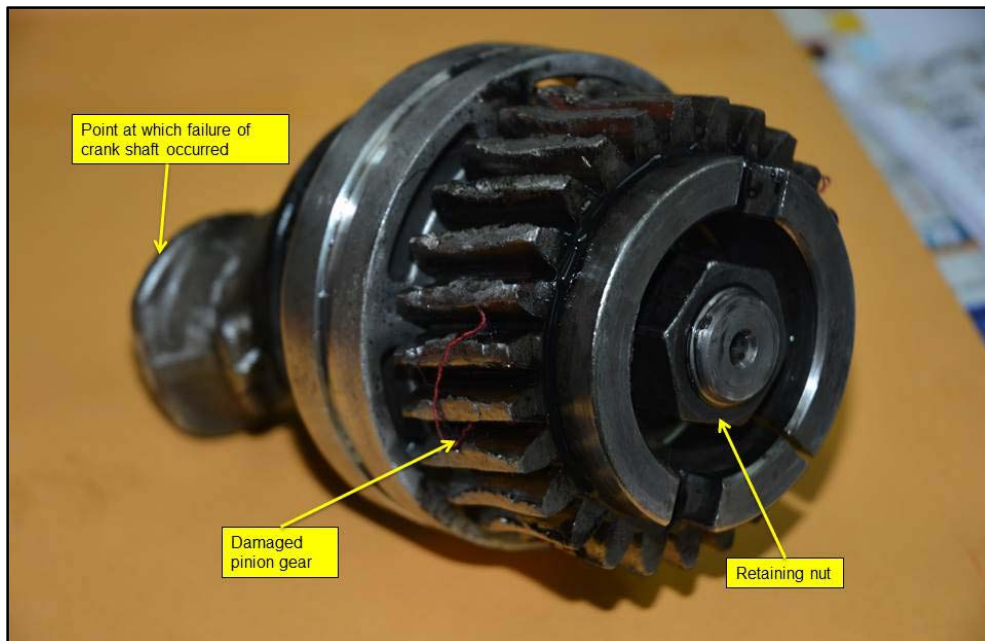
- 2.16 The STA commissioned an independent metallurgist to carry out a macro examination of the failed pinion gear.
- 2.17 The source of the failure was determined as a pre-existing crack in the pinion (see *Figures 13 - 15*).



**Figure 13: Damaged pinion gear**



**Figure 14: Adjacent end of failed crank shaft**



**Figure 15: Pinion and nut**

## PART 3 FINDINGS

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- 3.1 Bus 1707 deposited oil from the Falcon Street North Sydney overpass to Cowles Road at Spit Junction due to a mechanical failure of the air compressor drive shaft.
- 3.2 The compressor crankshaft failure was most likely attributed to an undetected fracture in the compressor pinion.
- 3.3 There was vapour emitting from the engine bay however, there was no evidence of fire. There was a potential risk of an ignition source for fire from the expelled engine oil and coolant.
- 3.4 Risks associated with the depositing of oil on the road and coolant and oil onto the hot surfaces of the engine were increased as a result of the continued operation of the bus.
- 3.5 The incident escalated when the driver did not effectively respond to repeated alarms.
- 3.6 As part of their initial driver training, STA drivers receive training on bus alarms and the processes to follow in the event that an alarm occurs.

## **PART 4 RECOMMENDATIONS**

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The following recommendations are made for STA and all bus operators.

- 4.1 Improve procedures and practices to identify pinion gear fracture.
- 4.2 Ensure bus drivers are proficient to respond to alarms and emergency procedures.
- 4.3 Implement ongoing refresher training to reinforce driver response to emergency scenarios. Training scenarios to include a range of fault code responses to improve driver familiarity with associated failures.

## **PART 5 APPENDICES**

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### **Appendix 1: Sources, Submissions and Acknowledgements**

#### **Sources of Information**

- John L Gray Pty Ltd, Metallurgical Investigation Report, April 2016
- 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, and the analysis. DIPs were asked to submit recommendations for amendments to the Draft Report that they believed would enhance the accuracy, logic, integrity 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