OTSI Office of Transport Safety Investigations

TECHNICAL INSPECTION FINDINGS

FIRES INVOLVING LINQ BUSLINES COACH 4244 MO

MARTINS CREEK and BERESFIELD, NSW

10 SEPTEMBER 2013 and 10 NOVEMBER 2013

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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.

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 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.

LINQ BUSLINES COACH 4244 MO FIRES

Introduction

A coach owned and operated by Linq Buslines Pty Ltd caught fire twice in the space of two months while operating passenger carrying services. The first occasion was at Martins Creek on 10 September 2013 when the driver was alerted to the fire by a following motorist. It was extinguished by the driver and the motorist using the onboard fire extinguisher. On this occasion there was relatively minor damage to a section of the engine bay.

The second occasion was at Beresfield on 10 November 2013 while the coach was on loan to Port Stephens Coaches. It was operating a rail replacement service after having just been reintroduced into service following repairs from the previous fire. Unlike the first occasion, no attempt was made to extinguish the fire with the onboard fire extinguisher due to the intensity of the fire. The coach burnt until the arrival of a NSW Fire and Rescue unit some 15 minutes after the driver became aware of the fire and telephoned “000” for emergency services assistance. The coach was severely damaged.

The 10 September 2013 Incident

When the first fire occurred, the coach was travelling on Dungog Road at Martins Creek with a single school child as passenger. A following motorist attracted the driver’s attention and alerted him to flames and smoke coming from the rear of the coach. The driver stopped and evacuated the school child to a safe place then, with assistance from the motorist, used the onboard fire extinguisher from the engine compartment to extinguish the fire.

The coach was towed to a holding yard at Sandgate, an outer western suburb of Newcastle, where it was inspected by OTSI investigators on 12 September 2013. The cause of the fire was determined to be a short circuit at the rear of the alternator. The fire impacted on the engine components in the vicinity of the alternator but damage was restricted to the engine bay area and was repairable. The fire did not enter the interior of the coach.

The 10 November 2013 Incident

On 10 November 2013 the same coach, 4244 MO, again caught fire. It was travelling on Anderson Drive, Beresfield, operating a rail replacement service from Telarah Railway Station to Newcastle. The driver was alerted to the fire by passengers who could smell smoke which had entered the interior of the coach. The driver then observed flames emanating from the rear of the coach in his rear vision mirrors. He stopped the coach at the first available safe place and evacuated the 24 passengers onboard, then phoned "000" to report the fire.

On this occasion, the driver did not attempt to fight the fire with the onboard portable fire extinguishers due to the intensity of the fire. A NSW Fire and Rescue unit from Tarro Fire Station attended and extinguished the fire. Due to the extent of the fire damage to the engine bay and interior areas, the coach was determined to be a total constructive loss.

Grass on the verge of the road beside the coach caught alight and also had to be extinguished by NSW Fire and Rescue. Police from Maitland also attended the scene and interviewed the driver and passengers. No one was injured as a result of the fire.

The Coach

The coach was a 1995 model Volvo B12B fitted with a 12 litre turbocharged diesel engine with an automatic transmission. The odometer showed 410,872 kilometres at the time of the first fire. The coach had had several owners before being purchased by Linq Buslines Pty Ltd on 12 August 2011. The coach consisted of a Motor Coach Marathon FCC 371 series body type[1] with a steel frame supporting a combination of aluminium and composite fibreglass panels. It had a single front door and separate side wheelchair access (see *Photograph 1*). The coach was fitted with high back seats, seat belts and below floor luggage storage accessible from both sides of the coach.

1 Motor Coach Australia was formed in 1982, initially manufacturing bus chassis with engine options. In 1986 it began to build bodies, both on its own chassis and those of other manufacturers. In 1995 it was placed in administration.

Photograph 1: Nearside view of coach (insert - wheelchair lift access)

The coach was licensed to carry 48 passengers or 44 with one wheelchair and 42 with two wheelchairs. The wheelchair access consisted of a side-loading scissor lift on the nearside, lifting the wheelchair through an opening panel into the coach.

At the time of the second fire, the odometer showed 411,824 kilometres indicating the coach had only travelled 952 kilometres since the first fire. Records showed that the bus had only been returned to service on 7 November 2013 after the repairs from the first fire had been completed.

The Drivers

The driver of the coach on 10 September 2013 had 13 years experience of bus and coach driving. She was the holder of a current heavy vehicle driver's license and a current public passenger bus driver authority issued by the Roads and Maritime Services (RMS).

The driver on the second occasion had initially driven buses from 1970 until 1985 and then had returned to driving 10 years ago. He was the holder of a current heavy vehicle driver's license and a current public passenger bus driver authority issued by the RMS.

The Coach's Electrical System

The coach's electrical requirement was supplied by two 24 volt batteries linked in parallel and located at the front off side of the coach. These batteries supplied electrical power through two main electrical control centres. The main control centre was located below the coach's floor on the bulkhead within the front of the nearside luggage storage area. The other was mounted above the engine in the engine bay at the rear of the coach.

On starting the coach's engine, power flowed from the batteries (positive terminal) through two ignition solenoids to the starting solenoid on the starter motor situated on the nearside of the engine. When the key switch start position was released and the engine was running, the alternator then supplied power to the rear mounted electrical centre which also returned power to charge the batteries. The coach's chassis acted as the main ground return line supply (negative terminal) to complete the circuit. If the emergency cut-out switch situated on the driver's dashboard panel was operated, the supply would be de-energised and remove supply from the continual power distribution rail.

Located within the rear-mounted electrical centre was an auxiliary engine start/stop switch which enabled mechanics to switch the engine on and off while conducting servicing and maintenance, without having to go to the driving position to do so each time they needed to.

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 the air conditioning unit, air compressor and the sensors located around the engine.

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

Examinations of the Bus

First Inspection

The initial examination of the coach was undertaken by OTSI investigators at a holding yard at Sandgate on 12 September 2013. The examination took the form of a visual inspection to try to establish the origin and likely ignition source of the fire.

The examination of all diesel injector fuel lines, turbocharger and coolant lines indicated that the fire had not originated from any of these sources. An examination of the alternator revealed that the fire had originated from a short circuit at the back of the alternator, initially melting the rear of the housing and wiring insulation in the vicinity (see *Photographs 2 and 3*).

Photograph 2: Alternator damage

Two Bus Field Service Tips issued by Volvo Bus Australia are noteworthy:

- A tip concerning *Tightening of Alternator Cables* issued on 29 October 2010 identified that: '*There is a possibility that if incorrect torque and/or the incorrect tightening method is used on the alternator cables, there is a risk of extreme heat*.' (See *Annexure 1*)
- A tip concerning *B12B Alternator Cable Inspection* issued on 14 June 2013 stressed the importance of checking '*both the security and integrity of all*

electrical cables, especially those in the engine bay on the alternator and starter motor.' (See *Annexure 2*)

The damage to the coach was confined to the area surrounding the alternator which included the following:

- alternator and associated wiring
- all engine drive belts
- coolant tank including hoses
- engine wiring harnesses
- sender wiring
- power steering hoses for reservoir and steering supply
- toilet drop pipe
- dipstick and dipstick tube assembly
- rear side engine bay door and skins
- rear bumper bar.

Photograph 3: Damage from the 10 September 2013 fire

The last repairs to be finalised before the coach was returned to service on 7 November 2013 were to the air conditioning which had to be re-wired due to the extent of fire damage to the wiring looms.

Second Inspection

The coach was again recovered to the Sandgate yard following the 10 November fire and an OTSI investigator examined the vehicle there on 12 November 2013. The examination involved a detailed and systematic inspection of the entire vehicle to attempt to determine the cause of the fire.

Engine

The engine was intact. Its surfaces were clean and the paint work in good condition which indicated the source of the fire was not associated with the engine or its operation. The only damage was minor secondary damage from the melting of plastic covered wiring and fittings located above the engine block. This was in close proximity to the position of the rear electrical centre which had melted onto the top of the engine block (see *Photograph 4*). There was no damage to the automatic transmission gear housing or any of its supply lines and controls.

Photograph 4: Engine bay damage from the 10 November 2013 fire

Fuel injector lines and supply

All fuel injector lines and fuel supply lines were examined and found to be intact with no leaks or damage. There was no indication that the fire had been caused by fuel, oil or coolant leaking onto hot surfaces of the engine, exhaust or turbocharger.

Engine oil

The engine oil was examined with no evidence being found of any lubricating oil leakage anywhere over or around the engine. The end of the dip stick and inspection tube had been melted but the dip stick could still be removed freely for inspection. The reading on the dip stick showed that the engine sump was full to the manufacturer's recommended level. There was no evidence of burning or overheating of the oil.

Turbocharger

There was no evidence of damage, exposure to excessive heat or fire patterns on the turbocharger. There were no signs of flammable fluids coming into contact with the hot surfaces of the turbocharger and its surrounds which could then have resulted in the initiation of the fire.

Compressor

The compressor was intact and had sustained only minor secondary damage as a result of melted plastic from wiring insulation and plastic fittings which had fallen onto it. All the compressor wiring was intact with no evidence of short circuiting.

Alternator

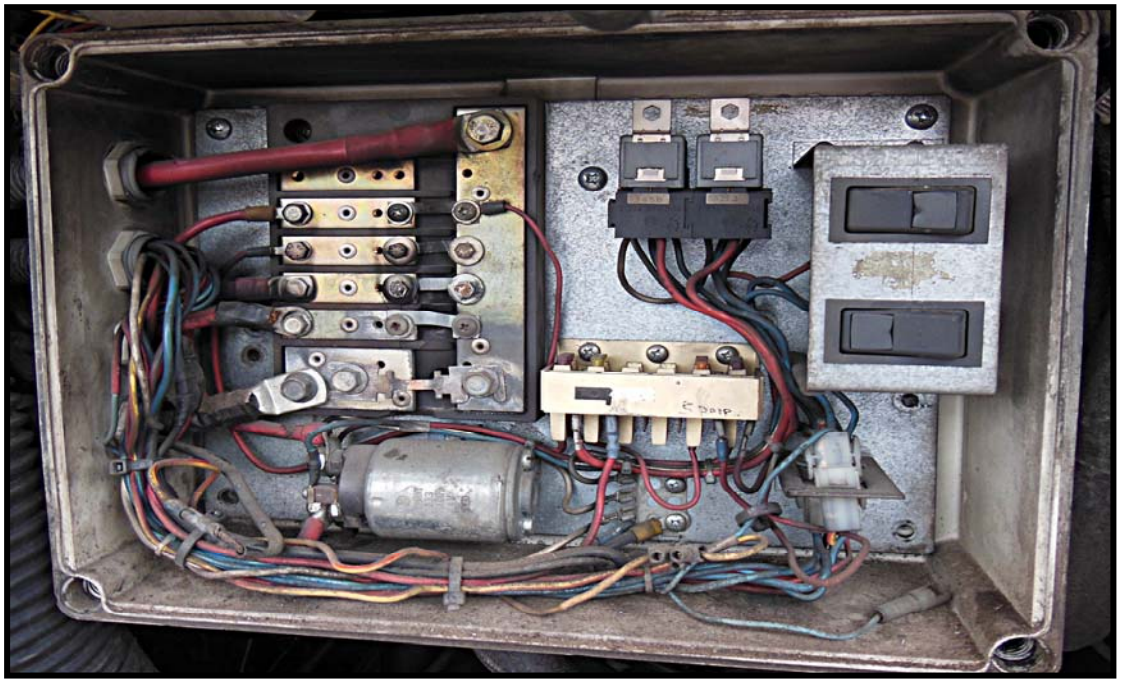
The front of the alternator sustained minor damage from the heat of the fire. Heat also caused distortion and partial melting of the plastic fans. Despite this, the rotor could still be partially turned by hand. The wiring at the rear of the alternator also showed secondary damage having been caused by other plastics melting and dropping onto the wiring loom. Unlike the first fire, there was no sign of any shorting of the wiring from the alternator and all contacts were in place and well secured.

Air Filter

The air filter was intact and showed no signs of oil impregnation or of fire damage.

Electrical Wiring

To assist in ascertaining the cause and source of the fire, a similar rear control centre on another model Volvo was viewed to identify components and determine electrical wiring connections (see *Photograph 5*). The wiring looms throughout the bus were then checked for any irregularities or evidence of electrical shorting.

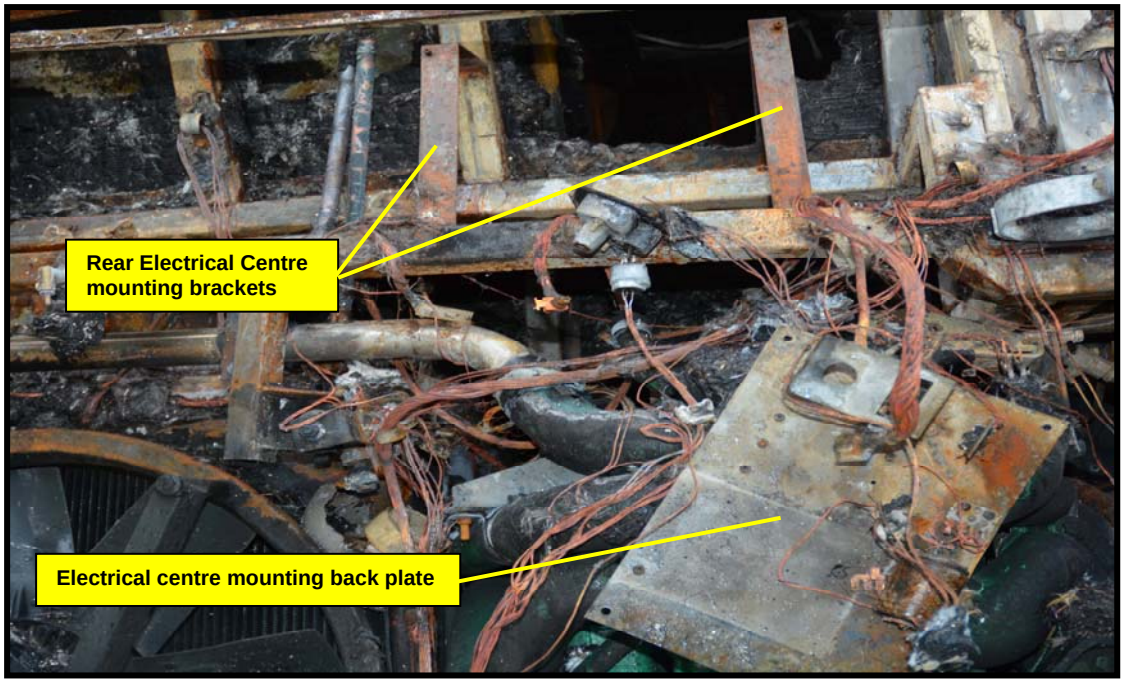


Photograph 5: Undamaged rear control centre housing with Perspex cover removed

Within the engine compartment, the outer plastic covering of the rear electrical centre had completely burnt away destroying the circuit board. All wiring looms from the electrical centre to the alternator, air conditioning, engine sensors and rear lighting were destroyed. The intensity of the fire had caused the metal mounting back plate to come off its metal brackets (see *Photograph 6*).

The fire pattern and damage around the rear electrical centre indicated that the fire had commenced at this unit with the plastic/Perspex housing and cover being totally consumed. Damage radiated out from the electrical centre to other parts of the engine bay and into the interior of the coach.

The wiring loom from the batteries to the starter motor mounted on the nearside of the engine was in good condition and well supported. It showed no signs of damage or evidence of short circuiting.



Photograph 6: Rear electrical centre

One of the two solenoids mounted next to the batteries was blown but this was attributed to shorting of the electrical supply after the fire had destroyed the wiring at the rear electrical centre. This solenoid was associated with the ignition system so, had it blown prior to the fire, the engine would have stopped running and not been able to be re-started.

On examination, wiring believed to be to the air conditioning unit on the roof showed evidence of shorting in part of the wiring harness. This wiring originated at the rear control centre. However, due to the extent of the damage, it was not possible to verify with absolute certainty that the wiring had been connected to the air conditioning.

The roof mounted air conditioning unit was destroyed as a result of the intensity of the heat generated by the fire (see *Photograph 7*). The plastic housing module melted and all wiring and connections were destroyed, making it impossible to accurately identify evidence of shorting or loose connections. If there had been a short circuit in the wiring or a loose terminal connection in the air conditioning wiring circuit, it would probably have resulted in shorting back in the rear control centre. Although this could not be verified as having occurred, it is considered the most probable cause of the fire.

Photograph 7: Air conditioning unit damage

Examination of the surviving damaged wiring leading to and from the rear electrical control centre showed the crimping of the terminal ends was good and no sign of shorting was detected. However, any shorting or arcing due to a loose connection at any of the contact anchor points could not be detected due to the extent of the damage. Additionally, some contacts could not be located and the effect of heat expanding metal fittings prevented identification of loose connections.

Maintenance

Maintenance records showed that coach 4244 MO had been fully maintained and serviced regularly every calendar month or at 5000 kilometre intervals since being purchased by Linq Buslines. The last service was on 12 August 2013 when the odometer reading was 408,363. The repairs to the coach from the fire on 10 September 2013 were completed on 7 November 2013.

Inspection of the records of all maintenance and repairs undertaken dating back to 29 August 2011, when the coach had an odometer reading of 330,008 kilometres, did not reveal any ongoing issues which might have caused or contributed to the fire.

Fire Protection

There were neither smoke nor fire alarms fitted to the coach, nor was there an automatic fire suppression system installed. There were warning lights and gauges incorporated in the driver's dashboard panel, some of which were also fitted with an audible alarm. These gauges and alarms provided for the monitoring of coolant, oil and turbocharger temperatures and pressures, the electrical supply and battery condition. The alarms were linked to sensors associated with various components located in the engine bay.

In neither fire incident did the driver observe any warning light or gauge irregularity prior to being made aware of the fire.

Fire Extinguishers

The Australian Design Rules require buses and coaches 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.* A coach is required to be equipped with two portable dry powder fire extinguishers: '*one to be mounted near the under-floor area or engine*' and the other to be located in the interior front section near to the driver.

With assistance from the following motorist, the driver of the coach on the occasion of the first fire successfully extinguished the fire using the onboard dry powder extinguisher which was mounted on the bulkhead in the nearside of the engine bay.

In the second fire incident, after evacuating the passengers and calling '000', the driver went to the rear nearside of the coach and opened the engine bay hatch to retrieve the extinguisher, only to find that it was missing (see *Photograph 8*). On completion of mechanical repairs following the first fire, the coach had been refitted with two new extinguishers in the provided locations. The rear fire extinguisher was subsequently removed and not refitted, and not found to be missing before the vehicle went back into service.

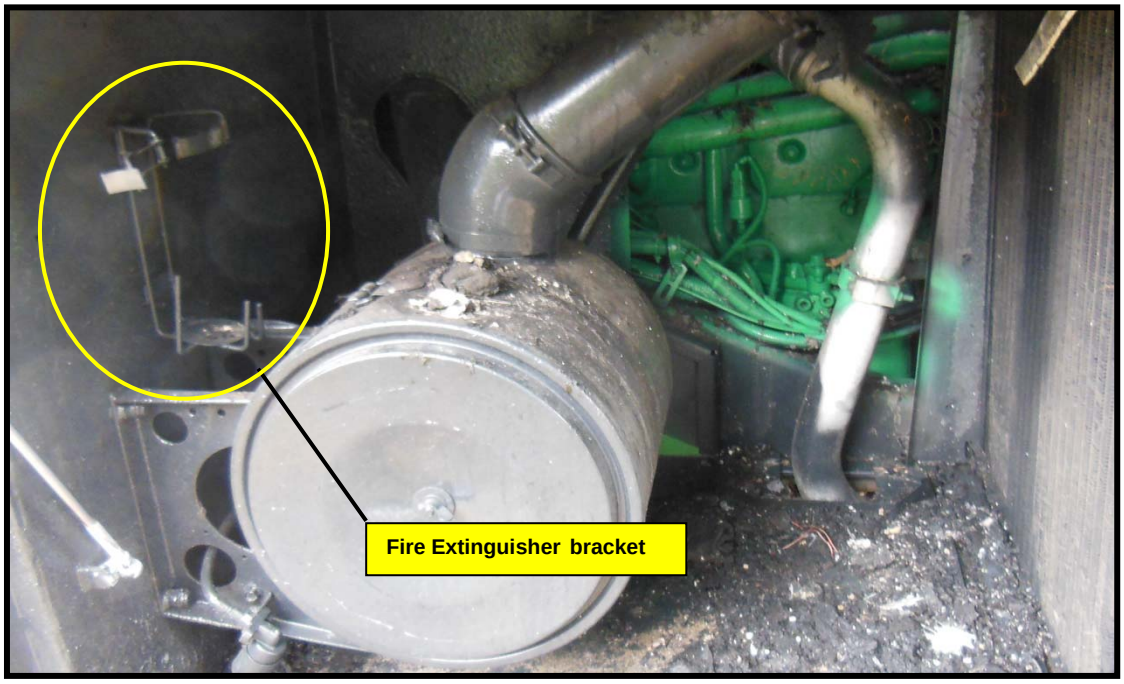
The driver described the fire at this stage as having reached well above the engine bay area and had progressed into the bus interior. The fire was now beyond the capability of small portable fire extinguishers.

The extinguisher in the cabin was stored in a compartment above the door, without any signage to indicate its location. The driver stated that this location was unknown to him as it differed from all other coaches and buses he had driven in his more than 38 years of experience. The location is most unusual as the portable extinguisher located in the cabin of buses and coaches is normally mounted on a bracket in a recessed panel next to or near the driver's seat position.

As a result of OTSI's bus fire investigation experience, it considers locating fire extinguishers in the engine bay not to be good practice. A report on bus fires in NSW from 2005 to 2012 identified:

> In several incidents examined, the rear-mounted extinguishers on coaches could not be accessed due to a combination of their proximity to and the intensity of the fire. Additionally, they are not necessarily stored in the same location on all vehicles and there is no requirement for their location to be clearly indicated from the outside of the vehicle.[2]

The report also identified a trend overseas to larger portable fire extinguishers than the nominal 2 – 2.5 kg extinguishers commonly carried in Australia.

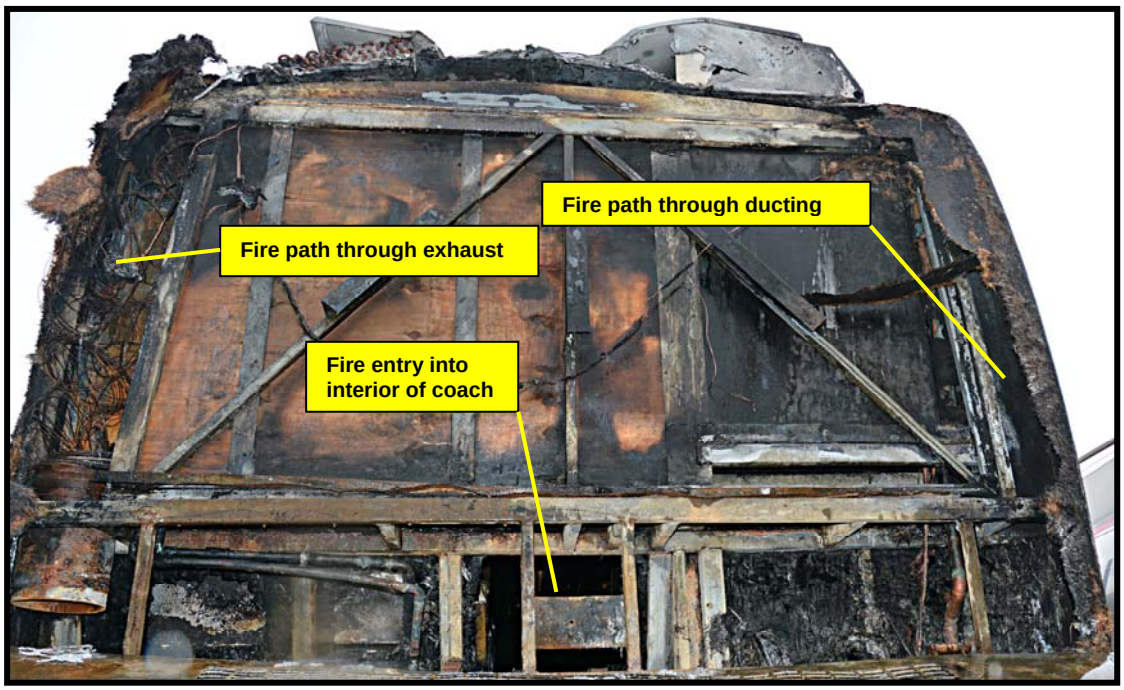


Photograph 8: Location of rear fire extinguisher

[2] OTSI Bus Safety Investigation Report, *An Investigation into Bus Fires in NSW 2005 - 2012*, available at www.otsi.nsw.gov.au

Fire Penetration into the Interior

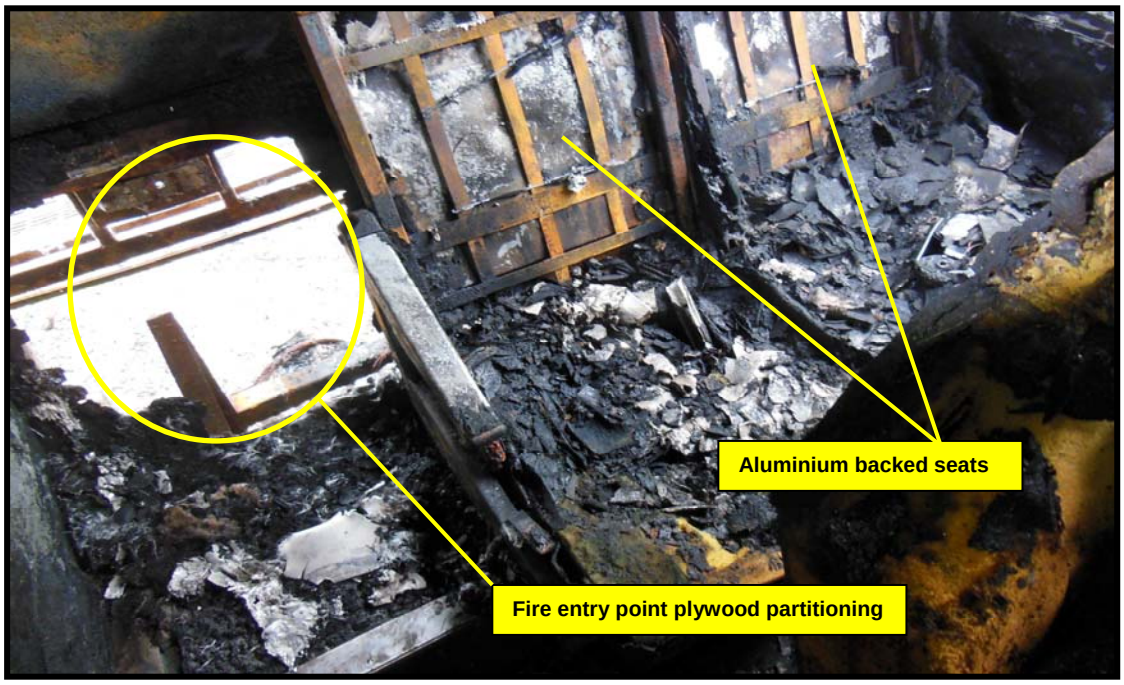
Having started in the rear electrical centre, the fire progressed upwards to the plywood bulkhead separating the interior of the coach from the engine bay. It also spread to both sides of the engine bay from where it could vent to the atmosphere above the roof line through ducting housing the exhaust stack on the nearside and electrical conduit and pipes for the air conditioning on the off side (see *Photograph 9*).



Photograph 9: Path of fire into interior and roof of the coach

As can be seen from *Photograph 10*, to penetrate the coach interior, the fire had breached the plywood bulkhead above the rear electrical centre. This was in line with the aisle which, at the rear of the passenger compartment, was between the twin rear seats on the nearside and the toilet on the off side. The seats were backed with aluminium and the toilet walls incorporated aluminium shielding. In contrast, there was no shielding to the bulkhead in line with the aisle.

The PVC drop pipe (waste outlet) into the engine bay from the toilet had melted but fire had not penetrated through the floor fitting. However, there was considerable smoke and plastic residue damage in the toilet, and the aluminium from the wall closest to the aisle had melted.



Photograph 10: Rear seating and fire penetration into the interior

The path and progress of heat and fire through the passenger compartment could be seen from the fire and damage pattern on the lining of the ceiling. The lining, consisting of a carpet-like fabric, was burnt in the rear section of the compartment, then scorched along towards the middle section, then only affected by smoke and residue through to the front of the coach. Both the roof-mounted air conditioning unit and the roof escape and ventilation hatch in the middle of the coach were destroyed (see *Photograph 7*).

The path and progress of the fire was also evident from the condition of the head rests and tops of the seats. The damage decreased in severity progressively from the rear of the coach to the front (see *Cover Photograph* and *Photograph 11*). The material used to cover the seats, the same as used for lining the ceiling, displayed good fire resistant properties. Molten plastic light fittings from overhead racks which had melted and fallen onto seats had not ignited the seating material. The material had charred where the fire was most intense, being at the rear seating.

Photograph 11: Interior damage

The rear nearside window was the only one which broke as a result of the intensity of the heat in the rear area. All other windows were significantly discoloured by deposits of plastic and particulates from the smoke.

Conclusions

The first fire in Linq Buslines coach 4244 MO on 10 September 2013 was caused by electrical short circuiting of the alternator wiring. The resultant fire destroyed the alternator and damaged nearby components within the engine bay.

The fire which severely damaged the coach on 10 November 2013 originated in the rear electrical centre mounted within the engine bay and was the result of electrical short circuiting or arcing. The exact point and cause of the short circuiting could not be accurately determined due to the extent of the damage to the electrical system. The most probable cause was a loose connection or shorting within the centre or a short circuit in wiring associated with installing the replacement air conditioning unit.

The fire entered the interior of the bus through the unshielded plywood bulkhead above the engine bay and once inside rapidly spread through the interior, consuming the air conditioning unit, rear seating and other interior fittings.

Although worthy of note, the absence of the fire extinguisher from the engine bay and the driver's lack of knowledge about the location of the other extinguisher played no part in the total constructive loss of the coach. The fire had reached such intensity and spread to the interior before a portable extinguisher, if available, could have been brought to bear and possibly extinguished or suppressed the fire.

The bus had been well maintained and regularly serviced and there was no indication that a lack of servicing or maintenance contributed to the fire.

Remedial Actions

Linq Buslines is now looking at 'best business operating practices' to minimise the exposure to future fire risk. The company has advised that, as at the start of February 2014, the following actions have been implemented or initiated, many of which have also been adopted by Linq's sister company Port Stephens Coaches:

- As a matter of policy, the driver sign-on sheet will require the driver to ensure all safety equipment is onboard at the commencement of shift. The same will be required of workshop staff on returning vehicles to service.
- The two companies are developing training for drivers in the use of extinguishers. It will involve a short training exercise and form part of the driver induction package.
- An audit of the fleets found the location of fire extinguishers to be a major issue despite their complying with regulations. In addition to being placed in the engine bay, some extinguishers were on the off side of the vehicle placing the driver in additional potential danger from passing traffic. Further, some vehicles had 'budget locks' fitted to the access panels. Both companies are in the process of relocating extinguishers to the nearside of vehicles or rear engine access bay compliant with regulations and fitting an additional 4.5kg extinguisher to the luggage bin area of all vehicles undertaking long trips.
- Linq Buslines intends pursuing with manufacturers the matters of:
  - improved fire retardant materials in the engine bay as well as sealing all open spaces to the rear header area
  - placing a fire extinguisher nozzle access hole in engine doors as a safer option to having to open the doors to fight a fire in the engine bay.

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 Linq Buslines Pty Ltd and the Roads and Maritime Services (as the NSW Bus Regulator).

Annexure A

VOLVO BUSES

BUS FIELD SERVICE TIPS

Tightening of Alternator Cables	Date	29/10/10	Page No	1/3
Issued by Steve Read	Replaces		Insert 32-100	

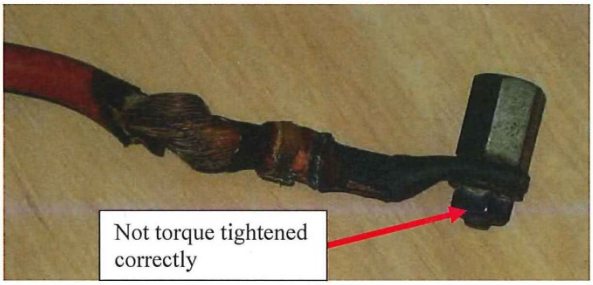
Tightening of Alternator Cables

Concerns: All Bus Models using Compact Alternators.

Description: There is a possibility that if incorrect torque and/or the incorrect tightening method is used on the alternator cables there is a risk of extreme heat.

It is extremely important to torque tighten the alternator cable connections correctly!

Below is an example of what can happen when the connection is not tightened correctly.



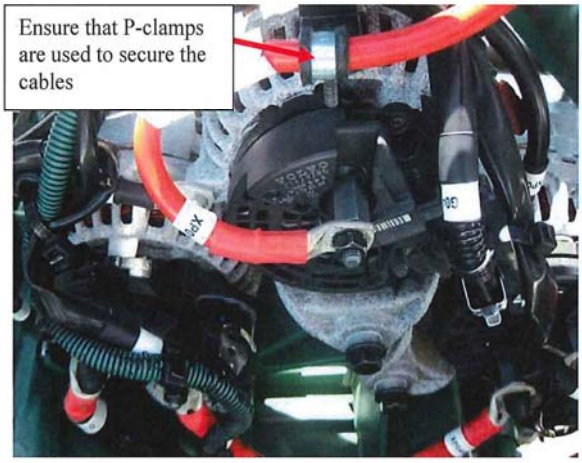
VOLVO BUSES

BUS FIELD SERVICE TIPS

Tightening of Alternator Cables	Date	29/10/10	Page No	2/3
Issued by Steve Read	Replaces		Insert 32-100	

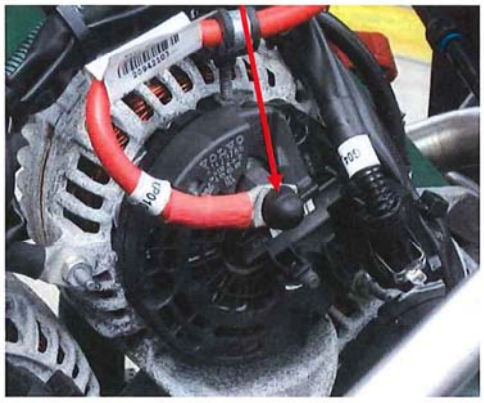
Method:

1. Check and ensure that all alternator cables are supported with P-clamps. Do not rely solely on the connectors (lugs) to support the weight of the cables.



2. Ensure that the B+ connection at the back of the alternators are torque tightened to 12±2 Nm by following the steps below.

   Remove rubber cap off nut.



VOLVO BUSES

BUS FIELD SERVICE TIPS

Tightening of Alternator Cables	Date	29/10/10	Page No	3/3
Issued by Steve Read	Replaces		Insert 32-100	

Keep the spacer nut secure with an open-end spanner.

Use a torque wrench and torque tighten outer nut to 12±2 Nm.
Note: Remember to keep the spacer nut secure with an open-end spanner while tightening the main nut.

3. Repeat steps 1 and 2 for all alternators.

Annexure B

VOLVO BUSES

Bus Field Service Tips

B12B Alternator Cable Security	Date	14th June 2013	Page No	1
Issued by Volvo Bus Australia	Replaces 7th June 2013		Insert 17 102	

B12B Alternator Cable Inspection

Concerns: All B12B Models

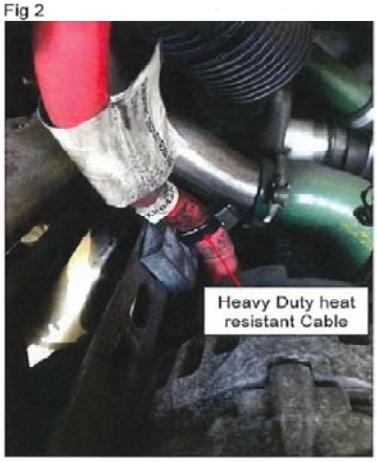
Description:
As part of a basic service, it is important to check both the security and integrity of all electrical cables, especially those in the engine bay on the alternator and starter motor.
Excessive movement between the rubber insulated P-Clamp and the alternator cable for example can allow excessive movement between the cable and the P-Clamp which may lead to contact with the steel clamp. The cable should not be twisted and **must** be held in a relaxed position whilst the bolt is tightened otherwise the clamp will load the insulation and may cut through.

Method:
Should the P-Clamp insulation be compromised or the cable loose, remove the clamp as indicated (Fig.1) and inspect for any signs of chaffing on the battery supply cable and the rubber insulator of the P-Clamp.
If signs of chaffing are evident, remove the P-Clamp and bolt, and secure the cable using a heavy duty heat resistant cable tie part number 70312532 and attach as shown in Fig. 2.

NOTE: It is important the cable tie is cut to length as in Fig 3
Fig 4. Displays the hoses that are important to inspect during the service routines to ensure the alternator cable does not make contact with adjacent components. Should the cable show signs of contact, the hose/s in question must be moved away from the alternator cable using a cable tie.

Fig 1.

Fig 2



VOLVO BUSES

Bus Field Service Tips

B12B Alternator Cable Security	Date 14th June 2013	Page No 2	
Issued by Volvo Bus Australia	Replaces 7th June 2013	Insert 17 102	

Fig 3.

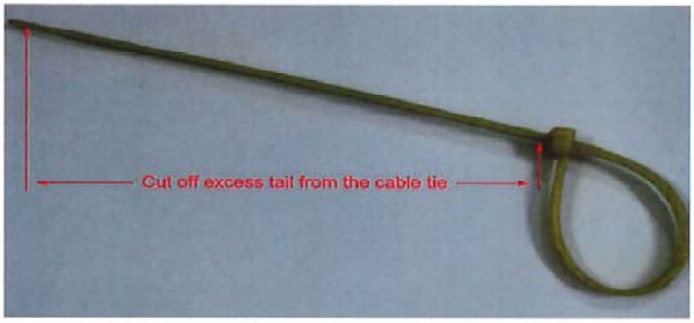
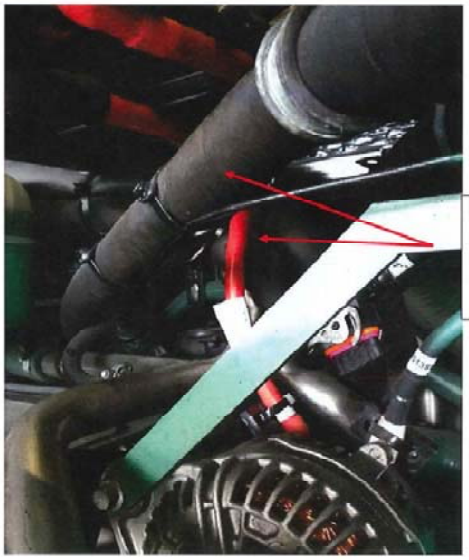


Fig 4.



The Alternator Cable must not make contact with these hoses. It is important to have 10mm clearance between the Alternator cable and the hoses to prevent chaffing.