MOVING PEOPLE

Industry Advisory

Fire Mitigation Advisory

Bus and Coach Industry

Fire Mitigation Advisory

BIC
Bus Industry Confederation
moving people

MOVING PEOPLE

Industry Advisory

Fire Mitigation Advisory

First Published September 2014.

Preface

The Bus Industry Confederation (BIC) makes no representation and provides no warranty that the information and recommendations contained in this Industry Advisory (Advisory) are complete or without exception. Reliance or use upon the information or recommendations is voluntary and the user accepts all risks and responsibility for any such reliance or use. To the maximum extent permitted by law the BIC excludes all liability to any person arising directly or indirectly out of any such reliance or use.

This Advisory makes no endorsement of products or services.

Acknowledgement

This Advisory was developed under a government sponsored project that was overseen by a Steering Committee comprising of:

> Qld Representatives: Anant Bellary, Principal Engineer (Vehicle Standards & Regulation), Tammie Perrett, Principal Advisor (Contracts) Translink (Division of Transport Main Roads) and Lisa Parker Director (SEQ Bus Contracts) Translink (Division of Transport Main Roads).

> NSW Representatives: Barry O'Neill Manager bus Contracts, Bus & Ferry Contracts Division, Transport for NSW and John Karaboulis Executive General Manager, Service Procurement and Performance Transport for NSW and Greg Dikranian Senior Research and Policy Analyst, Centre for Road Safety, Transport for NSW.

> WA representatives: Tim Woolerson, General Manager, Public Transport Authority of Western Australia and Paul Burke, TransPerth Fleet Manager.

> BIC Representatives: Michael Apps, Executive Director and Luke Hardy, Technical Manager.

> Industry Representatives: Dean Moule, Body Builder & Sales Engineering Manager, Volvo Bus Australia and Michael Kearney, Engineering Manager, Volgren.

Special thanks for Luke Hardy, Technical Manager, Bus Industry Confederation, as primary author of this Advisory.

Contents

Section 5 Reducing the Risk of Fire

Annexures

Figures

Tables

Section 1

IMPORTANT READING

Executive Summary and Key Recommendations

Fire mitigation on buses is seen as a key safety issue for bus operators and drivers, bus suppliers and manufacturers, bus passengers and government agencies at all levels. Currently every week in Australia at least one bus experiences a potentially fatal fire incident. The potential for a fatal bus fire in Australia does exist, especially for buses operating in high density urban environments or in traffic tunnels.

This Advisory has been developed as part of a joint project undertaken by the Bus Industry Confederation (BIC) and the Queensland, New South Wales and Western Australia transport authorities, to capture in one document the key actions to reduce the frequency and severity of fire on buses.

This Executive Summary presents the key findings and recommendations for bus fire mitigation.

Rates and Common Causes of Bus Fires — Finding

A review of available Australian bus fire data by the author has found that a bus in Australia is 4 times less likely to experience a fire than a bus in the United States and 10 times less likely than a bus in Sweden based on the respective number of vehicles in service in each country.

The most common causes of bus fires are failures in the engine compartment area including mechanical, electrical, fuel related issues and coolant fires. Such fires have become more common with the introduction of tighter emission standards Euro 4, 5, 6. In conjunction with tighter noise emission limits such as Australian Design Rule (ADR) 83, this has led to higher engine bay temperatures making it harder to inspect and maintain.

Fire Propagation and Driver Awareness – Finding and Recommendation 1

A common issue stated by drivers is that they were not aware that a bus fire incident was occurring. Drivers are typically told of such incidents by others. This is not unexpected given that the majority of the fires start in the engine compartment, which is well away from the driver's position, at the rear of the bus and outside of the passenger compartment.

The driver not being aware sees engine bay fires typically propagate to such an extent that the result is a full burn out of the bus, noting that the time for the fire to progress from the engine compartment to the passenger area could be as quick as 3 to 4 minutes. If the driver is aware, or the driver is able to respond in a timely manner, the result can be that the fire situation is addressed and the fire extinguished.

> Suitable detection systems with alarms be considered in all enclosed areas even on low risk buses and/or operations.
>
> Enclosed areas include the engine bay and where fitted, the luggage bins and on board toilet.

Fire Incident Monitoring and Reporting – Finding and Recommendation 2

When researching the frequency and causes of bus fire incidents, the most obvious issue was that there is no central point where records for Australian bus fires can be reviewed. The data available was incomplete and not extensive. This is at odds with the overseas experience where countries such as the US have quite detailed databases. If fire rates are to be reduced, there needs to be a clear and up to date understanding of what is causing fires and what ongoing actions need to be taken.

> A National database be established that can be used to record and analyse the details of all reported bus fire incidents. This will allow fire incidents to be analysed and reviewed. This will provide for regular industry wide updates in regards to any changes in fire causation, severity or improved methods to reduce the fire risk.
>
> The committee recommended that this database be managed by the BIC.

Bus Fire Mitigation is an Industry Responsibility – Finding

Bus fire mitigation is seen as a joint responsibility of all areas of the bus industry. Bus designers, manufacturers and suppliers need to design, manufacture and supply buses that have a low risk of initiating fire and if a fire should occur, that the bus resists the propagation of fire possible and practical.

The buses need to be designed and manufactured to allow operators to correctly and appropriately maintain the buses to the required standard. Operators then need to maintain the buses to the appropriate standards and have in place suitable fire mitigation programs and emergency response procedures.

Each of these bus industry sectors need to work together to minimise the risk of bus fires. If the driver is aware, or the driver is able to respond in a timely manner, the result can be that the fire situation is addressed and the fire extinguished.

The Four Elements to Fire Mitigation – Finding

Any remedies, or risk reduction measures, should follow a hierarchy of measures which can be summarised into four key elements:

1. 1st Element — Elimination and or minimisation by design.
2. 2nd Element — Use of appropriate engineering safeguards such as fire control systems, alarms and in higher risk situation active Fire Protection Systems.
3. 3rd Element — Use of appropriate and ongoing protection measures, such as correct maintenance processes and procedures, bus cleaning and ongoing review.
4. 4th Element — Use of administrative controls such as training and emergency response procedures and practices.

The recommended actions associated with each of these elements are detailed in this Advisory.

Assessing the Fire Risk – Finding and Recommendation 3

The risk associated with (or the outcome of) a bus fire varies greatly depending on a range of issues. The risks can be broken down into three areas: risk to the bus, risk to the passengers and risk to the surrounding environment. Passenger safety is paramount and passengers have to be able to exit the bus in a safe and orderly manner. The impact that a bus fire can have on the immediate surroundings is critical. A bus left burning on a rural highway is a totally different scenario to a bus burning in the middle of a city street or worse case, in a tunnel.

Therefore the level and complexity of the bus fire mitigation measures put in place by bus designers, manufactures and ultimately the bus operators, needs to be based on the assessed risk for the bus, the intended passenger and the operational environment.

> The level of fire mitigation should be based on the assessed risk for both the bus, passengers and the operational environment.

When to Conduct Fire Risk Assessments and Design Reviews – Finding and Recommendation 4

A Fire Risk Management Process is the systematic application of management policies, procedures and practices to identify, analyse, control, monitor and review fire risks at all phases of the equipment life. Any Fire Risk Management Process needs to consider the risk of bus fires over the complete life cycle of the bus.

> Appropriate risk or design assessments, which involve bus designers, suppliers, maintainers and operators, need to be conducted at each of the key phases of the buses life at the time of:
>
> - Developing the purchasing specification
> - Designing the bus
> - Manufacturing and commissioning the bus
> - Operating and maintaining the bus
> - Modification or updates to the bus.
>
> These assessments or reviews should be conducted in accordance with the processes detailed in this Advisory.

Fire Mitigation Measures – Finding and Recommendation 5

A recommended range of fire mitigation measures that can be taken to reduce the risk, frequency and severity of bus fires are detailed in this Advisory. The systems range from Basic, through to Intermediate to Advanced and each category provides a complete system that uses both passive and active systems to address bus fire issues.

> All new buses need to meet the Basic level of fire mitigation and that the use of Intermediate or Advanced systems, or combinations thereof, is determined based on the assessed risk.

The recommended passive systems are Fire Protection Systems that form part of the bus structure and or mechanical layout. Active systems are systems that are either activated by the driver or are automatically activated should a fire occur and are meant to minimise the effects of any potential fire.

Basic Fire Mitigation Measures — Recommendation 6

The recommended basic fire mitigation measures can be summarised as:

- Improved fire resistance and containment via the use of fire resistant partitions between the passenger compartment and areas such as the engine bay, battery boxes, wheel arches and fuel storage areas
- The use of fire resistant and low smoke materials in the passenger compartment
- Use of suitable shielding of key heat generators such as turbochargers and exhausts
- Proper venting of sub compartments such as the engine bay
- The use of appropriately sized fire extinguishers which are fully accessible to the driver and in accordance with the ADR's[1]
- Correct routing, mounting and isolation of electrical harnesses, hydraulic and fuel lines
- Use of correct types of hoses and fittings in areas where high pressure fluids are being used
- Use of appropriate overload protection systems for high current electrical areas. The use of an appropriate and correctly rated electrical protection devices for all electrical circuits, for example, circuit breakers, fuses, and other current limiting devices
- Fire detection systems with alarms to notify the driver of a fire or overheat situation in the engine compartment and other enclosed areas such as the luggage bay and if fitted, the toilet.

Intermediate and Advanced Fire Mitigation Measures — Recommendation 7

As determined by the risk analysis process, the recommended Intermediate and Advanced fire mitigation measures can be summarised as:

- Isolate the power on the bus should a fire occur, the inclusion of driver activated, or a remote activated battery isolation switch or similar system
- A system to monitor rear tyre pressures for high speed bus operations and to advise the driver if a tyre failure has occurred
- The inclusion of additional or larger portable fire extinguishers
- For higher risk buses and or higher risk operating environments, the use of either driver activated or fully automatic Fire Protection System fitted to the engine bay
- Either driver activated or automatically activated isolation of the fuel supply lines or fuel tank feed lines.

1 Vehicle Standard Australian Design Rule 58/00, Requirements for Omnibuses Designed for Hire and Reward 2006

Maintenance and Operational Requirements – Finding and Recommendation 8 and 9

A key part of addressing the rate of bus fires is to ensure that operators have in place correct and appropriate maintenance, operational and emergency response procedures. The level or complexity of on-bus fire protection in use and the maintenance and emergency response procedures is dependent on the assessed risk associated with the operation of the bus or buses.

Any system should ensure that buses are appropriately cleaned, inspected and maintained and that these processes should be in accordance with the bus manufacturers cleaning, inspection and maintenance procedures. Recommended minimum maintenance and inspection procedures are provided within this Advisory.

> All drivers be trained in the correct emergency response procedures so that if a bus fire incident occurs, the impact is minimised.

Recommendations are also provided in this Advisory for processes and training procedures for drivers including pre-departure checks, operational checks and emergency response.

> All operators review their respective procedures and practices for maintenance, emergency response and training in accordance with the details given in this Advisory.

During the development of this Advisory, it became obvious that there is no one simple fix to address bus fires. Reducing the rates and severity of bus fires involves active participation and action from all sectors of the bus industry. The required actions and fire mitigation processes vary for different types of buses and/or operational environments.

The Annexures in this Advisory provide a number of generic forms that cover suggested maintenance inspections through to Fire Risk Assessment Processes. These are provided to assist readers to implement the recommendations of this Advisory.

Definitions

Bus or buses — (and or Omnibus) — bus means a Bus or Coach that complies with the Australian Design Rules (ADR) definitions for an Omnibus as per the following:

4.4. Omnibuses

4.4.1. A passenger vehicle having more than 9 seating positions, including that of the driver.

4.4.2. An Omnibus comprising 2 or more non-separable but articulated units shall be considered as a single vehicle.

4.4.3. LIGHT OMNIBUS (MD)

An Omnibus with a 'Gross Vehicle Mass' not exceeding 5.0 tonnes.

4.4.4. HEAVY OMNIBUS (ME)

An Omnibus with a 'Gross Vehicle Mass' exceeding 5.0 tonnes." [2]

Bus Support Systems — Means systems put in place by the operator and or maintainer to reduce the fire risk, such as maintenance standards and practices, appropriate cleaning programs, driver training and the use of appropriate emergency response procedures.

Enclosed Spaces – Enclosed spaces on the bus are considered to be areas where fires have real potential to occur and areas that can be effectively monitored. These areas are considered to be engine bays, fitted luggage bins and or stowage areas and on board toilets.

Fire Hazard — Where there is the potential interaction of fuel sources, oxygen and ignition sources that could cause a fire.

Fire Incident — A situation where the three factors in the fire triangle **—** a fuel source, oxygen and an ignition source has combined to create a fire.

Fire Risk Assessment Process – The process used to assess the level of a fire risk associated with a particular situation such as bus type, operational environment or passenger group.

Fire Risk Evaluation – The process used to prioritise fire risk. What risk needs to be addressed first, what risks are the most significant, what potential risks are considered acceptable?

Fire Risk Management Process — A Fire Risk Management Process is the systematic application of management policies, procedures and practices to identify, analyse, control, monitor and review fire risks at all phases of the equipment life. Any Fire Risk Management Process needs to consider the risk of bus fires over the complete life cycle of the bus.

Fire Mitigation – Means to reduce the risk of fire to an acceptable level based on the Fire Risk Assessment Process.

Fire Triangle — Where there is the potential interaction of fuel sources, oxygen and ignition sources that could cause a fire.

Fire Protection Systems – Means the system used to extinguish a fire should a fire occur. Where required, such systems are normally mounted in the engine and or battery compartment and can be either manually or automatically activated. Such systems typically use water mist, foam or powder as extinguishing agents.

Hazard — A source of potential harm or a situation with a potential to cause loss.

On-bus Passive Fire Protection Systems — Means Fire Protection Systems that form part of the bus structure and or mechanical layout. Examples include a thermal barrier between the engine bay and the passenger compartment or a cooling system that is designed such that the likely leak points are not located over potential heat or ignition sources.

On-bus Active Fire Protection Systems — Means systems that are either activated by the driver or are automatically activated should a fire occur and are meant to minimise the effects of any potential fire. Examples include portable fire extinguishers, a driver activated battery isolation switch or fixed Fire Protection System.

Parties – Means the groups or stakeholders involved in the various aspects of the purchase, manufacture, operation and maintenance process — the purchaser, the designers, the suppliers and manufacturers, the operators and the maintainers.

Risk — The chance of an occurrence of an event that will have an impact upon objectives.

Type Approval – Means where a specific body and chassis combination or a specific bus or coach design has been reviewed via the Risk Assessment Process.

2 Vehicle Standard Australian Design Rule Definitions and Vehicle Categories 2005, Compilation Date: 31/05/2012

Background

Fire mitigation on buses is seen as a key safety issue for bus operators and drivers, bus suppliers and manufacturers, bus passengers and government agencies.

The potential for bus fires, and in the worse case resulting in injury or fatality, is real. The available Australian bus fire data indicates that a higher risk exists for buses operating in high density urban environments and traffic tunnels.

The available Australian data also suggests that bus fires have increased in frequency in recent years. This increase is partly due to the introduction of more stringent Australian Design Rules (ADR's) that restrict engine tail pipe and noise emissions. These standards have resulted in higher engine operating temperatures, higher fuel pressures and increased loading on cooling and electrical systems. Further exacerbating this is tighter noise emission requirements and the need to fully enclose the engine bay.

Bus operators have to contend with not only higher engine temperatures and pressures, but also an engine bay that is fully enclosed and more difficult to access and maintain.

Introduction

This Advisory has been developed as part of a joint project undertaken by the Bus Industry Confederation (BIC) and the Queensland (QLD), New South Wales (NSW) and Western Australia (WA) transport authorities, to capture in one document the key measures to minimise the risk of fire on buses.

The intended outcome is to establish a set of agreed industry guidelines that can be used by bus operators, regulators, government agencies and bus manufacturers and bus rolling chassis manufacturers to minimise the risk of a bus fire.

Following is an outline of the guidelines and information provided in this Advisory.

> An analysis of the frequency and causes of bus fire incidents in Australia and overseas.

> Methods for assessing the fire risk profile for a particular bus or fleet of buses.

> The development of a set of recommended performance based specifications and standards for each level of fire risk as identified by a risk analysis model.

> Performance based specifications for new bus design in terms of passive and active fire mitigation measures.

> Recommended processes that should be employed to assess and where necessary address the fire risk of any new bus design and or chassis and body combination.

> A range of supporting and background information on fire protection practices and systems.

> Recommended maintenance and operational procedures to reduce the risk of fire to passengers and the asset.

> Driver training advice and operational procedures.

The guidelines and information have been based on input from all sectors of the bus industry.

Advisory Steering Committee

This Advisory was developed under a government sponsored project that was overseen by a Steering Committee comprising of:

> Qld Representatives: Anant Bellary, Principal Engineer (Vehicle Standards & Regulation), Tammie Perrett, Principal Advisor (Contracts) Translink (Division of Transport Main Roads) and Lisa Parker Director (SEQ Bus Contracts) Translink (Division of Transport Main Roads).

> NSW Representatives: Barry O'Neill Manager bus Contracts, Bus & Ferry Contracts Division, Transport for NSW and John Karaboulis Executive General Manager, Service Procurement and Performance Transport for NSW and Greg Dikranian Senior Research and Policy Analyst, Centre for Road Safety, Transport for NSW.

> WA representatives: Tim Woolerson, General Manager, Public Transport Authority of Western Australia and Paul Burke, TransPerth Fleet Manager.

> BIC Representatives: Michael Apps, Executive Director and Luke Hardy, Technical Manager.

> Industry Representatives: Dean Moule, Body Builder & Sales Engineering Manager, Volvo Bus Australia and Michael Kearney, Engineering Manager, Volgren.

The role of the Steering Committee was to:

1. Develop and agree to the Terms of Reference for the project.
2. Monitor the progress of the project against the agreed Terms of Reference.
3. Review the findings of the investigations on an ongoing basis and provide input into these findings, the developed and negotiated recommendations.
4. Provide input into the investigations and support the key technical sub-groups as required.
5. Help ensure that the appropriate parties have active input into the contents and any recommendations made in the Advisory.
6. Review existing Australian bus fire incident data to determine if any patterns or trends exist or if any areas require priority treatment.
7. Review the need for the development and implementation of a standard bus fire incident reporting format with the view to developing a centralised database on bus fire incidents.
8. Review and agree to the final version of this Advisory.

This Steering Committee held a number of meetings and considered a range of data and submissions supplied by the bus industry in general, other associated industry suppliers or interested parties and government agencies.

Funding sources

The funding for the project and this resulting Advisory, was jointly provided by the QLD, NSW and WA transport authorities. The provision of this funding, the technical, operational and commercial support and advice provided by the three State Authorities is greatly appreciated by both the BIC and the bus industry in general.

The Australian Bus Industry

The Australian bus industry services more than 1.5 billion passenger trips per year.[3] This equates to the bus industry providing 1.5 billion urban public transport passenger trips per year with the coach sector moving more than 1.6 million domestic travellers per year.[4] To achieve this, buses operate more than 6 billion passenger kilometres per year.[5]

The industry contributes more than $10 billion a year to the Australian economy and employs more than 50,000 people.[6]

The bus industry's passenger task is expected to double by 2050.[7]

As of January 2011, there were 93,034 registered buses in Australia.[8] These buses are operated by more than 3,000 bus companies across the country.[9] Bus services are delivered by a combination of government owned and run fleets and private bus companies.

Out of the more than 50,000 people employed in the Australian bus industry, 10,000 people work in the bus manufacturing sector encompassing tradesmen, technicians and sales and administrative staff.[10] Typically there are around 1,500 new buses delivered to the Australian market annually.[11]

Safety in the Australian Bus Industry

The Australian bus industry provides safe services to the public however any bus related incident, whether it be a crash, fire or pedestrian accident, has the potential to become a major media and public interest story. Also given the numbers of passengers a bus can carry, it would only take one major bus fire incident to dramatically increase the number of bus related injuries and or deaths.

3 Cosgrove, D. 2011, *Long Term Patterns of Australian Public Transport Use,* Australasian Transport Research Forum 2011 Proceedings 28 — 30 September 2011, Adelaide, Australia Publication website: http://www.patrec.org/atrf.aspx
4 Tourism Research Australia, 2008, Transport Fact Sheet, Department of Resources, Energy and Tourism, Canberra
5 Minister for Infrastructure and Transport the Hon. Anthony Albanese MP, 2012, *Bus Industry — Keeping the Nation Moving*. Speech to Bus Industry Confederation Annual Dinner, Canberra, March 2012.
6 Bus Industry Confederation, 2010, Industry Survey.
7 Bureau of Infrastructure, Transport and Regional Economics and CSIRO, 2009, *Modelling the Road Transport Sector*, Treasury, Canberra.
8 Australian Bureau of Statistics, 2011, Census of Motor Vehicle Use, Australian Government, Canberra.
9 Bus Industry Confederation of Australia, Canberra 2010, Industry Survey
10 Tourism Research Australia, 2008, Transport Fact Sheet, Department of Resources, Energy and Tourism, Canberra.
11 Bus Industry Confederation, 2011, Based on bus sales data recorded in Australasian Bus and Coach Magazine.

Fire Mitigation Involves the Whole Industry

The development of this Advisory has identified that there are a range of materials, designs and systems that can be incorporated into buses to reduce the risk of a fire starting or the damage or severity of a fire once started.

Correctly implemented maintenance and operational procedures is also key in regard to reducing fire risk. It is important to note that the majority of bus fires can be traced to some type of component failure,[12] suggesting that there is a need for correct maintenance and inspection processes.

To achieve a successful outcome, bus fire mitigation rests with all sectors of the bus industry.

> Bus designers, manufacturers and suppliers need to design, manufacture and supply buses that have a low risk of initiating fire and if a fire should occur, that the bus resists the propagation of any fire where possible and practical.

> The buses need to be designed and manufactured to allow operators to correctly and appropriately maintain the buses to the required standard.

> Operators need to maintain the buses to the appropriate standards and have in place suitable fire mitigation policies and procedures.

> Operators need to have in place appropriate emergency response procedures that provide the bus driver with the skills and support necessary to respond to any foreseeable fire incident.

> The buses need to be specified, purchased and if required, optioned so that suitable or higher order Fire Protection Systems are included for certain bus types and/or operational environments.

There is a role for governments in certain circumstances to provide additional funding for extra Fire Protection Systems noting that these systems also need to be maintained on an ongoing basis.

12 Ahrens, M, 2010, U.S. Vehicle Fire Trends and Patterns, National Fire Protection Association

Section 2

REVIEW OF FIRE ON BUSES IN AUSTRALIA AND OVERSEAS

Review of Fire on Buses in Australia

Data provided by various representatives from the Australian Insurance Industry determined that:

- There are up to 70 bus fires per year in Australia (or more than 1 per week). This is around 0.1 % of the existing bus fleet based on an Australian bus fleet of approximately 93,034 registered buses (includes any bus with 10 or more seats)[13]
- That the projected losses from bus fires for 2012 are nearing $16 Million.[14]

A bus in Australia is 4 times less likely to experience a fire than a bus in the United States (US) and 10 times less likely than a bus in Sweden based on the respective number of vehicles in service in each country.

To examine these statistics further a review of the available Australian data was undertaken for the period 2009 to 2013. It should be noted that there is no central point where the records for bus fires can be reviewed. In fact the data was incomplete and not extensive.

In an attempt to understand the key causes of and circumstances related to recent bus fire incidents that have occurred in Australia, a review of the following data sources was undertaken:

- Available Media Reports
- Office of Transport Safety Investigations Reports (OTSI)
- Victoria Country Fire Authority Reports (CFA)
- Transport for NSW (TfNSW) supplied incident data
- Bus records and fleet statistics data from the Bus Australia Database at www.busaustralia.com.au.

As a result of the above analysis, a database was developed which, at the time of developing this Advisory, included data on approximately 85 bus fire incidents. Thirty-one of the recorded incidents were a consolidation of media reports, official reports and other cross references; hence the information on this sub-set of incidents was quite detailed.

The findings from the above review determined that the available Australian data showed similar trends to the overseas data which can be summarised as:

- Australian and Overseas data shows similar fire rate increases to the number of bus fires per year
- The data shows an approximate annual increase of fires in Australia of around 20% per annum, however taking into account bus fleet growth, this increase is better estimated as 15% per annum.[15] See Figure 1.
- Fires have occurred in all sectors of bus and coach operations, including tour and charter, school and normal route type services
- The majority of fires reviewed were engine compartment type fires. Anecdotal evidence and industry experience suggests that engine bay fires are the most common form of bus fire in Australia
- The causes of engine compartment fires included mechanical, electrical, fuel and coolant related fires
- Tyre fires on the rear axles were not uncommon
- Of the 31 fire incidents reviewed, in 25 of these incidents the driver was not aware that the bus was on fire. Instead the driver was made aware of the fire by passengers, other motorists or passers-by
- The time for the fire to progress from the engine compartment to the passenger area could be as quick as 3 to 4 minutes (this is comparable with overseas data)
- In the instance where the driver is unaware of the fire, the fires are more likely to result in a complete burn out of the bus
- Of the 11 bus fire incidents that OTSI formally reported on between 2000 and 2012, 9 were caused by failures of components in the engine bay, one was a failed tyre and the other was a dragging brake
- There has also been an increase in the number of smaller fires that have been successfully addressed by the use of a portable fire extinguisher.[16]

These findings are also summarised in Figures 1 to 7.

> A major recommendation of this Advisory is that a National database be established to record and analyse the details of bus fire incidents.

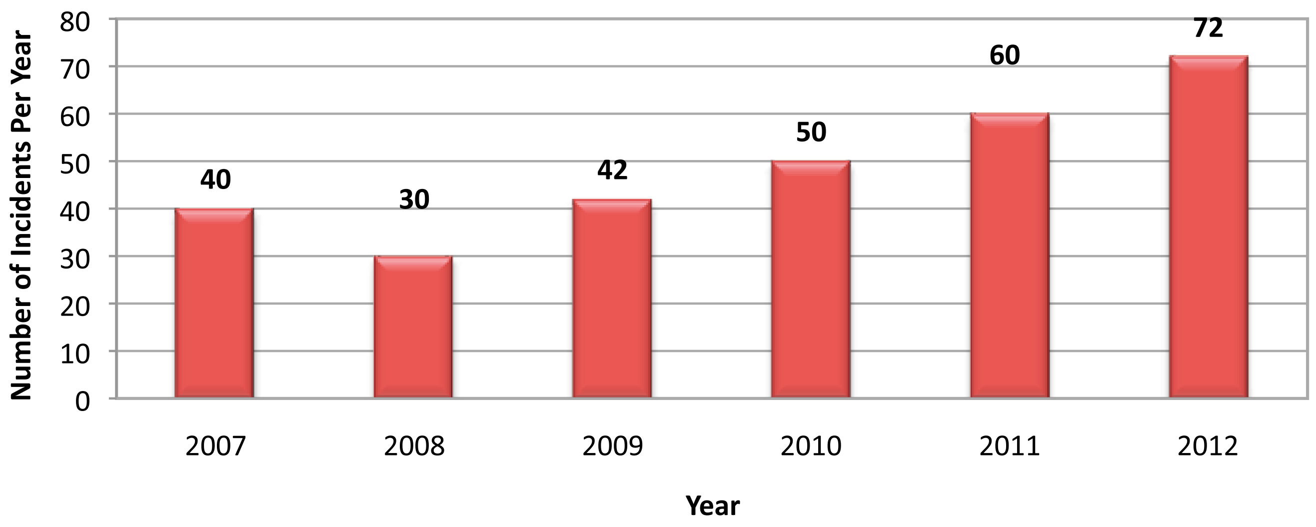
13 Australian Bureau of Statistics, 2013, Motor Vehicle Census*, Australian Government Canberra.
*where a bus is a motor vehicle constructed for the carriage of passengers. This category includes all motor vehicles with 10 or more seats, including the driver's seat.

14 Insurance Data from interviews with various Australian Insurers 2012. (See Figures 1-4 for results).

15 Ibid.,^

16 Office of Transport Safety Investigations, 2013, Bus Fire Information tabulated by OTSI for Jul 2012 to Sep 2013. NSW Government, Sydney.

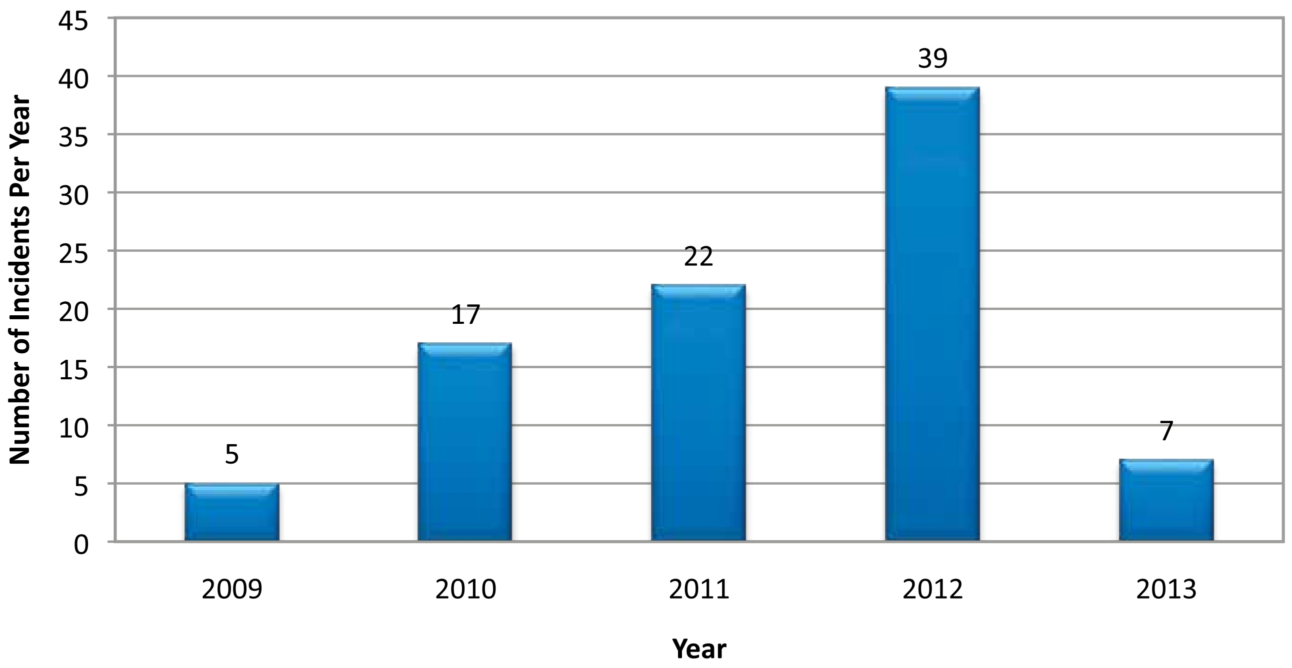
Figure 1 Industry Fire Losses Average Count by Year 2009 to 2012



Source: Hardy, 2013*

*Number of Bus Fire Claims in Australia per annum.[17] (Note: This graph shows an approximate annual increase in fires of 20%, however taking into account bus fleet growth this increase is better estimated as 15% per annum).

Figure 2 Number of Reviewed Incidents by Year 2009 to 2013

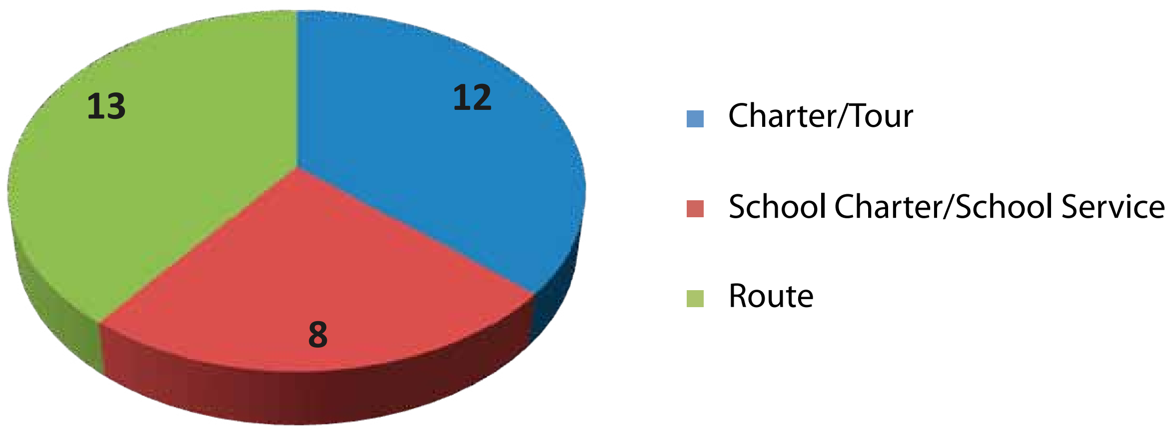


Source: Hardy, 2013*

*Number of Australian Fire Incidents Reviewed by Year.[18] (Note: these are only the incidents that were reviewed, the reported total number of incidents per annum is given in Figure 1).

17 Hardy, L, 2013 Collated Insurance Data, Bus Industry Confederation, Canberra.
18 Hardy, L, 2013, Collated Media and Published Data, Bus Industry Confederation, Canberra.

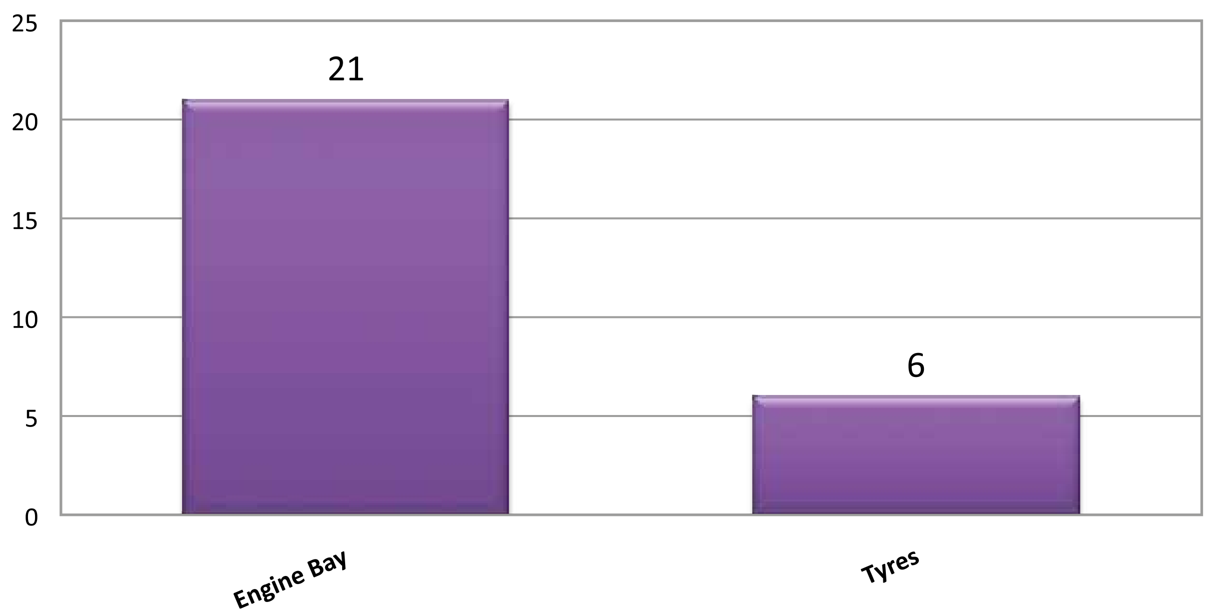
Figure 3 Service Being Operated for Review Incidents



Source: Hardy 2013*

*Reviewed Australian bus fire incidents by service type.[19] (Note: that there have been more published Charter/Tour and School Charter/School Service incidents than Route Type incidents).

Figure 4 Incidents by Type of Fire (Engine Bay and Tyres)

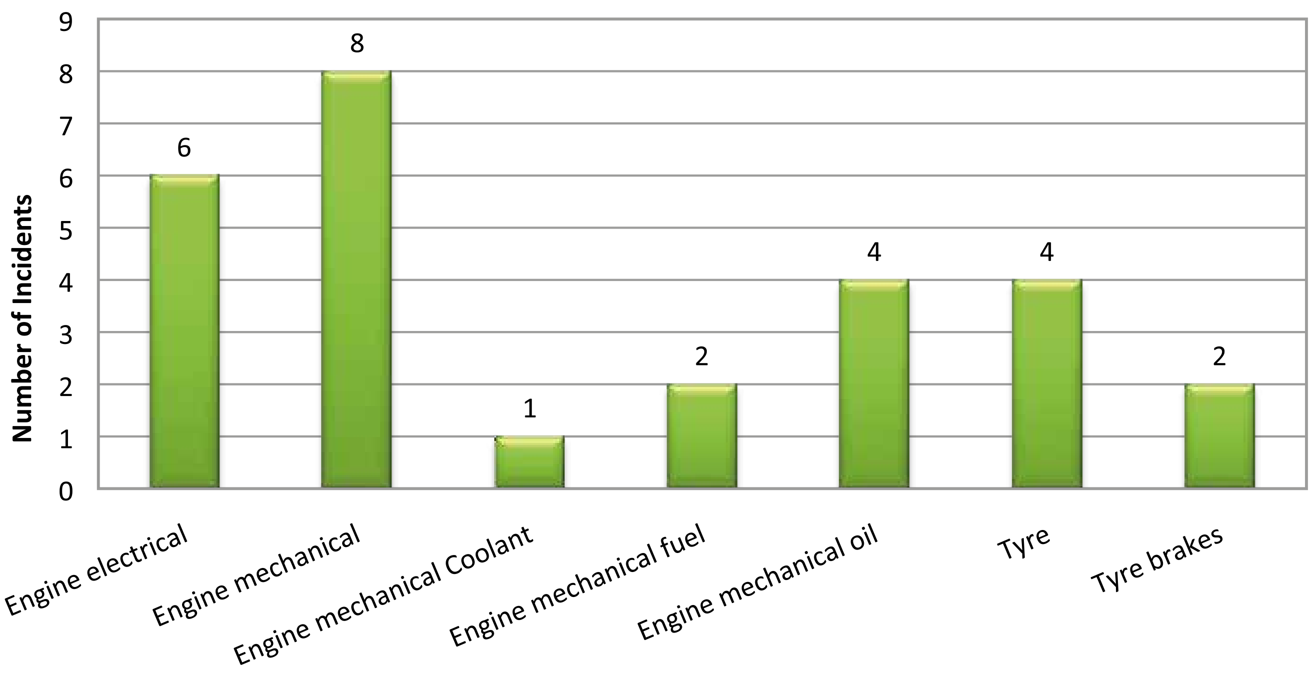


Source: Hardy 2013*

*Reviewed Australian Bus Fire Incidents by the location of the fire on the bus.[20]

19 Hardy, L, 2013, Collated Media and Published Data, Bus Industry Confederation, Canberra.
20 Ibid.,^

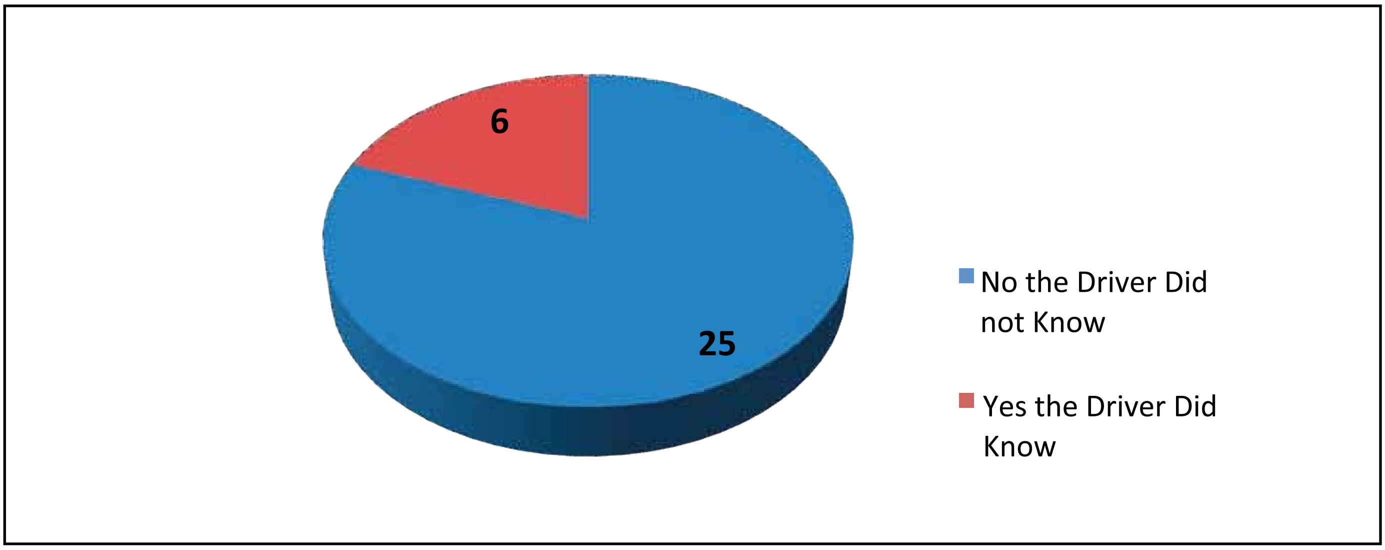
Figure 5 Incidents Reviewed by Type of Fire



Source: Hardy 2013*

*Reviewed Australian bus fire incidents by the type of fire experienced.[21]

Figure 6 Did the driver know the bus was on fire in the first instance?



Source: Hardy 2013*

*Reviewed Australian bus fire data by whether the driver knew the bus was on fire?[22]

Figure 6 shows that drivers are often not aware that a bus fire incident is occurring and are typically told of such incidents by others. This is not unexpected given that the majority of the fires start well away from the driver's position, at the rear of the bus and outside of the passenger compartment.

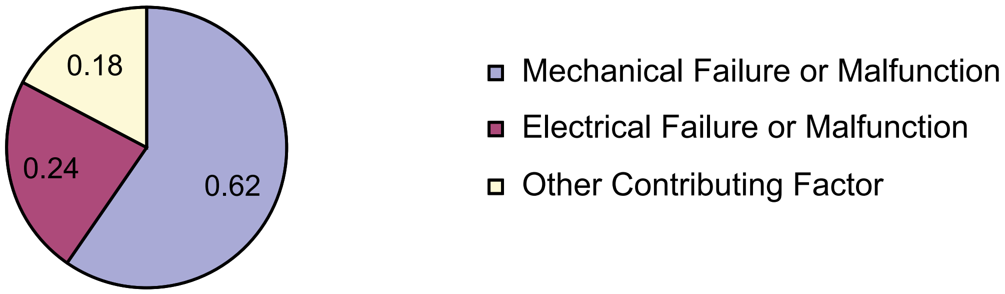
By the driver not knowing, the fires are typically allowed to propagate resulting in a full burn out of the bus. If the driver is aware, or the driver is able to respond in a timely manner, the result can be that the fire situation is addressed and the fire extinguished.[23]

21 Hardy, L, 2013, Collated Media and Published Data, Bus Industry Confederation, Canberra.

22 Ibid.,^

23 Information tabulated by OTSI for Jul 2012 to Sep 2013.

Figure 7 Causes of 2,400 US Bus Fires between 2003 and 2007[24]



Source U.S. Vehicle Fire Trends and Patterns, National Fire Protection Association Marty Ahrens 2010.

24 Ahrens, M, 2010, U.S. Vehicle Fire Trends and Patterns, National Fire Protection Association

Review of Fire on Buses International Experiences

A review of the available overseas data found that the frequency of bus fires is surprisingly high across a number of countries.

In the US two separate studies found that:

- Between 1993 and 2003 there was an average of 6 bus fires every day[25]
- Between 2003 and 2007 bus fires occurred 10 times more often than truck fires per vehicles in service.[26]

A Swedish study on bus fires found that between 1999 and 2004 there was an average of 49 bus fires reported in Norway per annum and 122 reported per annum in Sweden. This equated to buses being 5 to 10 times more likely to catch fire than trucks on a per vehicle basis. [27]

A US study in 2012 determined that bus fires were a serious and common occurrence and that a large number of bus fires were not reported, suggesting that the real numbers were much higher.[28]

The available US data from 2010 provides significant detail in regards to the causes of bus fires and it advises that:

- Between 2003 and 2007 there were 2,400 bus fires and 70% of these fires originated in the engine area, running gear or wheel area[29]
- Failure or issues with engine bay components resulted in the most frequent form of bus fire and these fires are commonly caused by mechanical component failures, fluid leaks or electrical issues. [30]

  A summary of these results is shown In Figure 7.

  OTSI has recently released their investigative report into Bus Fires in NSW[31] and have sighted additional overseas data that further supports the trends seen in the Australian data.

The relevant references from the OTSI report are given below:

> *"A review by a leading US insurance company of some 150 claims resulting from bus fires from 2007 to 2011 found that approximately 60% started in the engine compartment and approximately 20% in the wheel wells.[32] The "most typical" cause of the engine compartment fires was fuel leaks from hoses, loose fittings,*

25 Meltzer, N., Ayres, G. Truong, M., 2008, Motorcoach Fire Safety Analysis, Federal Motor Carrier Safety Administration.
26 Smyth, S. and Dillon, S. 2012. Common Causes of bus Fires, SAE International, August 2012 (2012-01-0989).
27 Johansson, E. and Yang, J., 2011, Motorcoach Flammability Project Final Report: Tire Fires – Passenger Compartment Penetration, Tenability, Mitigation, and Material Performance. Technical Note 1705
28 Ahrens, M, 2010, U.S. Vehicle Fire Trends and Patterns, National Fire Protection Association
29 Smyth, S. and Dillon, S. 2012. Common Causes of bus Fires, SAE International, August 2012 (2012-01-0989).
30 Ahrens, M, 2010, U.S. Vehicle Fire Trends and Patterns, National Fire Protection Association
31 OTSI Bus Safety Investigation Report: An Investigation into bus fires in NSW 2005-2012
32 Crescenzo, RA 2012, Bus Fires in the United States: Statistics, Causes and Prevention, Proceedings from 2nd International Conference on Fires in Vehicles – FIVE 2012, Chicago, USA, p.13.

seals and fuel lines. The next most significant cause was from electrical shorts."

"The development and effects of tyre fires have been further examined through experiments conducted by the United States National Institute of Standards and Technology (NIST). The experiments were concerned with fire penetration into the passenger compartment, fire-hardening against tyre fire penetration and fire growth within the passenger compartment. The results were published as a NIST Technical Note in 2011.37.

It was found that an established tyre fire could spread to adjacent combustible fibreglass panels within two minutes, then gain entry to the passenger compartment through broken windows above as quickly as within five minutes. A combination of environmental conditions and the nature of materials of bus construction will affect the time taken between initiation of a fire in a wheel well and its penetration into the passenger compartment."

Why Engine Bay Fires?

There are a number of reasons why engine bay fires are increasingly an issue, but two of the main reasons can be summarised as:

> Tighter Emission Standards, Euro 4, 5 and 6 which have typically resulted in:

- Higher engine operating temperatures
- Higher fuel injection and turbo charger pressures
- Greater use of high temperature catalytic converters
- And increasing loads on cooling systems (cooling fan drives etc.).

> In conjunction with the increased emission standards, the tighter noise emission limits as a result of ADR 83, has led to:

- Full engine encapsulation, hence the heat that is generated is more easily contained in the engine area
- Engines have become less accessible and hence are harder to inspect and maintain.

It is important to note that the vast majority of buses have their engines at the rear of the bus and in an engine compartment that is both sound and heat insulated. Hence the driver is much less likely to know that there is a fire issue with the bus engine as compared to a truck driver who is located either over or very near to the engine compartment. This is seen in the number of fires where the driver did not know the bus was on fire as shown in Figure 6.

Section 3

THE RISK ASSOCIATED WITH BUS FIRES

Ralf Neuman/Shutterstock.com

3 Key Fire Risk Factors

The risk associated with (or the outcome of) a bus fire varies greatly depending on a range of issues. However the main areas of risk can be categorised as:

- The bus – The degree of damage to the bus. Typically buses that experience engine bay type fires, if not addressed quickly, are either severely or totally burnt out.[33]
- The Passengers and Driver – This is paramount and luckily in Australia, in 1950, the only reported death due to a bus fire was in WA. (The media report at the time stated that one person died and the other 14 passengers exited the bus).[34]
- The Surrounding Environment – The effect the fire has on the surroundings. This issue is critical as a bus left burning on a rural highway is a totally different scenario to a bus burning in the middle of a city street or worse case, in a tunnel.

These three key areas of risk: the Bus, the Passengers and Driver and the Surrounding Environment all need to be considered when assessing the level of the fire risk of particular buses and operations.

The following sections detail the types of issues that need to be considered for each key area of risk. The process of conducting these risk assessments is discussed in Section 12 and is based on processes detailed in AS 5062—2006 Fire Protection for Mobile and Transportable Equipment, published on 8 November 2006.[35]

Fire Risk Issues for the Bus

The risk issues with the bus, or the fleet of buses, is complex and depends on a range of factors. Following is a risk profile summary of the types of issues that should be considered when assessing the bus or a fleet of buses.

- The age of the bus. Newer buses typically generate more heat and have higher fluid pressures, whereas older buses may have issues with deterioration of components such as electrical harnesses and hoses.
- The overall condition of the bus. Is the bus in good overall condition or are there issues with deterioration or hardening of electrical harnesses and fluid hoses?
- The level of maintenance. Has the bus been maintained to the required standards and manufacturers recommendations?
- Is the bus regularly cleaned and inspected?
- Is the bus easily cleaned or are there issues such as protection of electronic components that need to be considered and may reduce the effectiveness of the cleaning outcome?
- The history of the bus. Have there been any fire incidents with the type of bus?
- Is there any specific issue with the design or manufacture of the bus that either increases or decreases the likelihood of fire?
- Is there equipment on the bus that could affect the risk of fire?
- What is the condition of the engine bay insulation and encapsulation system?
- What, if any, fire mitigation systems are fitted to the bus that could reduce the likelihood and or outcome of any fire?
- Does the bus use alternative fuels or drive systems that may affect the likelihood and or outcome of any fire?
- The configuration of the bus in regards to passenger egress. Does it have one, two or more passenger doors? Is the bus a single deck or double deck bus?
- Is the bus fitted with a wheelchair ramp?
- Is the bus fitted with a wheelchair lift?

The answers to these questions affect the fire risk profile of the bus or fleet of buses. Refer Annexure C for a sample pro-forma sheet.

Fire Risk Issues for the Driver and Passengers

The safety of the driver and passengers is the main issue that needs to be considered when assessing the fire risk for a bus or fleet of buses. The following provides a summary of the types of issues that need to be considered when assessing the risk profile for the driver and passengers.

Drivers:

- Are the drivers well trained and able to react to a fire situation in the appropriate manner?
- Are regular retraining programs in place to remind drivers of the emergency response processes?
- Are the drivers allocated to the same or similar buses at all times and therefore they are more familiar with the equipment?
- Are the drivers regularly operating a different type of bus and therefore less familiar with the equipment?
- Are the drivers trained to undertake inspections?
- Are the drivers able to easily communicate with operational control staff if an incident should occur? Or is the driver operating remotely thereby the driver would need to be able to fully manage any incident?

33 Insurance Data from interviews with various Australian Insurers 2012. (See Figures 1-4 for results)
34 The West Australian, Monday 10 April 1950
35 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment.

Passengers:

- Are the passengers fully abled and capable of exiting the bus in a timely manner?
- Are the passengers aged or mobility impaired so that they need extra time and assistance to exit the bus?
- Are there passengers that require the use of wheel chair ramps or wheel chair lifts?
- Are the passengers likely to be asleep or otherwise incapacitated for extended periods thereby their judgment may initially be impaired should an incident occur?
- Will the passengers be able to understand clear directions from the driver?
- Will the passengers be able to read and understand any emergency signage in the bus?

Fire Risk Issues for the Environment

The risk issues associated with the environment in which the bus is operating are also complex and are dependent on a range of factors. The following provides a summary of the types of issues that need to be considered when assessing the environment risk profile of bus operations.

Operating Environment:

> The type of services provided:

1. Local Route Services – Lower speed, stop start and higher density type services where buses are exposed to heavy duty load cycles that put increased strain on cooling systems, fuel lines, air systems and air-conditioning units and also due to extended idle times, high engine bay temperatures.
2. Dedicated School Services – Varying speed operations that can expose the bus to a wide range of operating conditions.
3. Charter Services local – Varying speeds that can expose the bus to a wide range of operating conditions.
4. Charter Services long distance – High speed operations where tyre and wheel type issues are more likely and also passengers that could be sleeping and or slow to exit a bus if an issue occurs.

> Traffic densities — low, medium or high?

> Route accessibility, close congested roads or open and accessible roads.

> Operating speeds low and heavy duty or high speed and lighter duty operations.

> Are bus routes operating in and around high rise buildings?

> Are bus routes operating in tunnels and what are the configurations of the tunnels — short and open or longer and more enclosed?

> Is the bus operating on bus only routes or in mixed traffic?

> Is the bus operating on all sealed roads and therefore is dust and dirt build-up an issue?

> Is the bus operating on dirt roads or a combination thereof, therefore is dust and build-up an issue?

A bus fire in an urban environment has a different set of risks compared to a bus fire in a rural environment.

a katz/Shutterstock.com

Lindsay Basson/Shutterstock.com

Table 1 Statistics for recorded Vehicular Tunnel Fires Between 2000 and 2010[36]

Statistic	All Recorded Vehicular Fires in Tunnels between 2000 and 2012	Fires in Tunnels involving buses between 2000 and 2012	Fires in Tunnels no bus involvement between 2000 and 2012	Percentage involving buses
Number Fires Incidents for Period	26	8	18	31%
Injures from fires during this Period	138	34	104	25%
Deaths from fires during this period	85	53	32	62%

Bus Tunnel Fires

The specific issue of tunnels need to be assessed carefully in any risk assessment of the operating environment.

A bus fire in a tunnel is seen as potentially the most devastating of the possible bus fire scenarios. A modelling study undertaken in 2007 by the CSIRO on Road Tunnel Fire and Life Safety Issues considered a bus fire in a road tunnel and one of the findings in relation to the bus fires was that:

> *"The people in the immediate upstream section of the fire will not have sufficient time to evacuate and will be at risk of losing their lives. The first 120 m between exits, as shown previously, has about 100 people. Just using this section, one single accident involving a moderate fire will result with an expected death of at least 100 people."*[37]

Bus fires in tunnels do occur and a study by the Transportation Research Board Washington, DC in 2011, provided data for 26 road tunnel fires that occurred between 2000 and 2010.[38] This data is summarised in Table 1, and the key results are that:

- Of the 26 incidents, 8 (32%) of the fires involved buses
- The 8 incidents that involved buses, accounted for only 25% of the injuries
- But the 8 fires that involved buses alarmingly accounted for 62% of the deaths.

The higher percentage of deaths for fires involving buses can partly be attributed to the time required to evacuate the burning bus. A further finding from the above mentioned US study found in regard to the time required to evacuate the bus that:

> *"It is especially important when considering evacuation from a bus. A German study, Fire Protection in Vehicles and Tunnels for Public Transport*[39] *cites 2 min as the maximum period of time acceptable for evacuating a bus. Other studies report that 3 min is the expected time to fully empty a loaded transit bus."*

The above issues should be considered when assessing a vehicles risk profile.

36 Transportation Research Board of the National Academies. 2011, NCHRP SYNTHESIS 415, Design Fires in Road Tunnels: A Synthesis of Highway Practice, Washington, D.C.

37 Liu, Y., et al, 2007, Road Tunnel Fire and Life Safety Issues, Fire Science and Technology Laboratory CSIRO, Manufacturing and Infrastructure Technology.

38 Transportation Research Board of the National Academies. 2011, NCHRP SYNTHESIS 415, Design Fires in Road Tunnels: A Synthesis of Highway Practice, Washington, D.C.

39 Verband Deutscher, V. 2005. Fire Protection in Vehicles and Tunnels for Public Transport, VDV-Forderkreis, ISBN 3-87094-664-4 Dusseldorf, Germany, pp. 503.

Section 4

THE RISK ASSESSMENT PROCESS


Ralf Neuman/Shutterstock.com

Overview

There are an extensive range of risk assessment processes and procedures that could be employed to assess the fire risk for a bus or fleet of buses. Companies that are involved in the design, manufacture, supply or operation of buses should have an in-house Fire Risk Assessment Process that could be used to identify and assess the risks.

When to Conduct Fire Risk Assessments and Design Reviews

A Fire Risk Management Process is the systematic application of management policies, procedures and practices to identify, analyse, control, monitor and review fire risks at all phases of the equipment life. Any such Fire Risk Management Process needs to consider the risk of bus fires over the complete life cycle of the bus.

The key phases in the life cycle of the bus are in Table 2, along with the recommended type of risk assessment or review that needs to occur during each of the separate phases including parties that need to be involved with these assessments or reviews.

At each of the phases, consideration should be given to the outcome of fire mitigation which means that all parties are involved in this process — the purchaser, the designers, the suppliers and manufacturers, the operators and the maintainers — all of whom should have suitable fire risk management and review processes in place.

The risk assessment process should be carried out by personnel competent in risk assessment. Consultation regarding the fire hazards identified and risk reduction methods taken should be undertaken with at least three parties, including equipment operators and maintainers or experts in the field.

It should be noted that the concept of Type Approval (ie. a specific body and chassis combination or a specific vehicle design) in the above risk assessment process is encouraged. Once a design combination of body and chassis or a specific vehicle design is reviewed, the subsequent products of this type could follow the original assessment outcomes.

Fire Risk Assessments

A Fire Risk Assessment, which is the process of assessing the fire risk, should be part of a structured management process.

The required outcome of any fire risk assessment is that:

1. All potential Fire Hazards are identified.
2. Each identified Fire Hazard is then assessed for risk using the Fire Risk Assessment Process.
3. Each identified Fire Hazard is then prioritised based on the assessed risk.

This process is detailed as follows in the following three steps:

> Step 1: Fire Hazard Identification — Determine the possible fire scenarios for each identified fire hazard noting that a fire hazard exists where there is the potential for the interaction of fuel sources, oxygen and ignition sources to combine to form a Fire Triangle.

- What could happen?
- When and where can it happen?
- Why and how can it happen?

> Step 2: Fire Risk Assessment Process — Quantify the risk exposure by determining the likelihood and consequence of the fire scenarios for each Fire Hazard Identified.

- How likely is this to happen?
- What are the consequences if it does occur?

> Step 3: Fire Risk Prioritisation — Prioritise the fire risk

- What risk needs to be addressed first?
- What risks are the most significant?
- What potential risks are considered acceptable?

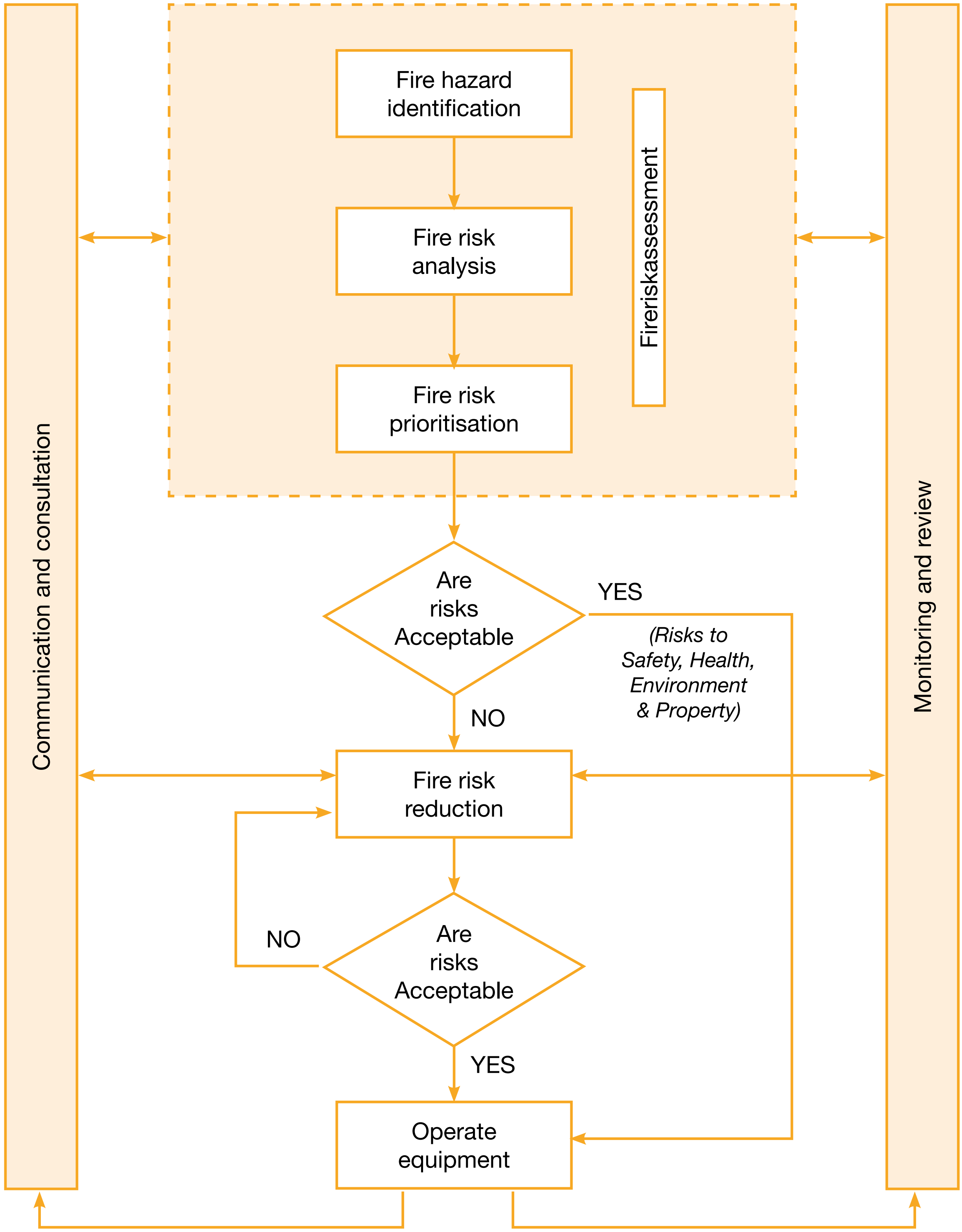
The above process is shown in a common Fire Risk Assessment Process in Figure 8.

Key inputs into the Fire Risk Assessment Process are the causes and/or findings from previous bus fire incidents. As explained within this Advisory accurate records of bus fire incidents and history in Australia are not extensive, but with international data, do provide a good insight into the most common causes and impacts of bus fires that can assist with Fire Risk Assessment processes.

Table 2 Bus Life Phases and the related Fire Risk Assessments and or Design Reviews

Phase of Bus Life	Action Required	Process Undertaken	Parties Involved
The development of a suitable contract for the purchase of the bus or buses, this contract should include the configuration, specification and options required.	The purchase specification should include the minimum standards as subscribed in ADR's and Australian Standards and also detail any additional Fire Protection Systems. A specification could require that it be in accordance with the minimum basic standards of this Advisory, and/or in accordance with the appropriate intermediate or advanced system recommendations as they are specified.	Risk Assessment	Owner (or if separate the Purchaser, Operator and Funder).
The Design of the bus or buses.	The design, and associated materials, must be reviewed to ensure that the bus is suitably fire resistant for its intended use and that the minimum basic standards required by this advisory must be met in product design.	Engineering Review to confirm compliance.	Designers, Manufacturers and Suppliers.
Manufacture and commissioning.	To ensure that the manufactured bus meets the design established via step B.	Review of final product to confirm that the specifications and the design requirements have been met.	Designers, Manufacturers and Suppliers.
Operation of the bus.	To ensure that the bus is being operated in an environment as intended and that appropriate training and procedures are in place.	Assessment and review to confirm appropriate processes and outcomes are in place.	Owner and Operator. (Manufacturer input is provided by operational and maintenance documentation).
Maintenance, including breakdown, planned and preventive maintenance.	To ensure that the bus is being maintained in accordance with the manufacturers recommendations and fire risk profile.	Risk Assessment	Owner and Operator. (Manufacturer input via operational and maintenance documentation).
When conducting any modification or updates.	To Ensure that any modifications or updates do not increase the fire risk.	Risk Assessment	Owner and Operator. (Manufacturer input via operational and maintenance documentation).

Figure 8 Fire Risk Assessment Process[40]



40 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment.

As shown in Figure 8, if the fire hazard identified is assessed as providing an acceptable risk, then the bus can be operated, if the risk is not considered to be acceptable, then further fire risk reduction methods need to be employed.

Fire Hazard Identification

To exist, a fire requires three basic components – fuel, air and heat and these three components then need to form a Fire Triangle as shown in Figure 9. To control a fire, or reduce the potential risk of fire, at least one of the three components must be removed.[41]

Figure 9 The Fire Triangle

A Fire Hazard exists where there is the potential for the interaction of fuel sources, oxygen and ignition sources to combine to form a Fire Triangle. These areas are considered to be Fire Hazards and should be assessed using the Fire Hazard identification and Fire Risk Assessment Process. A more detailed description of the Assessment Process is given in Figure 10.[42]

Consideration should be given to whether the properties of materials can change over time or with use, as the bus ages and items potentially deteriorate. Such changes may include the possibility of deterioration of the materials or items such as electrical harnesses and or hoses, resulting in an increased fire risk.

Fuel Sources

The first thing to look for when locating the fire hazards is to locate all potential fuel sources. When determining the location of all potential fire hazards, the first issue is to identify all fuel sources and then to categorise these fuel sources. The types of fuel sources that should be considered are:

Primary Fuel Sources such as:

- Flammable liquid fuels such as diesel or other liquid fuels
- Flammable lubricants like engine oils, hydraulic oils or greases
- Flammable liquids such as coolants that contain ethylene glycol
- Flammable gases such as refrigerant air-conditioning gases.

Secondary Fuel Sources such as:

- Dirt build-up which could contain or be contaminated with Primary Fuel sources such as oil and grease
- Surrounding materials such as engine bay insulation that may be deteriorated, damaged or contaminated
- Flammable materials such as electrical harnesses and shrouding.

Once identified, the properties of the fuel sources should be considered based on properties of the Fuel Sources such as:

- Ignitability
- Flammability
- Combustibility
- Quantity and continuity of supply
- Toxicity and combustion products
- Environmental impact of fire emissions.

Even though a fuel source is identified, there still needs to be an oxidiser and ignition or heat source to turn a fuel source into a fire, that is to complete the Fire Triangle.

Fire Oxygen or Oxidizers

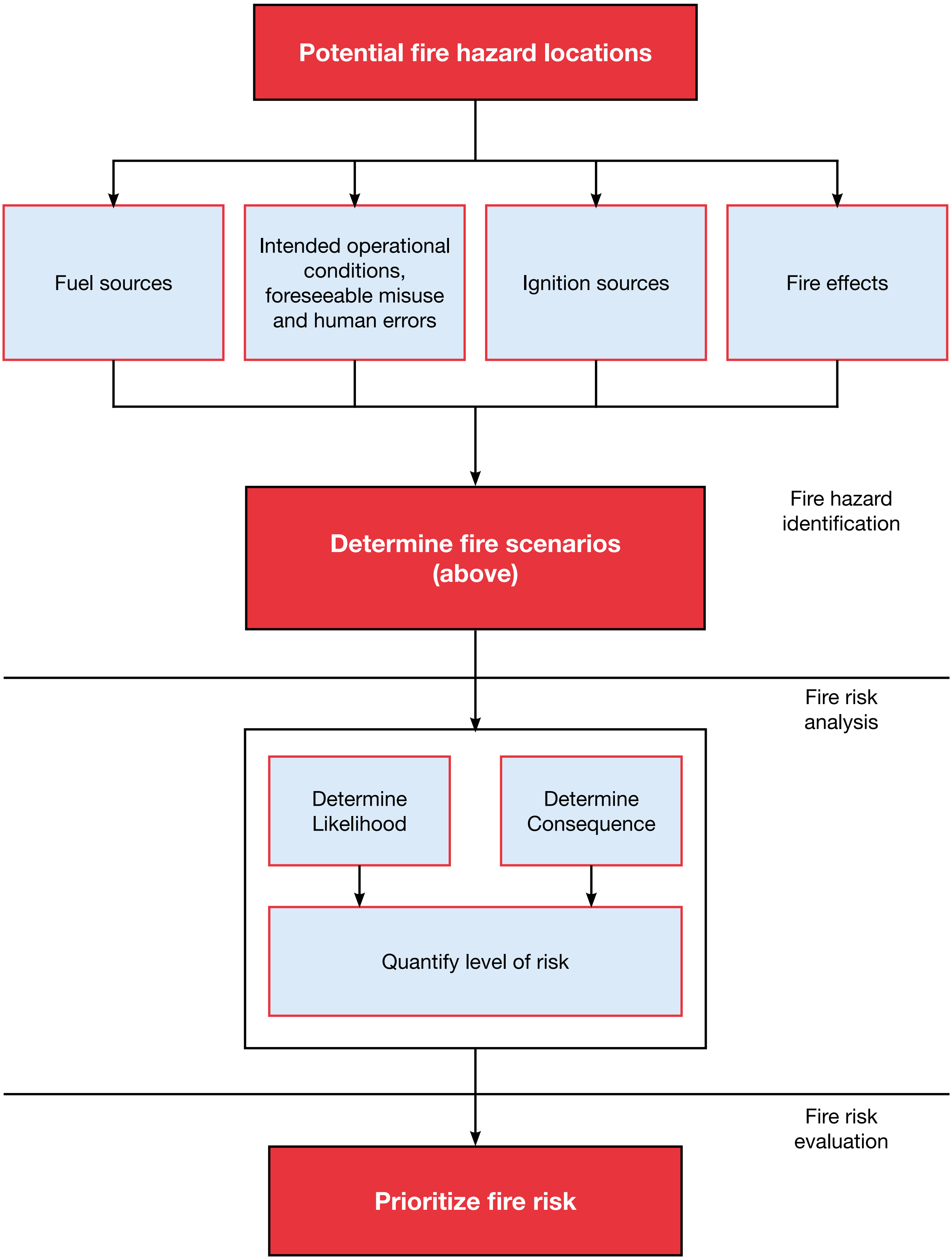
When assessing the fire hazard related to an identified fuel source, the existence and quantity of fire supporting substances and the probability of their occurrence should be determined. In the bus environment the obvious oxygen source is in the air itself and the highest concentration of oxygen is likely to come from leaking high pressure air lines or air storage tanks. A potential scenario maybe that a fire starts and a high pressure airline is then heat damaged and this leaks and provides increased levels of oxygen to a fire.

The most common chemical oxidiser is air, however other oxidizers that could support combustion such as ammonium nitrate should be identified. AdBlue or Urea also contain ammonium nitrate, but AdBlue is not listed as a hazardous substance according to several safety data sheets that were reviewed.[43]

41 http://www.csiro.au/Outcomes/Safeguarding-Australia/FireTriangle.aspx
42 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment.

43 Safety Data Sheet, Air1® pdf and AdBlue® Product safety information sheet according to Regulation (EC) No. 1907/2006, Article 32 Aqueous Urea Solution.

Figure 10 Fire Hazard Identification[44]



44 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment. page 14.

Fire Ignition or Heat Sources

Having identified the fuel sources and also determined that these fuel sources have access to an oxidiser, the third question to be answered is are there heat or ignition sources that could cause a fire?

Fire Ignition Sources

The types of ignition sources that exist in a bus are, but not limited to the following:

- **Heat energy** — for example, high temperatures and hot surfaces
- **Electrical energy** — for example, switch gear, motors, retarders, batteries, lights, cables, short circuit and electric arc, earth or conductor fault, discharge of static electricity, loose contact and induction heating
- **Mechanical energy** – for example friction, dragging brakes, overheating, or failed tyres.

Potential Areas of Fire Ignition Sources

The particular locations that can ignite a fire within a typical bus are considered to be, but not limited to, the following:

- Turbo chargers
- Fuel systems, including piping, hoses, pumps valving and injectors in close proximity to ignition sources
- Cooling system, including coolant lines, engine and transmission
- Exhaust systems
- Hydraulics systems, including piping, hoses, pump and valving
- Lubrication systems, including engine and transmission systems and grease systems
- Braking systems, including retarders and service brakes
- Electrical systems, including alternators, batteries, wiring and electrical panels
- Locations where combustible materials can accumulate, for example, belly plate's, engine valleys and wheel arches
- Tyres
- Potential fire hazard locations may be remote from the fuel or ignition source, for example, a liquid, a fuel, oil or coolant, can spray or drip onto a hot surface remote from the leak point
- An electrical short can carry heat to another area of the equipment.

Therefore any area on the bus that is assessed as being able to create a Fire Triangle, that is the potential interaction of fuel sources, oxygen and ignition sources, should be rated for risk and the areas of potential should be addressed by a Fire Hazard Reduction process which should focus on eliminating or reducing the fire risk via a reduction hierarchy.

Fire Hazard Reduction Hierarchy

Any identified Fire Hazard should set a fire risk reduction hierarchy as follows:

- Fire risk reduction should be achieved by design and or engineering measures, in conjunction with effective operational and maintenances practices that eliminate or minimize the fire hazards
- Design can only go so far to address the risk of fire; the other issues that affect the fire risk such as the operating environment, staff training and maintenance also affect the outcome
- A risk elimination or reduction hierarchy should be followed until the risk is reduced to an acceptable level
- The preferred hierarchy for risk reduction measures is set out in Figure 11. It shows the order of reduction measures for the preferred option to the least desirable option
- The residual risk after the use of controls, safeguards or fire protection measures shall be documented.

Figure 11 Fire Risk Reduction Measures

1st Elimination by design

↓

2nd Minimisation by design

↓

3rd Use of appropriate engineered safeguards

↓

4th Use of administrative controls e.g. safe work practices

↓

5th Use of appropriate fire protection measures

The Risk reduction measures should then be considered at each level of the hierarchy in accordance with Figure 12.

Fire Risk Assessment Summary

In summary, the Fire Risk Assessment Process needs to consider and deal with the three key risk areas of:

- The passengers and the driver
- The bus
- The surrounding environment

Each risk area has an associated range of issues that can and do affect the overall risk profile for either an individual bus or fleet of buses.

It is recommended that appropriate risk assessments and/or design reviews, are undertaken and all the relevant parties are involved; the bus designers, suppliers and manufacturers, operators and maintainers.

The key phases of the buses life that need to be considered are:

- The development of a suitable contract for the purchase of the bus
- Design of the bus
- Manufacture and commissioning
- Operation of the bus
- Maintenance, including breakdown, planned and preventive maintenance
- When conducting any modification or updates.

The Fire Risk Assessment Process needs to identify areas within the bus where the three parts of the fire triangle can exist; where there is the potential interaction of fuel sources, oxygen and ignition sources that could cause a fire. These locations are known as an identified Fire Hazard.

Each identified Fire Hazard needs to be:

- Assessed — in terms of risk exposure by determining the likelihood and consequence of a fire occurring
- Prioritised — Fire Hazards identified as being unacceptably high need to be treated by employing fire reduction measures. These fire reduction measures are discussed in detail in the following sections.

A set of Bus Generic Fire Risk Assessment Forms are provided in Annexure C of this Advisory. The Forms are generic and are intended to be used as a basis for conducting Fire Risk Assessments. However due to the high number of variables involved in any assessment, users should develop forms that suit their respective bus configuration and intended operational environment and ensure compatibility with their risk management processes.

Nataliya Hora/Shutterstock.com

Figure 12 Hierarchy of Reduction Measures

HIERARCHY OF

FIRE PREVENTION AND MITIGATION MEASURES

1. DESIGN

- Compartmentation
- Suitable materials
- Segregation
- Remote operation of equipment
- Segregation of hydraulics and electrics
- Electrical protection
- Non-flammable or non-combustible
- lubrication oils and hydraulic fluids
- Reducing temperature of hot surfaces
- Brake temperatures
- Turbo chargers
- Operator warning systems
- Cable routing
- Fire resistant hosing
- Ensure compliance to Bodybuilder Directives as supplied by the
- Chassis suppliers.

2. SAFEGUARDS

- Shields
- Emergency stops
- Escape routes

3. ADMINISTRATIVE CONTROLS

- Maintenance
- Housekeeping
- Competent people
- Safe work procedures
- Regulations
- Audits
- Driver Training

REDUCTION MEASURES

FIRE PROTECTION MEASURES

4. FIRE PROTECTION EQUIPMENT

- Hand-held
- Extinguishers
- Fire detection system
- Manually operated fire suppression system
- Fire detection

5. SITE FACILITIES

- Site standards
- Regulations
- Alarm plans
- Pre-determined fire plans
- Fire safety officers
- Trained personnel

6. PUBLIC FACILITIES

- Fire brigade
- Fire extinguishing agent
- Proximity to site

Section 5

REDUCING THE RISK OF FIRE

Reducing the Risk of Fire — Overview

The Fire Risk Assessment Process will identify the potential Fire Hazards that need to be addressed. To address these hazards, some form of fire risk reduction or remedy will need to occur.

Any remedies, or risk reduction measures, should follow a hierarchy of measures as described in Figure 11. All of these measures are of equal importance and the best designed and manufactured bus can be let down by poor maintenance, or alternatively, the best maintained bus can still be an issue due to poor design and/or materials selection.

In bus terms, these measures can be summarised into four key elements using the following hierarchy:

> 1ST Element — Elimination and or minimisation by design, compliance to relevant standards and use of appropriate construction methods and materials. Inclusion of passive types of systems built into the bus such as fire barriers.

> 2nd Element — Use of appropriate engineering safeguards such as fire control systems, alarms and in higher risk situations active Fire Protection Systems.

> 3rd Element — Use of appropriate and ongoing protection measures, such as correct maintenance processes and procedures, bus cleaning and ongoing review.

> 4th Element — Use of administrative controls such as driver training and emergency response procedures and practices.

The following sections in this Advisory are arranged in the same sequence as the hierarchy listed above. It needs to be clearly understood that if any one of the four stages fail, then a fire can occur. The best specified and designed bus can still fail if not correctly maintained, whereas a lesser design or quality bus may still have a low fire risk profile given good quality and ongoing maintenance. It also needs to be remembered that to occur, fire requires the three key elements of heat, air and fuel.

First Element – Specifications, Standards and Design

One of the intended outcomes of this Advisory was to develop a set of recommended performance based specifications and standards for each level of fire risk identified. The recommended performance based standards were established as a result of the research, feedback, committee consultation and industry input provided during the development of this Advisory.

The recommendations and standards are intended as guidelines for bus manufacturers, suppliers, bus purchasers and ultimately bus operators to consider in relation to the buses that they manufacture, supply, purchase or operate.

The development of these specifications and standards was based on the following:

- A review of both the local and international regulations in the area of fire mitigation on buses. Where practicable these regulations have been used and referenced where appropriate
- A review of available Australian and International data on bus fires, to confirm fire rates, common causes and associated risks
- A review of existing bus body and chassis designs to establish what fire worthiness features have been employed in terms of fire resistant designs and the use of non-combustible materials, insulation or fire barriers and active systems such as alarms, fire extinguishers, fire extinguishing systems, automatic fuel & battery isolators
- Analysis of Maintenance and Operational Procedures to help ensure that the specifications and standards developed would comply with and support the procedures used. This helped develop a third category of system referred to as Bus Support Systems which are discussed within this Advisory.

The intent of these specifications and standards is to help address the established causes and reduce the rate and ultimate impact of any fire. The principals used to construct these specifications and standards are discussed in the following sections.

It should be noted that the ADR's provide some regulation in regard to bus fire mitigation requirements and there are a number of Australian Standards that provide details for a range of fire mitigation practices and processes.

There are also relevant United Nations Economic Commission for Europe (UNECE EU) standards plus United States based specifications and codes that provide additional details in relation to fire mitigation and where practicable these international standards and codes have been used as a reference and data source.

Fire Mitigation Principals – Passive and Active Systems

To help reduce the risk of fire and to mitigate as much as practicable any adverse outcomes should a fire occur, the following principals have been considered in the development of the recommended performance based specifications.

The three basic types of systems considered are:

- Bus Support Systems
- On-bus Passive Fire Protection Systems
- On-bus Active Fire Protection Systems

Bus Support Systems are systems that are put in place to support the bus or fleet of buses to either minimise the possibility of a fire occurring, and then should a fire occur, minimise any adverse effects of the fire. Bus Support Systems can include maintenance standards and practices, appropriate cleaning programs, driver training and the use of appropriate emergency response procedures.

On-bus Passive Fire Protection Systems

On-bus Passive Fire Protection Systems are systems intended to minimise the risk of a fire occurring and if a fire should occur, to minimise the impacts or adverse outcomes of any fire. These systems form part of the bus structure and or mechanical layout. These systems are not required to be activated in any way. Examples of passive systems include a thermal barrier between the engine bay and the passenger compartment or a cooling system that is designed so that the likely leak points are not located over potential heat or ignition sources.

On-bus Active Fire Protection Systems

On-bus Active Fire Protection Systems are systems that are either activated by the driver or are automatically activated should a fire occur and are meant to minimise the effects of any potential fire. Examples of active systems include a portable fire extinguisher or a driver activated battery isolation switch.

Active Fire Protection Systems are seen to be the types of systems that can be employed in situations where either the risk assessment process has been determined, or the operator has decided, that the bus or bus fleet falls into a higher risk profile and hence the additional protection that is offered by the use of active systems, is warranted.

The level of protection starts with proper operational and maintenance practices that support the buses, including the use of passive or in-built systems that are intended to make the buses more resistant to fire. The level of protection can then be increased via the use of active systems such as alarms, and Fire Protection Systems such as additional fire extinguishers, through to fully automatic integrated Fire Protection Systems in areas like the engine bay and battery compartment.

These various options of Fire Protection Systems are discussed in the following sections.

Example of an On-bus Passive System – Floor hatches that are well secured and sealed to help contain any potential engine bay fire.

Example of an On-bus Active System – An engine bay Fire Protection System in the form of a remote activated fire extinguisher with a fixed distribution system.

Review of Current Australian and International Standards

A review of the current applicable Australian and International automotive standards was undertaken specifically in regards to fire protection measures to be used on buses. This review was intended to allow the appropriate standards or codes to be referenced in this Advisory wherever possible and appropriate.

Review of Current Australian Standards

This section outlines the Australian Standards and Australian Design Rules and International standards that relate to Fire systems and/or fire protection on buses.

Australian Standards

- **AS 2444—2001** Portable fire extinguishers and fire blankets—Selection and location Sixth edition 2001
- **AS/NZS 1850:2009** Portable fire extinguishers — Classification, Rating and Performance Testing
- **AS 1851—2005** (Incorporating Amendment Nos 1 and 2) Maintenance of Fire Protection Systems and Equipment 5 September 2005
- **AS 5062—2006** Fire protection for mobile and transportable equipment published 8 November 2006.

Australian Design Rules

A review of the ADR's has shown that the only reference to fire retardation is in Vehicle Standard Australian Design Rule 58/00 – Requirements for Omnibuses Designed for Hire and Reward 2006 specifically Clause 17 of ADR 58/00 which states "that interior linings not be readily flammable."

The ADR's do not set standards for fire resistance of bus body materials or interior linings and as such this Advisory has referenced appropriate Australian Standards and or codes, as listed above, and relevant international regulations.

International Regulation

The closest to a specification relating to flammability of interior materials, bus components and alarms is in the UNECE Regulation No.118. UNECE Regulation No. 107 provides some detail in regards to isolation of the engine and passenger compartment as well as requirements for fire alarm systems.

There are a number of US based regulations, codes and technical reports that deal with bus fire causation and mitigation, and these have been referenced in the following sections as required. Noting that the American Public Transportation Association (APTA) produced a paper titled *Recommended Practice for Installation of Transit Vehicle Fire Protection Systems 2008*[45] and this document is referenced in Appendix 7.

Design and Implementation of Safety Systems

The design and function of the following systems, especially the On-bus Active Fire Protection Systems, need to be designed so that the systems are fail-safe.

Regardless of what is occurring on the bus, the respective systems need to operate when activated and be so designed as to not create further or potential safety issues (either automatically or when operated by the driver). For example, a fire system that isolates power to the bus should not also isolate the park brake alarm unless the park brake is applied.

Herein lies an issue of function and complexity as opposed to ease of use and reliance on the driver's actions. The more automated a system is made, the easier it can be to be operated by the driver but this normally increases the complexity of the system. As stated above, when designing automatically operated systems there needs to be careful consideration given so that the driver remains in reasonable control of the bus at all times.

The developed set of recommended performance based specifications and standards are not intended to dictate to designers and/or manufacturers the level of automation or manual intervention used in active systems, more so that consideration is given to the effects of any such system on other aspects of the bus.

As stated previously, the specification, design, materials used and final configuration of any bus should be based on the Risk Assessment Process (see Section 4).

On-bus Passive Fire Protection Systems

Passive systems are systems built into the bus to either reduce the risk of a fire ignition, and if a fire occurs, reduce the effects..

45 American Public Transport Association, 2009, Recommended Practice for Installation of Transit Vehicle Fire Protection Systems, APTA Document Number BTS-BS-RP-003-08.

The potential passive systems that could be employed are segregated into their respective location on the bus and are outlined in the following sections.

The detailed recommended specifications for each of the following On-bus Passive Systems is given in Annexure A.

Engine and Battery Compartment Passive Systems

The types of passive systems that can be employed in the engine compartment include:

- The provision of a partition of heat-resisting material fitted between the engine and passenger compartment to help contain any potential fire
- Ensuring that any floor hatches or maintenance access areas provide suitable thermal protection
- Reducing the engine compartment temperatures via the shielding of key heat generators
- Providing appropriate engine bay ventilation so that the hot areas within the compartment are suitably cooled
- Ensuring that the materials used in the engine bay do not absorb fuel, or are suitably protected from, oils or other flammable materials
- Ensuing that the accumulation and/or retention of fuel, lubricants, vapours or gases in the engine compartment is prevented by suitable layouts and the provision of drainage orifices
- Ensuring that there is adequate ventilation of battery enclosures.

Reducing the Potential Outcome of Component Failure Passive Systems

The types of passive systems that can be employed to reduce the potential outcome of a mechanical or electrical failure include:

- Taking care to locate, where practical, coolant lines so that should a leak occur, the coolant does not fall into excessively hot surfaces
- Where the climatic conditions permit (such as tropical environments), consider using non-glycol type of coolants for higher risk operations is recommended to reduce the fire risks from glycol leaks
- Running electrical harnesses, where practical, so that they are as much as practicable away from excessive heat and/or potential mechanical damage
- The use of an appropriate and correctly rated electrical protection device for all electrical circuits, for example, circuit breakers, fuses, and other current limiting devices. Running hydraulic hoses and lines so that they are as much as practicable away from excessive heat and/or potential mechanical damage that could cause leakage

- Using hydraulic lines and hoses that comply fully with all relevant standards and codes and also used in accordance with the chassis and hydraulic suppliers recommendations
- Use of bulkhead fittings, or other methods of isolation and protection, where electrical and or hydraulic conduits penetrate enclosures or partitions
- Arrangement of electrical harnesses and hydraulic lines so as to facilitate regular visual inspections as much as is practical
- Mount electrical harnesses and hydraulic lines so as to minimise the potential for fatigue-related fractures through improved bracketing methods for cabling and hose routing
- Any such layouts and arrangements should also consider the potential for physical damage to services during maintenance work.

Maintenance Access and Cleaning Ability

The correct and regular cleaning of the bus is seen as critical in reducing the fire risk, and therefore the types of passive systems that can be employed to allow the bus to be accessed and cleaned in a suitable manner include:

- Appropriate maintenance access is provided to ensure that maintenance staff can easily inspect and repair all sections of the engine and drivetrain system[46]
- The engine compartment and battery compartment are designed and constructed so that they can be easily cleaned and not damaged by appropriate high pressure hot water cleaning over time
- Manufacturers and suppliers to always provide cleaning procedures for critical areas such as the engine and battery compartments
- As stated in the US TCRP Synthesis 12 Transit bus Service and Cleaning Functions report:

  Engine Cleaning

  "All survey respondents clean their engines on a regular basis as part of their regularly scheduled service inspections. A clean engine helps with the visual inspection process and allows mechanics to access components more easily (and cleanly). Pressurized steam is the preferred engine cleaning method."[47]

- Ensure engines components are of sufficient robustness that they will not be damaged when subjected to appropriate and suitable cleaning methods
- Manufacturers to provide owners and operators with practical cleaning instructions and recommendations and these in turn need to be followed by the parties conducting the cleaning.

Passenger Compartment

The types of passive systems that can be employed in the passenger compartment include:

- The use of fire-retardant and low-smoke materials within the passenger area[48]
- The provision of suitable and ADR[49] compliant emergency exits for both the driver and passengers
- The provision of suitable and ADR[50] compliant emergency exit signage that clearly advises both the passengers and the driver of where the emergency exits are located and how they are to be used.

Detailed specifications for these recommended On-bus Passive systems are given in Annexure A.

46 These types of clauses are used in a number of bus supply tenders and access is also specified by chassis suppliers

47 TCRP, Synthesis 12: Transit bus Service and Cleaning Functions, pp.19

48 American Public Transport Association, 2010, Standard Bus Procurement Guidelines RFP, Washington, DC.

49 ADR 44/00 and 58/00.

50 ADR 44/00 and 58/00.

Second Element — On-Bus Active Fire Protection Systems

On-bus Active Systems are either manual or automatic systems that are activated should a fire occur to reduce the impact of fire. The potential active systems that could be employed are segregated into their respective locations on the bus.

Drivers need to be appropriately trained in the operation of any active type of system so they can undertake the role of a fire warden should an incident take place.

Detailed recommended specifications for each of the following On-bus Active Systems is provided in Annexure B.

Driver Activated Systems

The types of active systems that could be employed to reduce the potential adverse outcome of a fire include:

- Fire warning systems or alarms to notify the driver of a fire or overheat situation in the engine compartment and other enclosed areas such as the luggage bay and if fitted, the toilet
- To isolate the power on the bus should a fire occur, the inclusion of driver activated or a remote activated battery isolation switch or similar system
- A system to monitor rear tyre pressures for high speed bus operations and to advise the driver if a tyre failure has occurred
- The use of appropriately sized fire extinguishers which are fully accessible to the driver and in accordance with the ADR's[51]
- The inclusion of additional or larger portable fire extinguishers
- For higher risk buses and or operating environments, the use of either driver activated or fully automatic Fire Protection System fitted to the engine bay
- Either driver activated (or automatically activated) isolation of the fuel supply lines or fuel tank feed lines.

Passenger Compartment Active Systems

The types of active systems that can be employed in the passenger compartment include:

- Passenger warning systems which could be audible, visual or both
- Driver operated or automatically operated and linked to the fire alarm system
- Systems that allow the passengers to easily exit the bus, such as the doors opening once a fire has been detected (and the bus is stationary and secured).

Grades of Active Fire Protection Systems

The grades of Fire Protection Systems proposed in this Advisory are based on a set of recommendations that have been grouped into three broad categories:

> Level 1 — Basic Level — incorporates a range of recommendations that should be employed to help make buses and bus fleet fire safe.

> Level 2 — Intermediate Level — adds to the basic system but includes a range of active fire protection alarms and manually operated systems that are intended to provide the bus or bus fleet with a higher level of protection.

> Level 3 — Advanced Level — adds to the Basic and Intermediate systems, but incorporates a range of automatically activated Fire Protection Systems.

These three broad levels are intended to build upon each other in accordance with the assessed risk. Bus designers, manufacturers and or operators may use only selected items from each level or category depending on their individual requirements.

Following is a summary of the three levels or grade of Fire Protection Systems.

> Basic Fire Protection System

- The use of appropriate bus support systems such as conducting correct maintenance and inspections and undertaking regular bus cleaning processes
- Other bus Support Systems include the use of appropriate Emergency Response procedures and ensuring that drivers and other operational staff are properly trained
- Inclusion of a range of passive Fire Protection Systems, which are built into the bus or fleet of buses with the intent to both reduce the risk of fire and if a fire should occur, reduce the effects
- The inclusion of the required emergency exits, fire extinguishers and other items as required under the ADR's and Australian Standards.
- One Portable Fire Extinguisher (or two Portable Fire Extinguishers as required by ADR's).

> Intermediate Fire Protection System

- The Basic System and
- A second or larger fire extinguisher
- A Fire Alarm System that monitors the critical areas on the bus and alerts the driver if a fire or excessive heat situation occurs

51 Australian Design Rule 58/00, 2006, Requirements for Omnibuses Designed for Hire and Reward.

- Separate fuel isolation valving
- Driver Activated Engine Bay Fire Protection System. This may be in the form of:
  i. A larger portable fire extinguisher and an access portal into the engine compartment for the fire extinguisher or
  ii. an integrated Fire Protection system.
- For high speed operations, tyre pressure monitoring system on the rear axle(s).

> Advanced System Fire Protection System

- The basic and intermediate system and
- A fully automatic Engine Bay Fire Protection System.

The level of protection offered increases from the Basic through to the Advanced Fire Protection System as outlined in Table 3.

The grades set are offered as a guide only and to achieve the desired level of protection, designers, manufacturers and/or bus operators may use different combinations of systems. For example including a fire extinguisher access portal into the engine compartment on all buses could be seen as a viable option.

The level of Fire Protection used should be based on the Assessed Risk for both the bus, or buses and the operating environment

Basic Fire Protection System

- Use of Passive protection systems.
- Appropriate Maintenance, Cleaning, Training and other bus Support Systems.
- Fire Extinguishers as required by the ADR's.

↓

Intermediate Fire Protection System – (Active System)

Basic System plus,

- Separate Fuel Isolation Valving.
- Driver Activated Engine Bay Fire Protection System (this may be a larger portable fire extinguisher or an integrated system).
- Fire alarm system

↓

Advanced System Fire Protection System – (Active System)

Intermediate system plus:

- A fully automatic and or fully integrated Engine Bay Fire Protection System.

Fire Protection System Details by Grade of System

For all three grades of Fire Protection Systems, Basic, Intermediate and Advanced, the combination or configuration of systems used are dependent on the risk assessment process when developing the bus specification and initial design.

Although there are common components in all of the systems, the functionality to be provided by each grade of system increases in difficulty and complexity. The higher the grade of system the more automated the system becomes. Automation reduces the level of intervention required by the driver, however with increases in automation comes the need for the systems to be self-monitoring and fail-safe.

A summary of the components required and functions provided for each grade of system is given in Table 3.

The Standards and Specifications for Fire Protection Systems

This section of this Advisory outlines the recommended performance based specifications and standards in regards to the on-bus active systems for the Fire Protection Systems. Given the importance and relative complexity of these systems, the following also provides some explanation to the types and functions of the components used in these systems.

Where practicable the recommendations are in accordance with sections of the AS 5062—2006 Fire protection for mobile and transportable equipment.

> Note: Whenever a Fire Protection System is fitted to a bus, the individual component of the system needs to be able to perform the assigned function in a reliable and appropriate manner. This Advisory outlines the recommended requirement for each of the components. Where practicable the recommendations are in accordance with sections of the AS 5062—2006 Fire protection for mobile and transportable equipment.[53]

Types of Fire Suppression Systems and their Requirements of Use

There are two main types of fire suppression systems.

> Manually operated fire suppression systems

> Automatically activated fire suppression systems

Fire Extinguishers

The most basic fire suppression system is the fire extinguisher.

The most obvious driver activated Fire Protection System is the portable Fire Extinguisher, but the requirements, terminology and classification of fire extinguishers can be confusing, and to help assist in this area, the following is provided:

- The use of appropriately sized fire extinguishers as determined by Australian Design Rule 58/00 – Requirements for Omnibuses Designed for Hire and Reward 2006 requires:

  "58.2.4 FIRE EXTINGUISHER

  There shall be provided on every omnibus in such a position as to be readily available for use a fire extinguisher which is selected and located in accordance with AS 2444-2001 "Portable Fire Extinguishers — Selection and Location"[53]

- The ADR refers to the Australian Standard AS 2444-2001 Portable Fire Extinguishers and Fire Blankets — Selection and Location and this standard requires that passenger carrying vehicles or buses in urban areas carry one appropriately sized fire extinguisher and for outside urban areas, or for buses fitted with integral luggage compartments, then two appropriately sized fire extinguishers are required. This is detailed in the following extract from AS 2444-2001.

- Fire extinguishers must be accessible, where possible on the nearside of the bus and must not be located in the engine bay and/or drive train area.

  Minimum Rating, Classification and Number of Extinguishers For Vehicles"[54]

Type of vehicle	*Minimum rating and classification of extinguishers*	*Minimum number of extinguishers*
Passenger-carrying vehicle *In urban areas or on short trips outside urban areas*	*2A:20B* *(fitted with hose)*	*1*
Outside urban areas or when fitted with integral luggage compartment	*2A:20B* *(fitted with hose)*	*2* *(one to be mounted near the under-floor area or engine)*

The required minimum size is a ***2A:20B Type Portable Fire Extinguisher***, fitted with hose. This rating and size requirement is explained in detail in Appendix 3 along with the maintenance requirements for these types of extinguishers.

52 AS 5062, 2006, Fire Protection for Mobile And Transportable Equipment.

53 Vehicle Standard, 2006, Australian Design Rule 58/00 – Requirements for Omnibuses Designed for Hire and Reward.

54 AS 2444, 2001, Portable fire extinguishers and fire blankets — Selection and location, pp.19.

Table 3 Types and Functions of Fire Protection Systems

Types of Fire Protection Systems		
Basic System	***Intermediate System***	***Advanced System***
Passive Fire Systems ***With ADR Compliant Fire Extinguisher(s) and Operational/ Maintenance Procedures.***	***Fire Alarm System*** ***With Integrated Manually*** ***Operated Fire*** ***Suppression System***	***Fire Alarm System*** ***With Automatically*** ***Operated Fire*** ***Suppression System***
Components Typically Incorporated in Systems		
• Use of appropriate bus Support Systems • Use of passive protection systems such as heat shields, fire barriers, adequate ventilation • One or two Fire Extinguishers • Driver training • Appropriate Maintenance and Inspection processes • Appropriate Emergency Response practices • Fire and or heat detectors	• Fire and or heat detectors • Fire alarms • Fire indicator panel • Fire extinguishing agent • Manual actuation devices • Containers • Discharge pipework and nozzles • Manual battery and fuel isolations. Access portal or multiple portals into engine compartment and or luggage area • Optional bus tyre pressure monitors for rear axle(s).	• Fire and or heat detectors • Fire alarms • Fire indicator panel • Fire system activating system and valving • Fire extinguishing agent containers • Discharge pipework and nozzles • Manual actuation devices • Optional automatic battery and fuel isolations • Optional bus tyre pressure monitors for rear axle(s)
Functions to be Provided		
• Reduce the risk of fire initiation • Reduce the ability of any potential fire to quickly move into the passenger compartment • Provide appropriate responses from the driver and other operational staff • Initiate safety functions	• Rapidly detect a fire • Rapidly detect a loss in tyre air pressure • Provide Fuel isolation • Provide battery isolation • Initiate an alarm signal • Manual activation of discharge of extinguishing agent • Provide a signal or other indication confirming agent discharge • Initiate safety functions	• Rapidly detect a fire • Rapidly detect a loss in tyre air pressure • Automatic battery isolation • Automatic Fuel isolation • Initiate an alarm signal • Automatically activate discharge of extinguishing agent • Provide a signal or other indication confirming agent discharge • Initiate safety functions • Self-Monitoring of detection systems

Fire Alarm System with Manually Operated Fire Suppression System

A manually operated fire suppression system should perform at least the following functions:[55]

- Rapidly detect a fire
- Initiate an alarm signal
- Provide a signal confirming agent discharge
- Initiate safety functions where fitted
- Allow the manual activation discharge of extinguishing agent
- Provide a signal, or other indication, confirming agent discharge.

Fire Alarm System with Automatically Operated Suppression System

A fire alarm system with automatically operated fire suppression system shall perform at least the following functions:[56]

- Rapidly detect a fire
- Initiate an alarm signal
- Automatically activate discharge of suppression agent
- Provide a signal confirming agent discharge
- Initiate safety functions where fitted
- All automatic fire suppression systems should be provided with a means of manual activation.

The key components of these fire suppression systems are reviewed in the following sections.

Fire or Heat Detectors Types

There are two basic types of detectors that could be used in a Fire Protection System and these are thermal sensors that detect heat and optical sensors that detect flame and or smoke.

Thermal Sensors

There are three common thermal sensors utilised in transit applications, these are:[57]

- **Fixed Temp:** A thermal sensor detects heat above a given set point
- **Rate of Rise:** A thermal sensor detects a rapid rise
- **Linear Thermal:** A wire or tube that detects heat.

55 AS 2444, 2001, Portable fire extinguishers and fire blankets — Selection and location, pp.19.
56 Ibid.,^
57 American Public Transport Association, 2009, Recommended Practice for Installation of Transit Vehicle Fire Protection Systems, APTA Document Number BTS-BS-RP-003-08.

Optical (or Smoke) Sensors

An optical flame sensor detects the energy produced by a flame and must be suitable for the operating environment of a transit vehicle:[58]

- Optical detectors are in effect light sensors. When used as a smoke detector, it includes a light source (incandescent bulb or infrared LED-Light-Emitting Diode), a lens to collimate the light into a beam, and a photodiode or other photoelectric sensor at an angle to the beam as a light detector
- In the absence of smoke, the light passes in front of the detector in a straight line
- When smoke enters the optical chamber across the path of the light beam, some light is scattered by the smoke particles, directing it at the sensor thereby triggering the alarm.

Thermal sensors are typically used in the engine compartments and other areas where higher temperatures are produced, whereas optical sensors are typically used in other areas such as luggage compartments or toilets.

Fire or Heat Detector Requirements

The fire or heat detectors should perform at least the following functions:

- Comply with the relevant Australian Standard or Code and for reference Appendix 4 lists the key Australian Standards for Smoke Detector and Alarm standards
- Be suitably robust to provide reliable operations in areas such as the engine compartment
- Be resistant to oil, dirt and other contaminates
- Resist vibrations and or accidental impact that could occur during maintenance activities
- Be able to resist any cleaning processes used in the compartment in which they are fitted
- For the engine compartment they would need to resist high pressure water cleaning methods
- Be able to reliably and rapidly detect the types of temperature variations in accordance with the requirements of United Nations Regulation No. 107 Revision 3 18 October 2011.[59]

Fire Alarm and Control Panel System Requirements

The fire alarm and control panel system should perform at least the following functions:

- Be fitted to all enclosed spaces such as the engine compartment, the battery compartment, and where fitted the luggage compartment and the toilet

58 Ibid.,
59 Addendum 106: Regulation No. 107 Revision 3 18 October 2011

- Rapidly detect the outbreak of fire or an excessive temperature situation
- Initiate an alarm signal to allow manual safety functions to occur
- The alarm system should be operational whenever the engine is running and or the ignition is activated[60]
- When activated, the alarm system should provide a reliable and uninterrupted signal to the Fire Indicator Panel
- At a minimum the system control panel should include an alarm and signal system. Both a fire and a fault should activate a visual and audible alarm
- All fire alarm and control panels must comply with the relevant Australian Standard or Code.[61]

Fire Alarm Power supply

Power for the Fire Protection System control indication panels should be provided from at least two separate power supplies, as follows:[62]

- The primary power supply should be of sufficient capacity to independently provide power for all system functions when the equipment is running
- The secondary power supply should be capable of supplying sufficient power to operate all system functions. The secondary power supply should be supervised and generate a fault condition when no longer able to meet this requirement
- When the suppression system is designed for the practicable simultaneous protection of multiple enclosures, the power supplies should be calculated to satisfy the maximum simultaneous demand
- Loss of electric power should not prevent the manual operation of the fire suppression system.

Extinguishing Agent

The type, quantity and discharge rate of the extinguishing agent should be selected to suppress the likely fire scenarios identified in the risk assessment and should be in accordance with the requirements of AS 5062—2006.[63]

The following is an extract from the Standards developed by the US based National Fire Protection Association (NFPA)[64] and describes the different extinguishing agents and standards that each type of agent is required to meet.

"Foam fire suppression systems

Foam fire suppression systems shall be designed in accordance with NFPA 11 and the requirements of this Standard. Foam fire suppression systems are total flooding systems suitable for normally unoccupied enclosed spaces with flammable liquids and surfaces coated with combustible materials. Typical application is for enclosed machinery spaces.

Water Mist

Water mist fire suppression systems shall be designed in accordance with AS 4587 or, NFPA 750 and the requirements of this Standard. Water mist systems are typically total flooding systems suitable for enclosed spaces where three-dimensional pressure fires, flammable liquids and surfaces coated with combustible materials are present. NOTE: The system performance may be enhanced by the use of an additive to the water.

Gaseous agent

Gaseous agent fire suppression systems shall be designed in accordance with AS 4214 and the requirements of this Standard. Gaseous agent fire suppression systems are typically total flooding systems suitable for fully enclosed spaces. Typical applications include electrical and electronic equipment where there is a requirement for a non-conductive and clean extinguishing agent.

Powder

Powder fire suppression systems shall be designed in accordance with NFPA 17 and the system's listed design manual. Dry powder fire suppression systems are local application systems providing rapid fire knockdown and are suitable for unenclosed or ventilated spaces where three dimensional pressure fires, flammable liquids and surfaces coated with combustible materials are present.

Dual agent

Dual agent fire suppression systems shall be designed in accordance with NFPA 17, NFPA 17A and the system's listed design manual. Dual agent fire suppression systems are powder local application systems combined with a water-based cooling system. They provide rapid fire knockdown followed by cooling of identified high temperature re-ignition sources."

Aerosol

Aerosol systems are total flooding systems suitable for normally unoccupied fully enclosed spaces with flammable liquids and surfaces coated with combustible materials. Typical application is for enclosed machinery spaces."

60 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment.
61 Ibid.,^
62 Ibid.,^
63 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment.
64 http://www.nfpa.org/

Quantity of Agent

The quantity of extinguishing agent should be, as a minimum, the quantity required to satisfy the extent of protection determined from the risk assessment and the requirements of the AS 5062—2006.[65]

Additional quantities of extinguishing agent may be required to compensate for any special conditions that would adversely affect the protection efficiency. The design quantity of extinguishing agent should be adjusted to compensate for:

- Non-closable openings with forced ventilation such as engine compartments
- The free air volume of air receivers that may discharge into the protected area
- Altitude (substantially above or below sea level)
- Other circumstances requiring agent quantity adjustment
- Delayed engine shutdown.

Standards for Installation of Protection Systems

As research found that there was no specific Australian standard for the installation of Fire Protection Systems into buses, the BIC received approval to reproduce the American Public Transportation Association (APTA) document Recommended Practice for Installation of Transit Vehicle Fire Protection Systems October 2007 APTA Fire Safety Working Group, and as this document is bus specific, a complete reproduction of this document is provided in Appendix 5.

65 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment.

The Third Element — Recommended Inspection and Maintenance Practices

A key part of the development of this Advisory was to review the current Industry practices for bus maintenance and inspection to determine best practice in regards to reducing the fire risk. This involved sampling a cross section of operators' maintenance and inspection practices to compile a set of guidelines regarding the key items to be maintained and/or inspected so as to reduce the potential of fire.

This information was also reviewed in conjunction with the various Safety Bulletins and Guidelines issued by the various State Authorities, and input and comment from the Steering Committee Members.

The key areas are identified as:

> Cleanliness

> Maintenance and Inspections

> Driver Inspections

Cleanliness

Regular and thorough cleaning of the engine, engine compartment, front and rear axles and the general underbody areas is seen as being critical in reducing the risk of fires.

This applies to modern higher temperature engines and older types of buses, the ongoing and regular removal of any built up of:

- Dirt
- Grease
- Oils
- Coolant residue.

This reduces the potential sources of fire ignition and it also removes potential fuel for any such fire. Regular cleaning also helps maintenance staff see and or identify potential issues when conducting inspections and carrying out maintenance.

All cleaning should only be conducted in accordance with the manufacturers recommendations and should be part of regular maintenance procedures. Buses should be checked for correct operation of the engine and other systems after the bus has been cleaned.

Examples of poor cleaning practices.

Examples of good cleaning practices.

Maintenance and Inspections

General maintenance and inspection processes need to be designed so that buses are inspected and maintained to a standard that reduces the risk of fire in the respective operating environment. The level of maintenance and inspection conducted needs to be in accordance with the Risk Assessment Analysis. This means that higher risk operating environments, or specific bus types, may require a more frequent and elaborate maintenance and inspection program.

The maintenance process needs to be regular, controlled and has to meet the desired outcomes. The maintenance process must meet local regulated or contracted requirements and also be compliant to the manufacturer's recommendations.

Summary of Maintenance Inspection Requirements

- Maintenance Managers and staff are required to ensure that all driver defect reports are rectified and repairs documented
- Check that battery, alternator and starter cables are securely connected
- Check that all exposed cables are secure and not chafing and that there is no loose wiring within the engine compartment
- Check all hoses, pipes, filters, fittings and sensors for leaks and chafing
- Check that all clamps and cable ties are connected correctly and are secure
- Check the engine, transmission and surroundings for evidence of fluids leaking or misting
- Check that there is no oil or fuel on the engine bay surfaces
- Check all heat and sound insulation in the vehicle is in good order, i.e. no tears or accumulation of oils or fluids
- Check that there is no oil leaking from the turbocharger
- Regularly check fuel lines are not leaking and that all connections and brackets are tight and in good condition
- Clean all fluid or grease deposits or rubbish from the engine, transmission and surroundings
- Check that the radiator, intercooler and oil cooler are free of debris and fans are operating normally
- Check that all belts and pulleys are secure and free of wear and play.
- Check the levels of coolants and oils
- Check that the retarder or exhaust brake (if fitted to the vehicle) is functioning properly
- Check that heating systems (engine pre-heat and interior) are running correctly
- Check that the exhaust system is secure and not leaking, airtight and isolated
- Check that wheel hubs have sufficient grease or for oil filled hubs, sufficient oil
- Check the adjustment and security of brakes
- Ensure no liquids, fuel, power steering fluid, engine oil and hub/gear oil can come into contact with hot surfaces
- Ensure that any fire and smoke detection systems fitted in the vehicle are correctly connected and working
- Ensure that the fire extinguishers are present in the bus, function correctly (no missing parts) and are in date.

Note: This list is based on feedback from a range of operators and Steering Committee members and includes aspects of both the Checklist for fire on buses/coaches from TfNSW issued 22 November 2013 and the bulletin Preventing Bus and Coach Fires from NZ Transport).

Appendix 6 provides a generic list of the types of items and components that need to be checked when undertaking regular maintenance inspections with the aim to reduce fire risk.

Driver Inspections

A key part of the bus inspection process involves the driver of the bus. The bus inspection processes should be set up so that the drivers conduct pre-departure checks and also that they record any defects or issues that may have arisen during their shift when they return the bus.

This Advisory outlines the types of items that the drivers should check prior to departure. It should be noted however, that the drivers are not normally trained and/or qualified in bus maintenance and that a driver would be inspecting the bus on a flat area and hence certain under body issues would be virtually impossible to detect.

Pre-Departure Driver Checks

The types of items that a driver should be able to inspect before departing are as follows:[66]

- Look for tyres that are flat or partly flat
- Check that tyres on dual wheels are not touching one another
- Make sure that no liquids are leaking onto the road or surface from the engine compartment. (Water coming from the air conditioning system is okay – any other dripping, spray or misting is not)
- Check that the brakes release properly and that the air gauges are all in the normal position
- Check that there is no oil coming from the exhaust pipe and no debris in the pipe
- Check for excessive blue smoke from the exhaust – this could indicate the turbocharger is burning oil
- Check that the vehicle has an unexpired fire extinguisher
- Report any active faults to maintenance staff or a workshop for rectification.

During Operation Driver Checks

When operating the bus, drivers should:

- Check the temperature gauges for overheating
- Check the low tyre pressure monitor if the vehicle has one
- Check the air pressure gauge and/or warning light. Low air pressure can cause spring brakes to apply and bind
- Check the ABS warning light
- Check that the retarder is working properly
- Check for any alarms or alerts on the instrument panel, if in doubt seek advice on what the issue is.

After Operation Driver Checks

After completing a long trip or at the end of the day, drivers should:

- Record any problems in the vehicle's defect card/ sheet
- Report any active faults to maintenance staff or a workshop for rectification.

Appendix 8 provides a generic driver Pre-departure and Operational Check Sheet.

66 Based on the following
Transport for NSW, 2013, Information Alert 21 Checklist for Fire on Buses/ Coaches, NSW Government, Sydney.
New Zealand Transport Agency, 20112, Preventing bus and coach fires
Input from bus operators and suppliers gathered in interviews.

The Fourth Element — Administrative Controls Training, Emergency Response and Operational Processes

Recommended Operational Emergency Response Practice

A survey of the operational emergency response practices and processes were undertaken and as with the maintenance, the types of actions and practices to be employed are dependent on the systems used on the bus or buses. The key to correct emergency response programs is considered to be that:

- Programs are simple and understood by everyone in the organisation
- Staff are fully trained in these programs
- Refresher training is conducted on a regular basis
- Programs are developed in conjunction with the emergency response agencies within the operating area
- Emergency response programs are developed with the bus manufacturer and suppliers
- Programs address any special situations such as what to do when transporting disabled or elderly passengers.

Operational Emergency Response

Training Programs

Emergency Response Training Programs should be delivered to drivers and operational staff and include at a minimum:

- The location and use of the fire extinguishers. Multiple training is required if different extinguishers are fitted to each bus
- The evacuation of passengers whether they are mobile, wheelchair bound, elderly, and/or children
- The correct use of any cut off valves or switches that cut of isolate fuel or electrical supplies (if applicable)
- The warning systems in each different style of bus and what action they should take when an alarm is activated
- What actions need to be taken should an event occur.

Emergency Incident Response Check List

A summary of the types of actions that should be taken in the event of an incident are given below:

1. Stop immediately (in a safe place if you can).
2. Apply the parking brake and hazard lights.
3. Open the doors.
4. Tell the passengers to leave the vehicle immediately and indicate the nearest safe place to assemble.
5. Stop the engine and switch off the master switch (if it is immediately accessible).
6. Check that passengers have evacuated the vehicle.
7. Leave the vehicle yourself.
8. Call the operational base and or the emergency services. Provide as much information as possible about your location, the nature of the fire, number of passengers and any injuries.
9. Identify the source of the fire.
10. If it is safe to do so, use the fire extinguisher to fight the fire.
11. DO NOT OPEN THE ENGINE COMPARTMENT IF THAT IS WHERE THE FIRE IS.
12. Secure the surrounding area and warn other traffic as best you can.
13. Make sure that passengers and bystanders are at a safe distance.
14. Follow the advice of emergency services and assist them as best you can.
15. Advise the passengers what arrangements are being made for them.

Simple and straightforward instructions, along with regular training of drivers and operational support is key to provide appropriate levels of response. Appendix 2 provides a sample of a one page emergency response sheet that could be tailored to the specific bus or buses with a copy of the instruction kept in each bus.

ANNEXURES

Annexure A — Detailed Specifications On-bus Passive Fire Protection Systems

The following specifications detail the recommended passive systems that can be employed to minimise the potential and impact of bus fires. The use of these passive systems is recommended to be employed on all types of new buses regardless of the determined risk profile.

These requirements are based on the pretext that the stated requirements may not be totally practicable and achievable in every single case. And that the bus specification, design and final manufactured configuration are subject to the risk assessment and design certification and review processes detailed within this Advisory.

The following includes some sections and references from Addendum 106: Regulation No. 107 Revision 3 18 October 2011[67] as well as references to AS 5062—2006 Fire protection for mobile and transportable equipment[68] and the Standard Bus Procurement Guidelines RFP American Public Transportation Association Washington, DC, 20006-1215 published: October, 2010.[69]

Engine Compartments Body Fixtures

The following are the recommended performance based specifications and standards in regards to the On-bus Passive Systems for the engine compartment body section.

1. To isolate the areas where fires are most likely to occur, a partition of fire-resisting material should be fitted between the engine and passenger compartment (or any other major source of heat) such as auxiliary heater.
2. All fixings, clips, gaskets, etc, used in conjunction with the partition should be heat resistant and suitable for the operating environment.
3. These partitions are to provide a barrier between the engine and passenger compartment that is air and smoke tight and it should also provide a suitable thermal barrier.
4. The engine compartment should be tested or type tested to ensure that it is providing an air and smoke tight barrier between it and the passenger compartment.
5. Only necessary openings should be allowed in the partition between the engine bay and passenger compartment and these should be fire-resistant. Any passageways for items like air-conditioning lines should be separated from the engine compartment by fire-resistant material. Piping through the partition should have fire-resistant fittings or be appropriately sealed at the partition.
6. Wiring may pass through the engine bay and passenger compartment partition only if connectors or other suitable sealing means are provided to prevent or retard fire propagation through the partition.
7. Any hatches or maintenance access points between the engine and the passenger compartment, ie. through the partition, are to be suitably sealed and are to provide a fire barrier that is at least equivalent to the thermal barrier provided by the compartment isolation partition itself. These panels and their fasteners should be constructed and reinforced to minimize warping of the panels during a fire that may compromise the integrity of the partition. The importance of suitably sealed hatches was highlighted in the OTSI Hills Dale report.[70]
8. The design of the engine compartment and the materials used within or near to it must be such that high-pressure hot water and steam cleaning equipment using detergents should not cause damage nor affect the operation of the bus. All cleaning should be conducted in accordance with the manufacturer's recommendations and undertaken using the manufacturers approved cleaning practices.
9. Insulating materials used in or near to the engine and battery compartment must be suitably protected against accidental damage including wear and tear. In particular, any surface coatings and/or coverings must be sufficiently robust so that they will not tear or be damaged by the use of approved cleaning methods.
10. No flammable sound-proofing material or material liable to become impregnated with fuel, lubricant or other combustible material should be used in the engine compartment unless the material is suitably covered by an impermeable sheet.
11. Accumulation and/or retention of fuel, lubricants, vapours or gases in any part of the engine compartment should be prevented where practicable by suitable layout of the compartment and the provision of drainage orifices.
12. The engine compartment must incorporate appropriate engine bay ventilation so that the hot areas within the compartment are suitably cooled. These venting systems need to be in accordance with any directions and or standards as determined by the manufacturer.

Battery Boxes and Mains Electrical Systems

Following are the recommended performance based specifications and standards in regards to On-bus Passive Systems for the battery boxes and mains electrical systems.

1. Batteries must be suitably secured so that they cannot move within the battery compartment.
2. The battery terminals should be suitably covered so that accidental positive battery terminals cannot be accidently earthed or the batteries themselves should be fully covered with battery covers.
3. Battery enclosures should be suitably vented to ensure that any generated gases are not contained within the compartment.

67 Addendum 106: Regulation No. 107 Revision 3 18 October 2011
68 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment.
69 American Public Transport Association, 2010, Standard Bus Procurement Guidelines RFP, Washington, DC.

70 Office of Transport Safety Investigations, 2011, Report on the Hillsdale bus Fire bus fire Involving STA bus Mo4878, NSW Government, Sydney.

Wheel Arches

Following are the recommended performance based specifications and standards in regards to On-bus Passive Systems for the wheel arches.

1. Sufficient clearance and air circulation should be provided around the tyres, wheels and brakes to preclude overheating when the bus is operating on the design operating profile.[71] Such clearances are set by manufacturers and are dependent on the design and specification of the chassis involved.
2. Wheel housings should be constructed of fire-resistant material.
3. Designs should also consider the potential heat build-up from a tyre fire and how it could affect the side panelling and other surrounding areas of the wheel arches of the bus.[72]
4. It is understood that some configurations of bus designs do not have wheel arches and in this case, consideration should be given to using alternative methods to contain a potential wheel or tyre related failure. Methods such as inclusion of appropriate shields or dividing panels should be considered.

Passenger Compartment

Following are the recommended performance based specifications and standards in regards to On-bus Passive Systems for the passenger compartment.

1. The use of fire-retardant and low-smoke materials within the passenger area in accordance with the ADR's and the relevant Australian standards.[73]
2. The provision of suitable and compliant emergency exits for both the driver and passengers, all in accordance with the ADR's.
3. The provision of suitable lighting and emergency exit signage, in accordance with the ADR's.
4. The passenger compartment should be suitably isolated from potential sources of fire such as the engine and battery compartment and the fuel supply system.

Engine and Drivetrain Systems and Components

Following are the recommended performance based specifications and standards in regards to the On-bus Passive Systems for the engine and drivetrain systems and components.

1. Any of the key heat generators, such as the turbocharger and exhausts etc, should be suitably shielded.[74]
2. Proper venting of hot areas should be employed to minimise heat build-up wherever practicable as per manufacturer's recommendations.
3. The engine and other drivetrain and ancillary components are to be designed to allow for and not be damaged by appropriate high pressure cleaning in accordance with the manufacturer's recommendations.
4. The location and placement of coolant lines needs to be considered so that the lines:
   i. Do not rub or wear against other components
   ii. Where it can be practically achieved, they are located so that if a leak occurs the coolant will not drip onto a hot surface.
5. Where technically and operationally practicable, the use of non-glycol type coolants for certain higher risk operations are encouraged.
6. The reason for this is that the engine coolant can be ignited by heat. A typical scenario is that there is a hose with a leak which allows the coolant to leak onto a hot surface. Over a period of time the coolant evaporates, leaks and evaporates again, and may leave a build-up of resin behind (typically white powder). This build-up contains Ethylene glycol. After the water content has evaporated, Ethylene glycol in coolant has a Flash point of 111 °C and under certain conditions can be ignited by a hot engine component. See Appendix 1 for details in the Safety Alert issued by Roads & Maritime Services — Compliance and Regulation.[75]
7. Segregation of fuel and ignition sources should be considered as a design measure for fire risk reduction, including, but not limited to, the following:[76]
   i. Routing and/or securing of hydraulic and fuel hoses away from high-risk ignition sources such as the turbocharger and exhaust pipework, where practicable
   ii. Mounting electrical harnesses and hydraulic lines so as to minimise the potential for fatigue-related fractures through improved bracketing methods and cable and hose routes.

71 American Public Transport Association, 2010, Standard Bus Procurement Guidelines RFP, Washington, DC.
72 Johansson, E. and Yang, J., 2011, Motorcoach Flammability Project Final Report: Tire Fires – Passenger Compartment Penetration, Tenability, Mitigation, and Material Performance. Technical Note 1705
73 American Public Transport Association, 2010, Standard Bus Procurement Guidelines RFP, Washington, DC.
74 Addendum 106: Regulation No. 107 Revision 3 18 October 2011
75 Roads and Maritime Services NSW, 2013, Information Alert 20 Coolant Leaks Roads & Maritime Services — Compliance and Regulation, NSW Government Sydney.
76 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment.

Engine and Driveline Hoses and Pipes

Following are the recommended performance based specifications and standards in regards to the On-bus Passive Systems for the engine and drivetrain components (note a number of these recommendations align with the recommendations made in AS 5062-2006[77]).

1. Hoses of all types, whether they be fuel, hydraulic or coolant lines, can be both a potential ignition and fuel source. Careful consideration should be given to the type of hoses and fitting to be used.
2. Only hoses and fittings complying with the Manufacturers Standards, the Australian Standards, or other recognised standards or codes should be used.
3. The Australian Standard AS 5062—2006 Fire Protection For Mobile And Transportable Equipment requires that for fuel lines and hydraulic hoses and the associated fittings that:
   i. Only hoses and fittings that comply with AS 3791 Hydraulic Hose or other recognised Standard are to be used.[78]
   ii. And specifically clause 1.5.2 states:

      "1.5.2 Fittings — Fittings for hose may not be interchangeable, and it is recommended that fittings and hose be properly matched, and that fitting and hose manufacturers' recommendations be followed."[79]
4. Use of hoses and pipes that are correctly rated for their application.
5. Use of pipes instead of hoses where possible.
6. Routing of hoses away from hot surfaces where this is practicable.
7. Use of adequate clamping of hoses and pipes with consideration given to vibration during operation and susceptibility to damage during maintenance.
8. Use of shields where hydraulic hoses have an assessed risk of damage by impact, for example in wheel arch areas and under the body.
9. Routing of pipes and hoses in a manner that will provide mechanical protection against wear and damage were practicable.

77 Ibid.,^
78 AS 3791, 1991, Hydraulic Hoses (Amended 1995).
79 Inid.,^ pp.4

Engine and Driveline Electrical Systems

Following are the recommended performance based specifications and standards in regards to the On-bus Passive Systems for the engine and drivetrain electrical systems (note a number of these recommendations align with the recommendations made in AS5062-2006[80]).

1. Use of protection devices for electrical circuits, for example, circuit breakers, fuses, current limiting devices.
2. Use of correctly rated electrical circuits.
3. Protection of electrical components against mechanical damage where possible.
4. Design of electrical connections so that they do not loosen or overheat under normal conditions of service and when maintained in accordance with the manufacturers recommended procedures and processes.
5. Harnesses secured using suitable mechanical protection, for example, outer tubing, guards and sheathing.
6. Harnesses to be enclosed in areas to be assessed as higher risk, for example, conduits and glands to prevent ingress of fuel sources and contaminants.
7. Harnesses to be suitably sealed where electrical conduits penetrate enclosures or partitions.
8. Harnesses to be arranged so as to facilitate regular visual inspections and to prevent contact with any hot surfaces.
9. Given that the common industry practice is to use cable ties to secure electrical harnesses (as well as a range of other hoses, lines and other conduits), the use of high temperature cable ties is recommended, ie. cable ties that will not degrade over time due to heat (cable ties with ratings of 150 Deg C or similar are recommended).

80 AS 5062, 2006, Fire Protection for Mobile and Transportable Equipment.

Annexure B — Detailed Specifications for On-bus Active Fire Protection Systems

Introduction

Where buses fall into a higher risk category according to the Fire Risk Assessment Process, or the operating environment indicates that a higher risk category is considered appropriate, the use of some level of Fire Protection System over and above the portable fire extinguishers as specified by the ADR's may be required.

This section reviews the types of systems and options available as well as the types of components and functions that any additional Fire Protection System should meet.

Engine and Enclosed Compartment Alarm Systems

Where their use is considered appropriate, the following are the recommended performance based specifications and standards in regards to the on-bus active alarm systems (includes sections and references from Addendum 106: Regulation No. 107 Revision 3 18 October 2011 and compliance to these regulations is recommended).[81]

1. The engine compartment should be equipped with an alarm system providing the driver with both an acoustic and a visual signal in the event of excess temperature in the engine compartment and in each compartment where a combustion heater is located.
2. The alarm system should be designed so as to detect a temperature increase in the engine bay, luggage bins and toilets that is in excess of the temperature occurring during normal operation.
3. It is considered to be satisfactory if the following areas of the engine compartment and each compartment that is separately enclosed, are monitored for excess temperature:[82]
   i. Areas in which, in case of leakage, flammable fluids (liquid or gas) may come into contact with exposed components, e.g. the turbocharger or the exhaust-system, including engine mounted components, whose working temperature is equal to or greater than the ignition temperature of the flammable fluids (liquid or gas)
   ii. Areas in which, in case of leakage, flammable fluids (liquid or gas) may come into contact with shielded components, e.g. areas whose working temperature is equal to or greater than the ignition temperature of the flammable fluids (liquid or gas)
   iii. Areas in which, in case of leakage, flammable fluids (liquid or gas) may come into contact with components, e.g. the alternator, whose temperature, in case of failure, may be equal to or greater than the ignition temperature of the flammable fluids (liquid or gas) or may generate an ignition source or spark
   iv. Any such alarm system should be operational whenever the engine is running and or the ignition is activated.

Wheel Arches – Active Systems

Following are the recommended performance based specifications and standards relating to the On-bus Active Systems for the wheel arches on buses that are in high speed operations.

1. A temperature measurement device such as a thermocouple located near the wheel may be used as a source for early warning to bus drivers of adverse heating and an impending fire.[83]
2. Alternatively the tyres fitted to the rear axle, or axles, should be fitted with pressure monitors that monitor the pressure of each of the tyres on the axle or axle set.
3. Either the temperature or tyre monitoring system should be self-monitoring and be configured so that either system alerts the driver of any issues as they occur.

Driver Activated or Automatic Isolation Systems

Following are the recommended performance based specifications and standards relating to the On-bus Active Systems for the driver activated or automatic isolation systems.

1. A battery isolating switch should be provided adjacent to the batteries to isolate power to the bus if required.
2. Any isolating switch should disconnect the battery except for safety devices such as the Fire Suppression Systems. The location of the master battery switch should be clearly identified on the exterior access panel and be accessible in less than 10 seconds for deactivation.[84]
3. Turning the master switch off with the power plant operating should shut off the engine. The master switch should be capable of carrying and interrupting the total circuit load.[85]

81 Addendum 106: Regulation No. 107 Revision 3 18 October 2011
82 Ibid.,^

83 Johansson, E. and Yang, J., 2011, Motorcoach Flammability Project Final Report: Tire Fires – Passenger Compartment Penetration, Tenability, Mitigation, and Material Performance. Technical Note 1705
84 American Public Transportation Association, 2010, TS 40.1.6 Master Battery Switch Standard Bus Procurement Guidelines, Washington, DC.
85 American Public Transport Association, 2010, Standard Bus Procurement Guidelines RFP, Washington, DC.

Annexure C – Identification and Rating of Fire Hazards

Table 4 Example Risk Analysis Pro-Forma Sheet

Potential Hazard (Example only of the types of items that should be checked on the bus or buses when reviewing the buses risk status.)	
A	***Potential Ignition Sources***
1	Interior Body
2	Electrical Cabinets
3	Electrical Harness runs
4	Dash Area
5	Other electrical components
6	Exterior Body
7	Fuel tank(s) & lines
8	Battery Compartment
9	Battery Fluid Levels
10	Battery terminals & cables
11	Engine Bay Electrical
12	Electrical systems, including alternators, batteries, wiring and electrical panels.
13	An electrical short can carry heat to another area of the equipment.
14	Electrical Connections & Cables to Alternator
15	Engine Bay Fuel and Hydraulics
16	Potential fire hazard locations may be remote from the fuel or ignition source, for example, a liquid, say fuel, oil or coolant, can spray or drip onto a hot surface remote from
17	Fuel systems, including piping, hoses, pumps valving and injectors in close proximity to ignition sources.
18	Hydraulics systems, including piping, hoses, pump and valving.
19	Lubrication systems, including engine and transmission systems and grease systems.
20	Engine Bay Mechanical Systems
21	Cooling system, including coolant lines, engine and transmission.
22	A/C Boost Pump Connections & Hoses
23	Coolant / Intercooler Hoses; Pipes & Air Flow
24	Exhaust systems.
25	Turbo chargers.
26	Turbo Connections
27	Belts and pulleys.
28	A/C Compressor
29	Braking systems and service brakes.
30	Locations where combustible materials can accumulate, for example, belly plate's engine valleys and wheel arches.
31	Underbody
32	Exposed cables and harnesses
33	Clamps and cable ties, harness runs
34	Fuel and hydraulic lines are secure and leak free.
35	Front Axle & Suspension
36	Front Axle
37	Braking systems and service brakes.
38	Rear Axle & Suspension
39	Rear Axle
40	Braking systems and service brakes.
41	Brakes & Disc Pads
42	Air Lines & Hoses are Free of Leaks & Secured
43	For Leakage from Hubs onto Linings
44	Brake Cylinders Levers & Forks
45	Tyres and Wheels
46	Recaps for tread separation
47	Tyre wall condition with particular attention to bead area
B	***Potential Areas of Fire Movement***
1	Interior Body
2	Engine cover & Floor hatches
3	Flooring
4	Exterior Body
5	Engine bay insulation material for contamination
6	Movement outside of Bus.
7	Venting Areas

	Is There Access to a Fuel Source?	Is there Access to an Oxidiser?	Comments and Details	Risk Rating for Area Identified			Details of Further Treatment Required
	Yes/No	Yes/No		Likelihood	Consequence	Risk	
n the leak point.							

Risk Rating for Identified Fire Hazard

Risk assessment and prioritisation involves assessing the likelihood of a risk occurring and the consequences of the risk on the project objectives and success criteria should it occur.

The risks are compared against likelihood and consequences, and allocated a risk rating from a risk matrix. The outcome of this analysis is provided in Table 5. Table 6 provides guidelines on the required level of treatment based on the risk rating.

The result of a risk evaluation is a prioritised list of risks that require further action. This step is about deciding whether risks are acceptable or need treatment.

Low or tolerable risks are risks that are acceptable and/or can be managed by the organisation. 'Acceptable' means the organisation chooses to 'accept' that the risk exists, either because the risk is at a low level and the cost of treating the risk will outweigh the benefit, or there is no reasonable treatment that can be implemented.

Table 5 Ranking Matrix for Risk and Opportunity Priority

Consequence / Likelihood	Significant	Major	Minor
Frequent	High	High	Medium
Possible	High	Medium	Low
Rare	Medium	Low	Low

Table 6 Risk Treatment Guidelines.

Risk Ranking	Risk Treatment Guidelines
High	Fire Mitigation Processes Required starting with design immediate action required
Medium	Specific attention is required to reduce fire risk.
Low	Manage by routine procedures

Appendix 1 TfNSW Information Alert Coolant Faults

NSW GOVERNMENT | Transport Roads & Maritime Services

Information Alert 21

22 November 2013

Dear Operator

Checklist for fire on buses/coaches

ISSUE:
Data captured by Roads and Maritime Services' (RMS) bus incident database reporting system and Office of Transport Safety Investigation (OTSI) reports show there have been a number of bus fire incidents in the last few months. Results range from minor damage to the complete loss of vehicle.

As part of the Safety Management System (SMS) operators should conduct a risk assessment for fires on buses. Part of the risk assessment should include evacuation procedures for all passengers, whether they are mobile, wheelchair bound, elderly and/or children, training procedures for drivers and fire extinguisher access.

It is recommended that all operators read the outcome of the OTSI investigation regarding Bus Fires in NSW 2005-2012 report that can be accessed via the internet at http://www.otsi.nsw.gov.au/bus/investigations.php.

The Bus Industry Confederation (BIC) with the help of industry stakeholders is currently in the process of developing an Emergency Response Procedure for fires on buses and coaches. However, RMS has also created a checklist to assist operators in relation to fires on buses. This checklist should be incorporated into the maintenance scheduling, pre shift inspections and end of shift procedures for all buses and coaches. It is recommended that the RMS checklist is used in conjunction with information released by BIC.

NOTICE:
This notice is to inform operators of the risks involved with fires on buses, so that operators can give due consideration to the issues and implement the required procedures.

Rebecca Kalkandis
A/Principal Manager
Public Passenger Services

Roads and Maritime Services - Public Passenger Services Compliance and Regulation

For further information contact Sandra Doyle, A/Senior Project Officer, Bus Operator Accreditation Scheme on 9891 8913

Checklist – Fires on buses

Transport Roads & Maritime Services

INFORMATION AND ADVICE

Check list against fire on buses

There have been a number of fires on buses recently and in order to prevent fires on buses Roads and Maritime Services (RMS) has created an information alert based on outcomes of investigations by the Office of Transport Safety Investigations (OTSI) with recommendations for inspections to be incorporated in the maintenance schedules, pre departure checks and end of shift procedures for all buses.

Pre-departure checks for fires on buses

- Visual inspection of tyre pressure and tread integrity, ensure dual tyres are not touching each other.
- Inspect hubs for discolouration due to overheating.
- Inspect engine bay and underneath the vehicle for damaged/loose hoses or pipes, fluid (fuel, oil or coolant) leaks, exhaust leaks or loose wiring.
- Ensure all fluid levels are correct including coolant and oil.
- Ensure air system is operating correctly. Test operation of brakes, pressure gauges, warning lights and buzzer alarms.
- Ensure that all faults that are found are recorded on the driver's defect reporting system and provided to the operator or maintenance staff.
- Ensure the driver is aware of where all fire extinguishers are located and that the extinguishers are present, accessible and serviceable.
- The driver is aware of where emergency cut off switches are (if applicable).
- The driver is to inform all passengers when they have boarded and are seated of the emergency exits (long distance, tourist and charter services).
- Ensure there is no baggage or items blocking any of the emergency exits or walkways.

While driving

Drivers should stay alert and monitor:

- Coolant temperature gauges.
- Activation of engine or electrical warning systems, lights and alarms.
- Check smoke or heat detection systems if fitted to the bus.
- Avoid any overheating of the bus. Stop vehicle if the engine, brakes, and/or retarder become overheated or when sensing unusual odours or smoke or if smoke is detected visually.
- Ensure the vehicle is parked in a safe place and emergency procedures are followed if fire and/or smoke is detected.
- The proper functioning of the retarder (hydraulic or electric).
- Any loss of power including engine and air-conditioning.
- If any abnormalities are detected, ensure vehicle is secured in a safe location and emergency procedures are followed.

End of shift procedures

The driver should check/complete:

- In CNG gas buses ensure that the gas is turned off before leaving the vehicle (if applicable).
- Complete a visual inspection ensuring no liquids are leaking underneath the bus.
- Report any damage and/or mechanical damage to bus to the operator or maintenance staff.
- Ensure any external heat sources if fitted are switched off.
- Inspect the engine bay for presence of rubbish or other foreign materials.
- Examine wheel hubs for signs for overheating.
- Ensure the battery switch has been opened to minimise the risk of electrical fires whilst the vehicle is unattended.

Level 4,16-18,Wentworth Street Parramatta NSW 2150
Locked Bag 5085 Parramatta NSW 2124 **T** 02 9689 8888 | **F** 02 9689 8875 | **E** boas@transport.nsw.gov.au
www.transport.nsw.gov.au |

Emergency training

All staff must be trained in emergency procedures. This training should be documented as a part of the Bus Operator Accreditation Scheme (BOAS) and Safety Management System (SMS).

- All drivers should be trained in the location and use of the fire extinguishers. (Multiple training is required if different extinguishers are fitted to each bus.)
- Evacuation of passengers should be addressed whether they are mobile, wheelchair bound, elderly, and/or children.
- Driver training of any cut off valves or switches (if applicable) that will reduce the spread of fire should be conducted and documented.
- Drivers require training of all warning systems in each different style of vehicle driven.

Emergency procedures

The following procedures are a minimum that operators should be providing for their driver training in relation to evacuation of a bus in the event of a fire or emergency.

- Try to park the bus in a safe area.
- Apply the parking brake.
- Notify passengers and staff to exit the bus in a safe and timely manner.
- Open the doors and escort passengers to a safe distance from the vehicle.
- Shut down any emergency switches if applicable (CNG gas emergency shut off, master switch for batteries).
- Identify the location of the fire.
- Inform the appropriate emergency services (000) and bus depot. Give as much information as possible about the incident, where the vehicle is located and where the fire is on the vehicle.
- Where appropriate and safe to do so use the on board fire extinguishers to put out small, containable fires.
- Secure the incident area. Put warning signs around the bus.
- Wait for emergency services and ensure that all passengers and staff are at a safe distance from the vehicle and assess any passengers or staff for injuries.
- On return to depot ensure you document the incident and report it to management.

Vehicle maintenance staff

- Maintenance Managers and staff are required to ensure that all driver defect reports are rectified and repairs documented.
- Ensure that any fire and smoke detection systems fitted in the vehicle are correctly connected and working.
- Ensure that connector cables from the alternator and starter are properly connected and in good condition.
- Ensure that there is no loose wiring within the engine compartment.
- Ensure that all hoses delivering fluids around the engine are in good condition with no tears or holes. Ensure all clamps are connected correctly and are secure.
- Ensure no liquids, fuel, power steering fluid, engine oil and hub/gear oil can come into contact with hot surfaces.
- Ensure engine is cleaned regularly allowing no build up of flammable deposits.
- Ensure no oil is leaking from the waste gate pivot of the turbocharger.
- Check sensors are not a source of leaking.
- Ensure coolant and oils are at the correct levels.
- Regularly check fuel lines are not leaking and that all connections and brackets are tight and in good condition.
- Ensure the retarder (gas exhaust, hydraulic or electric) is functioning properly. All environment equipments are without any defects (no broken valves, lines, no leaking of fluids).
- Ensure exhaust system is airtight/isolated.
- Ensure preheating systems are running correctly (engine and interior).
- Levels of grease in the wheel hubs are sufficient.
- Ensure the braking systems are in order.
- Ensure that the fire extinguishers are present in the bus, function correctly (no missing parts) and are in date.
- Ensure that emergency exits are marked clearly and function correctly.

EMERGENCY RESPONSE PROCEDURES FOR BUS OR COACH FIRES

S STOP · **A** ALERT · **F** FINALISE · **E** EVACUATE

If you see, smell or are advised of smoke or flames (or the fire alarm or pressure monitor activates), you must adhere to the following procedures to ensure the safety of both yourself and any passengers in or around the vehicle.

Step 1 Remain Calm.

Step 2 Pull vehicle over immediately to the near side lane/kerb ensuring that it is safe and out of danger from other road users, trees and buildings.

Step 3 Secure vehicle by applying the park or handbrake.

Step 4 Open all doors and SHUT down engine as soon as practicable.

Step 6 Instruct passengers to disembark in an orderly and safe manner and move away to a safe location.

Step 7 If vehicle is fitted with master isolator switch, this must be switched off.

Step 8 If vehicle is fitted with a fuel isolator switch, this must be switched off.

Step 9 Contact Emergency Services on “000” to seek assistance.

Step 10 Contact Depot Operations to notify of incident and seek guidance.

Step 11 Access vehicle fire extinguisher and attempt to contain fire (if the fire is contained to the engine bay or luggage compartment, you must NEVER open the engine hatch to attempt to extinguish fire).

Step 12 If access to exit doors is restricted due to fire, driver instructs the nearest available person to utilise emergency window hammers to break emergency windows to allow access from the side of the vehicle.

Step 13 Check the welfare of your passengers and assess any injuries.

Appendix 3 Fire Extinguisher Standards and Approved Examples

The Size and Type of Fire Portable Fire Extinguisher Required for Buses

The minimum size, type and mounting location for the Portable Fire Extinguisher(s) to be used on buses is determined by Australian Design Rule 58/00 – Requirements for Omnibuses Designed for Hire and Reward 2006. ADR 58/00 which states the following in regard to Portable Fire Extinguishers on buses:

> *"58.2.4 FIRE EXTINGUISHER*
>
> *There shall be provided on every omnibus in such a position as to be readily available for use a fire extinguisher which is selected and located in accordance with AS 2444-2001 "Portable Fire Extinguishers — Selection and Location".*[86]

The ADR refers to the Australian Standard AS 2444-2001 Portable Fire Extinguishers and Fire Blankets — Selection and Location and this standard requires that passenger carrying vehicles or buses in urban areas carry one appropriately sized fire extinguisher and for outside urban areas or for buses fitted with integral luggage compartments, then two appropriately sized fire extinguishers are required. This is detailed in the following extract from AS 2444-2001.

86 Vehicle Standard Australian Design Rule 58/00, Requirements for Omnibuses Designed for Hire and Reward 2006

Table 7 Minimum Rating, Classification and Number of Extinguishers for Vehicles

Type of vehicle	Minimum rating and classification of extinguishers	Minimum number of extinguishers
Passenger-carrying vehicle In urban areas or on short trips outside urban areas	2A:20B (fitted with hose)	1
Outside urban areas or when fitted with integral luggage compartment	2A:20B (fitted with hose)	2 (one to be mounted near the under-floor area or engine)

Source: Australian Standard AS 2444-2001 Portable Fire Extinguishers and Fire Blankets[87]

Table 8 Example of how to read a Fire Extinguisher Rating (2A:40B[E])

2	A	40	B	(E)
Rating relative to a specific size of carbonaceous fire	Fire involving carbonaceous materials E.g. wood, paper, timber etc.	Rating relative to a specific size of flammable liquid fire	Fire involving flammable liquid E.g. petrol, oil, turps etc.	Fire involving energised electrical equipment E.g. switchboards, photocopiers, computers etc.

Table 9 Identifying the Correct Extinguisher to use on Different Types of Fire

FPA Fire Protection Association Australia

Portable Fire Extinguisher Guide

Fire Protection Association Australia Website www.fpaa.com.au

Two colour schemes for fire extinguishers exist: PRE 1999	FROM 1999	EXTINGUISHANT	CLASS A Wood Paper Plastics	CLASS B Flammable & Combustible Liquids	CLASS C Flammable Gases	CLASS E Electrically Energised Equipment	CLASS F Cooking Oils and Fats	CLASS D For fire involving combustible metals use special purpose extinguisher
		WATER	YES	NO	NO	NO	NO	Dangerous if used on flammable liquid, energised electrical equipment and cooking oils/fat fires
		WET CHEMICAL	YES	NO	NO	NO	YES	Dangerous if used on energised electrical equipment
		FOAM	YES	YES	NO	NO	LIMITED	Dangerous if used on energised electrical equipment
		POWDER	YES (ABE) NO (BE)	YES (ABE) YES (BE)	YES (ABE) YES (BE)	YES (ABE) YES (BE)	NO (ABE) LIMITED (BE)	Look carefully at the extinguisher to determine if it is a BE or ABE unit as the capability is different
		CARBON DIOXIDE	LIMITED	LIMITED	LIMITED	YES	LIMITED	Not suitable for outdoor use
		VAPORISING LIQUID	YES	LIMITED	LIMITED	YES	NO	Check the characteristics of the specific extinguishing agent

LIMITED indicates that the extinguishant is not the agent of choice for the class of fire, but that it may have a limited extinguishing capability.
Solvents such as alcohol or acetone mix with water and therefore require special foam
Green text indicates the class or classes in which agent is most effective

Source: FPA Portable Fire Extinguisher Guide[88]

87 AS 2444, 2001, Portable fire extinguishers and fire blankets — Selection and location. pp.19
88 FPA Portable Fire Extinguisher Guide www.fpa.com.au

The required minimum size is a 2A:20B Type Portable Fire Extinguisher, fitted with hose. This rating and size requirement is explained in the following sections.

Portable Fire Extinguisher Rating and Classification Standards

Fire extinguishers complying with Australian Standards are marked with a classification and rating, determined in accordance with AS/NZS 1850:2009 Portable fire extinguishers — Classification, Rating and Performance Testing. Extinguishers are rated by their performance and suitability for a particular class of fire, i.e. a water extinguisher will be marked 2A and a dry chemical extinguisher will be marked 2A:40B:E.[89]

The classes of fire are:[90]

Class A: Fires in ordinary combustible materials, such as wood, cloth, paper, rubber and many plastics.

Class B: Fires in flammable and combustible liquids, greases, and oils.

Class C: Fires in combustible gases.

Class D: Fires in combustible metals.

Class E: Fires which involve energised electrical equipment.

Class F: Fires for cooking oils and fats.

The number before the letter is a measure of the relative performance within that class range, namely:[91]

- between 0 and 10 for **Class A**
- 2 and 80 for **Class B**
- 1 and 4 for **Class F**

When a fire extinguisher is rated for more than one class of fire, it is expressed in alphabetical order, eg. 2A:40B(E)[92] as shown in Table 8.

Types of Portable Fire Extinguisher

The above standards then determine the type of fire extinguisher that can be used on the different types of fires, as shown in Table 9.

As is seen in Table 9, there are two options of portable fire extinguishers that can meet the 2A:20B type requirement and that is either foam or a dry powder (ABE) type of extinguisher. Table 10 provides an example of each type of extinguisher for reference purposes only.

89 Metropolitan Fire & Emergency Services Board Community Safety Directorate, 2009, Guideline No: GL-16

90 AS 2444, 2001, Portable fire extinguishers and fire blankets — Selection and location. pp.19

91 Metropolitan Fire & Emergency Services Board Community Safety Directorate, 2009, Guideline No: GL-16

92 Fire Protection Association of Australia Tasmanian Branch, 2007, Guide to the Selection and Location of Portable Fire Extinguishers and Fire Blankets

Options for Larger Fire Extinguishers

As stated, the minimum standard of Fire Extinguisher for buses is 2A:20B, which is either a 9L foam or 1.5 kg dry chemical extinguisher. If a larger extinguisher is to be used, it still needs to be the Class A and B type extinguisher, but the rating numbers increase due to the large size and hence performance.

Table 11 shows the typical commercially available details of larger dry chemical extinguishers:[93]

93 Wormald Portable Fire Equipment Solutions www.wormald.com.au

Table 10 Examples of Different Types of Fire Extinguishers

	1.5 Kg Dry Chemical Extinguishers	9 L Stored Pressure Foam
Agent Capacity	1.5 kg	9.1 litres
Agent Type		AFFF Foam
Weight Full (approx)	3.2 kg	11.9 kg
Fire Rating	2A:20B	2A:20B
Approvals	AS/NZS 1841.4	AS/NZS 1841.4
Discharge Time	12 sec	48 sec
Effective Range	5 m	4.5 m
Dimensions — Height — Width — Depth	375 mm 100 mm 100 mm	683 mm 180 mm 180 mm
Cylinder Pressure Test	5 Yearly	5 Yearly
Periodic Test Pressure	2.5 Mpa	2 Mpa

Table 11 Examples of Large Dry Chemical Extinguishers

	1.1 kg ABE	2.3 kg ABE	4.5 kg ABE	9.0 kg ABE
Agent Capacity	1.1 kg	3.5 kg	4.5 kg	9.0 kg
Agent Type	Foray®Powder	Foray®Powder	Foray®Powder	Foray®Powder
Weight Full (approx)	2.4 kg	4.2 kg	7.9 kg	14.6 kg
Fire Rating	1A: 10B:E	3A:30B:E	4A:80B:E	6A:80B:E
Approvals	AS/NZS 1841.5	AS/NZS 1841.5	AS/NZS 1841.5	AS/NZS 1841.5
Discharge Time	10 secs	13 secs	22 secs	24 secs
Effective Range	4.6 m	5.2 m	5.8 m	6.7 m
Dimensions — Height — Width — Depth	362 mm 140 mm 88 mm	432 mm 216 mm 113 mm	470 mm 216 mm 148 mm	573 mm 241 mm 183 mm
Cylinder Pressure Test	5 Yearly	5 Yearly	5 Yearly	5 Yearly
Periodic Test Pressure	4.14 MPa	4.14 MPa	4.14 MPa	4.14 MPa

Source: Wormald Portable Fire Equipment Solutions

The 2.3 kg (3A:80B:E), 4.5 kg (4A:80:E) or even the 9.0 kg (6A:80B:E) units have higher performance ratings than the minimum 1.5 kg (2A:20B) units. The E coding means that these units are also rated for Electrically Energised Equipment.[94]

94 FPA Portable Fire Extinguisher Guide www.fpa.com.au

Maintenance of Portable Fire Extinguisher

Portable Fire Extinguishers used in buses are required to be maintained in accordance with AS/NZS 2444 which stipulates AS/NZS 1851.1 in reference to the maintenance requirements.

AS/NZS 1851.1 includes a number of procedures that must be followed including;

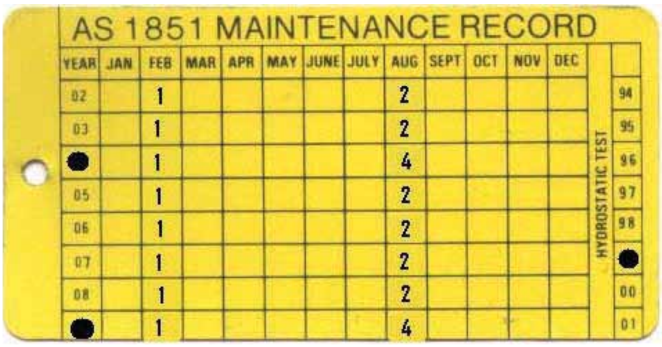
- Recording of maintenance performed
- Reporting any discrepancies found during servicing
- Use of suitably trained staff to carry out the servicing procedures.

For maintenance record tag purposes, maintenance work involving inspection and servicing is classified according to inspection and service intervals as follows:[95]

- '1' denotes six monthly intervals
- '2' denotes yearly intervals
- '3' denotes three yearly intervals
- '4' denotes six yearly intervals
- '5' denotes 'after use' procedures.

The maintenance intervals of different fire extinguishers are set out in maintenance schedules that stipulate various functions of maintenance that must be carried out and the level of inspection (e.g. 1, 2, 3, 4 or 5) intervals. Recharging of fire extinguishers 'after use' must be carried out in accordance with procedures specified in schedules contained in an AS 3676 Portable fire extinguishers — guide to servicing.

Irrespective of what type of fire extinguisher is utilised, a 6 monthly check is required on a number of components and functions of the fire extinguisher. Consequently, when checking the maintenance record tag of a fire extinguisher located in a bus, the tag should indicate a number (1, 2, 3, 4 or 5) stamped in to indicate that some degree of maintenance has been carried out every 6 months.[96]



AS 1851 MAINTENANCE RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	HYDROSTATIC TEST
02		1						2					94
03		1						2					95
●		1						4					96
05		1						2					97
06		1						2					98
07		1						2					●
08		1						2					00
●		1						4					01

Example of a Portable Fire Extinguisher Maintenance Tag with eight years of service levels.

95 Vehicle Standards Instruction, 2003, Fire Extinguishers in Buses, Public Passenger Vehicles Inspection Number P 5.0.
96 Ibid.,^

Appendix 4 Key Smoke Detector and Alarm Standards

The following lists the Australian Standards for smoke detectors and or alarms and it should be noted that any alarm used should comply with the relevant standards. Australian Standards and Draft Standards are available from Standards Australia retail, SAI Global, www.saiglobal.com.

1. **AS 12239-2004** Fire detection and fire alarm systems – Smoke alarms.
2. **AS 1603.2-1997** Automatic fire detection and alarm systems – point type smoke detectors.
3. Amendment-1998 to AS 1603.2-1997.
4. **AS 1603.7-1996** Automatic fire detection and alarm systems – optical beam smoke detectors.
5. Amendment-2001 to AS 1603.7-1996.
6. **AS 1603.8-1996** Automatic fire detection and alarm systems – multi point aspirated smoke detectors
7. **AS 1670.1-2004** Fire detection, warning, control and intercom systems – system design, installation and commissioning – Fire.
8. Amendment 1-2005 to AS 1670.1-2004.
9. **AS 1670.4-2004** Fire detection, warning, control and intercom systems – sound systems and intercom systems for emergency purposes.
10. **AS 3786-1993** Smoke alarms:
    - i. Amendment 1-1995 to AS 3786-1993
    - ii. Amendment 2-1995 to AS 3786-1993
    - iii. Amendment 3-2001 to AS 3786-1993
    - iv. Amendment 4-2004 to AS 3786-1993
11. **AS 7240.7-2004** Fire detection and alarm systems – point type smoke detectors using scattered light, transmitted light or ionisation.
12. **AS 7240.12-2007** Fire detection and alarm systems – line type smoke detectors using a transmitted optical beam.

Appendix 5 APTA Fire System Recommendations

APTA BTS-BS-RP-003-08
Document renumbered June 2009

Recommended Practice for Installation of Transit Vehicle Fire Protection Systems

Approved October 25, 2007
APTA Fire Safety Working Group

Approved May 3, 2008
APTA Bus Safety Committee

Approved October 5, 2008
APTA Bus Standards Task Force

Abstract: This recommended practice provides guidelines for vehicle fire protection system including detection and suppression systems in case of detected fire.

Keywords: fire, fire protection, suppression, detection, fire suppression, bus fire, vehicle fire, engine fire, wheel fire, tire fire

Introduction

(This introduction is not a part of APTABTS-BS-RP-003-08, Recommended Practice for Installation of Transit Vehicle Fire Protection Systems.)

This Recommended Practice for Installation of Transit Vehicle Fire Protection Systems reflects the consensus of the APTA Bus Standards Program members on the items, methods, and procedures that have provided the best practice based on the experiences of those present and participating in meetings of the Program Task Forces and Working Groups. Recommended practices are voluntary, industry-developed, and consensus-based practices that assist equipment suppliers, vehicle and component manufacturers, and maintenance personnel in the construction, assembly, operation, and maintenance of transit bus vehicles. Recommended practices may include test methodologies and informational documents. Recommended practices are non-exclusive and voluntary; they are intended to neither endorse nor discourage the use of any product or procedure. All areas and items included herein are subject to manufacturers' supplemental or superseding recommendations. APTA recognizes that for certain applications, the practices, as implemented by operating agencies, may be either more or less restrictive than those given in this document.

This recommended practice provides guidelines for transit bus fire suppression systems in conjunction with a vehicle fire.

APTA recommends the use of this recommended practice by:

Individuals or organizations that inspect and maintain transit buses

Individuals or organizations that develop specifications for transit buses

Individuals or organizations that build or manufacturer fire suppression systems

Individuals or organizations that contract with others for the inspection and maintenance of transit buses

Individuals or organizations that influence how transit buses are inspected and maintained

Test results must meet or exceed federal, state, or other local regulatory agency requirements if different from the recommendations outlined in this document.

Participants

The American Public Transportation Association (APTA) greatly appreciates the contributions of the Bus Transit Standards Bus (Fire) Safety Working Group, who provided the primary effort in drafting the Recommended Practice for Transit Bus Installation of Transit Vehicle Fire Protection Systems.

Recommended Practice for Installation of Transit Vehicle Fire Protection Systems

1. Overview

This document establishes a recommended practice for installation of transit vehicle fire protection systems. Individual operating agencies may modify these guidelines to accommodate their specific equipment and mode of operation.

Fire protection system includes a fire detection system which may or may not include a fire suppression system.

This practice is to be used in addition to the fire protection equipment manufacturer's installation recommendations.

1.1 Scope

This recommended practice applies to the installation of a fire protection system on heavy duty transit vehicles and over the road coaches. This document is not inclusive of systems installed on small transit vehicles such as cutaways and vehicles used in paratransit. Vehicles used in paratransit may require additional design consideration above and beyond this document.

1.2 Purpose

The purpose of this recommended practice is to define the minimum performance requirements for detection of and suppression of thermal events on transit vehicles. The resulting fire protection system shall be capable of detecting and minimizing potential damage of fire events in those zones of the vehicle identified in this document.

2. References

This guideline is to be used in conjunction with the original equipment manufacturer (OEM), fire protection equipment manufacturer service manuals and any authorities having regulatory jurisdiction. It is the responsibility of the user of this document to reconcile any discrepancies or conflicts that may arise between these guidelines, manuals and applicable codes or regulations.

NFPA, SAE, NEC, DOT,
BT-RP-007-05, Bus Shutdown

3. Definitions, abbreviations, and acronyms

For the purposes of this guideline, the following terms, definitions, abbreviations, and acronyms apply.

3.1 Definitions

3.1.1 Original equipment manufacturer is the vehicle manufacturer.(this document only)

3.1.2 Listed : Equipment, materials or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production labeled equipment or materials, and by whose labeling the manufacturer indicated compliance with appropriate standards or performance in a specified manner.

3.1.3 Transit Vehicle: A transit operated heavy-duty vehicle used in transit or over the road service with the exception of vehicles used in paratransit service.

3.1.4 Fire Protection: Fire detection system with or without a fire suppression system.

3.1.5 Fire Suppression: A system designed to suppress or mitigate damage from a fire.

3.1.6 Pilot vehicle: First article of an order.

3.1.7 Zones: Location within the vehicle

Zone 1 Engine compartment
Zone 2 Exhaust Systems (external to engine compartment)
Zone 3 Battery
Zone 4 Wheel Well
Zone 5 HVAC Compartment
Zone 6 Operator's Work Station
Zone 7 Articulated Turn Table
Zone 8 Fuel Storage (inclusive of roof mounted hybrid battery)
Zone 9 Electrical Junction Boxes
Zone 10 Interior

3.2 Abbreviations and acronyms

HVAC Heating Ventilation Air Conditioning System
OEM Original Equipment Manufacturer
AFSS Automatic Fire Suppression System

3.3 Potential Causes of Fire or Ignition Sources for Each Zone

Zone 1	Engine Compartment - electrical, combustible or flammable liquids/solids/gases, hot surfaces, belts, clutches, turbo fire, ignition of exhaust blankets, catalytic converter, particulate diesel filter/trap
Zone 2	Exhaust Systems (external to engine compartment) – high temperatures, exhaust leak, tail pipe fire, ignition of exhaust blankets, catalytic converter, particulate diesel filter/trap, and monitoring systems
Zone 3	Low Voltage Battery – electrical, flammable liquids/solids/gases, cables, equalizers, circuit breakers, fusible link malfunction, corrosion, overcharge, battery box
Zone 4	Wheel well – under inflated tire, overheated bearings, leaky wheel seal, flammable liquids/solids, high heat in brake area, road debris
Zone 5	HVAC Compartment – electrical, flammable liquids/solids/gases, high heat
Zone 6	Operator's Work Station – electrical, flammable liquids/solids/gases, high heat, tobacco smoking, debris build up
Zone 7	Articulated Turn Table – friction, debris build up, electrical cabling, vandalism, tobacco smoking
Zone 8	Fuel Storage/High Voltage Energy Storage – Fuel leaks, arcing, debris, flammable liquids/solids/gases, cables, equalizers, circuit breakers, fusible link malfunction, corrosion, overcharge
Zone 9	Electrical Junction Boxes – shorts, electrical, flammable liquids/solids, cables, equalizers, circuit breakers, fusible link malfunction, corrosion, chaffing
Zone 10	Interior – tobacco smoking, debris, HVAC duct, fluorescent light ballast, corrosion, cabling, chaffing, signage, wire harnesses, vandalism, advertisements

4. Fire Detection System

4.1 Sensors

There are two basic sensor devices that are used to provide early warning of fires. Thermal sensors detect heat and optical sensors detect flame.

4.1.1 Thermal Sensors:

Three common thermal sensors utilized in transit applications are

Fixed Temp: A thermal sensor detects heat above a given set point
Rate of Rise: A thermal sensor detects a rapid rise
Linear Thermal: A wire or tube that detects heat

4.1.2 Optical Sensors:

An optical flame sensor detects the energy produced by a flame and must be suitable for the operating environment of a transit vehicle.

4.1.3 Recommended Sensor Technology

Vehicle configurations vary, it is recommended that the detection system be designed based on a transit property's specific configuration in consultation with the OEM and AFSS supplier. .

Location	Historical Frequency	Base Line	Enhanced = baseline + _____
Zone 1	High	4 spot thermal or equivalent length of linear thermal	Mix of thermal sensors and optical infrared sensor
Zone 2	High	System that provides early warning of over heat conditions that would alert driver to minimize potential for combustion.	Consult with OEM & AFSS supplier to further address individual transit concerns
Zone 3	Medium	No baseline sensor protection.	1 spot thermal or equivalent length of linear thermal
Zone 4	High	No baseline sensor protection.	Any system that includes sensors to provide early warning of over heat conditions that would alert driver to minimize potential for combustion. Consult with OEM, AFSS & brake suppliers to further address individual transit concerns or identify emerging technologies.
Zone 5	Medium	No baseline sensor protection.	Consult with OEM & AFSS supplier to further address individual transit concerns
Zone 6	Low	No baseline sensor protection.	Consult with OEM & AFSS supplier to further address individual transit concerns
Zone 7 Low Low			
Zone 8 Low Low			
Zone 9 Low Low			
Zone 10 Medium Medium			

4.2 Display and/or Control Panel

4.2.1 System Controls

A control panel should be provided for all detection and/or suppression systems. The control panel should provide, at a minimum, electrical supervision of system power and detection; and system actuation wiring circuits if so equipped. The control panel should be visible and accessible to the seated driver/operator.

It is recommended that a separate manual means of activation of the suppression system be provided regardless of availability of system power. Manual actuators shall include operating instructions and shall be located within easy view and reach of the vehicle operator without requiring movement from the normal seated position. The manual actuator shall have a protected device to avoid accidental activation (guard, pin etc.). They should require a minimal amount of force or movement to activate and in no case more than 40lbs of force or movement no more than 14in to secure operation.   A means of remotely monitoring the agent cylinder pressure is available if desired.

4.2.2 Alarm and Signal

At a minimum the system control panel should include an alarm and signal system. Both a fire and a fault should activate a visual and audible alarm.

Lights:

System OK light: (Green)
Fault/Trouble light: (Yellow)
Fire Indicator: (Red)

Audible Alarm:

Detection or fault.
Means shall be provided to silence the alarm.
Distinct and recognizable by the operator.

4.3 Wiring, Cabling and Connectors

All lines, wiring, hoses, cables, and lines must be properly bracketed, insulated, and isolated to avoid chaffing and to protect against heat sources, using heat shields. Wiring should be routed to avoid damage from abrasion pinch points, heat, road debris, excessive stretching and damage from the exhaust system and turbo charger. Engine component connections should be water proofed or shielded to prevent the intrusion of moisture. UL listed or equivalent wire for fire suppression system applications must be used.

4.4 Auxiliary Outputs

Auxiliary outputs may be required to meet the requirements of APTA BS-RP-008-05 Recommended Practice for Transit Bus Fire Safety Shutdown for additional information.

4.5 Power Requirements/Options

Baseline: Power for the fire protection system shall be provided by the bus electrical system directly from the vehicle battery terminals or through dedicated power and ground buss bars. Nominal power consumption of the system should not exceed 300mA. If the system is connected to the switched side of a battery disconnect switch, system performance may be compromised when the switch is in the off position.

Enhanced: A battery-backup system may be used to provide limited-to-full system functionality in the event primary system power is interrupted.

5. Fire Suppression Systems

In addition to all of the above requirements, the following components are required for an integrated detection and suppression system. Integrated systems must be approved by an accredited third party.

5.1 Storage Containers

Stored-pressure type containers shall be designed to meet the requirements of the U.S. Department of Transportation (DOT) and Transport Canada (TC).

Containers shall be corrosion resistant.

Each container shall have an indicator (pressure gauge) to show that it is in a ready condition or in need of recharging. The gauge should be readily visible to an operator during a pre-trip inspection with out the use of tools. In the event that the gauge is inaccessible remote monitoring is acceptable.

Containers may be mounted in interior or exterior locations provided the location will not exceed the manufacturer's operating temperatures or be subject to excessive environmental extremes.

5.2 Distribution System

Distribution system should be designed and approved in accordance within the AFSS manufacture's design and installation parameters.

5.3 Nozzles

Quantity, location and orientation of nozzles shall be in accordance with AFSS design specifications and determination of hazard zones to be protected. A typical installation has a minimum of three nozzles protecting an engine compartment.

Nozzles should be mounted in such a fashion that normal maintenance practices do not require the removal or adjustment of any system discharge nozzle.

Discharge nozzles shall be provided with blow-off caps or other suitable devices or materials to prevent the entrance of moisture or other environmental materials into the distribution piping. The protective device shall blow off, open or out upon agent discharge.

5.4 Suppression Agent

The amount and type of suppression agent shall be determined based on a transit property's specific configuration in consultation with the OEM and AFSS supplier. The typical installation for a Zone 1 (engine compartment) is 20-25 pounds of dry chemical or equivalent. Due diligence should be applied to atypical installations utilizing alternative agents.

6. Certifications

The system design and pilot vehicle installation shall be reviewed and approved by the AFSS manufacturer in accordance with their requirements. A copy of the written approval must be provided to the procurement agency.

Any modification that may effect the performance of the AFSS shall require recertification by the AFSS supplier.

Appendix 6 CNG bus Options

Compressed Natural Gas (CNG) buses pose a number of specific issues when considering bus fire mitigation; however it should also be noted that the CNG system itself is very highly regulated and the standards and codes that CNG vehicles need to comply with are quite intensive.

CNG as a fuel source has proven to be a very safe and effective and to date Australia has not had a recorded bus fire that was caused by the CNG system itself (or the CNG fuel). But CNG buses have experienced fires that were initiated by other causes.

A CNG bus or fleet of buses, needs to go through the same risk assessment process as do other buses, but there are a couple of key items that CNG should include and these are over and above current regulations.

These items are:

- For CNG buses an emergency mechanical engine stop control must be incorporated adjacent to the rear engine compartment and accessible from the offside of the bus. This engine stop must enable the fuel supply to the engine to be isolated in the event of an emergency. It shall be readily identifiable and must not be positioned behind any locked door or hatch
- Also for CNG buses, an emergency fuel shut off lever shall be fitted and must isolate the high pressure feed line to the engine bay. This high-pressure fuel shut off must be able to be activated from within the driver's cabin, via a mechanical means. The emergency fuel shut off lever must be readily identifiable and it must not be positioned behind any locked door or hatch.

Appendix 7 Generic Bus Inspection Sheet

Table 13 System and Inspection Checklist to Reduce the Risk of Fire

Item or System to be Checked or Inspected to Reduce the Risk of Fire	Requires rectification		Rectified
	Yes	No	
Administration			
Ensure that all driver defect reports are rectified and repairs documented.			
Interior Body Checks			
Check Engine cover & Floor hatches for sealing and security.			
Check Emergency Lights & Decals			
Check Emergency Hammers & Function			
Check Fire Extinguisher Charge and Condition and that is in Date			
Passenger Door Emergency Exit Function			
Exterior Body Checks			
Check Engine bay insulation material for contamination			
Check Fuel tank(s) & lines for leaks & security			
Battery Compartment			
Check Battery Fluid Levels			
Check Battery terminals & cables for condition & security.			
Check Battery carrier & hold down straps for condition & security			
Engine Bay			
Check Alternator Mounting			
Check Electrical Connections & Cables to Alternator			
Check Electrical Connection & Cables to Stater Motor			
Check that all belts and pulleys are secure and free of wear and play.			
Check A/C Compressor for Leaks			
Check A/C Boost Pump Connections & Hoses			
Check Coolant / Intercooler Hoses; Pipes & Air Flow			
Check Tension on Power Steering Oil Lines & Steering Gear			
Check for Exhaust Leakage			
Check Turbo Connections			
Check Fuel system for leaks & lines for condition & security			
Check Engine for excessive oil leaks			
Ensure that any fire and smoke detection systems fitted in the vehicle are correctly connected and working.			

Item or System to be Checked or Inspected to Reduce the Risk of Fire	Requires rectification		Rectified
	Yes	No	
Underbody			
Check that all exposed cables are secure and not chafing and that there is no loose wiring.			
Check that all clamps and cable ties are connected correctly and are secure.			
Check all fuel and hydraulic lines are secure and leak free.			
Front Axle & Suspension			
Check front Axle Vent			
Check Hubs have sufficient grease and or oils.			
Rear Axle & Suspension			
Check Rear Axle Vent			
Check Hubs have sufficient grease and or oils.			
Brakes& Disc Pads			
Check Air Lines & Hoses are Free of Leaks & Secured			
Check For Leakage from Hubs onto Linings			
Check Brake Cylinders Levers & Forks			
Check Brake Lever Travel			
Check Electronic Cables to Wear & ABS Sensors			
Tyres and Wheels			
Check Recaps for tread separation			
Check Set pressures to manufacturers specs & test valves for leaks			
Check Tyre wall condition with particular attention to bead area			
Cleaning			
Wash Engine bay area & Batteries			
Clean all fluid or grease deposits or rubbish from the engine, transmission and surroundings.			
Check that the radiator, intercooler and oil cooler are free of debris.			
Clean the battery surfaces and terminals			
Pressure Tests			
Check for Coolant Leaks and Conduct regular Cooling System Pressure Tests			
Before Road Test			
Check Engine Oil Pressure Gauge Reading			
Check Warning light for ABS is Activated			

The above list would vary dependent on the bus or buses being inspected, but the items listed are the basic items that can contribute to the fire risk.

Appendix 8 Generic Driver Pre-Departure and Operational Check Sheet

Table 14 Driver Pre-Departure and Operational Check Sheet Pro-Forma

Driver Pre-departure and Operational check sheet Pro-Forma			
Items to be checked or observations required		**Requires Rectification**	
		Yes	**No**
A	***Driver Pre-Departure Checks***		
1	Look for tyres that are flat or partly flat.		
2	Check that tyres on dual wheels are not touching one another.		
3	Make sure that no liquids are leaking onto the road, or into the engine compartment.		
4	Water coming from the air conditioning system is okay – any other dripping, spray or misting is not.		
5	Check that the exhaust brake is working correctly if your vehicle has one.		
6	Check that the brakes release properly and that the air gauges are all in the normal position.		
7	Check that there is no oil coming from the exhaust pipe and no debris in the pipe.		
8	Check for excessive blue smoke from the exhaust – this could indicate the turbocharger is burning oil.		
9	Check that the vehicle has an unexpired fire extinguisher.		
B	***Checks When Operating the Bus***		
1	Check the temperature gauges for overheating.		
2	Check the low tyre pressure monitor if your vehicle has one.		
3	Check the air pressure gauge and/or warning light. Low air pressure can cause spring brakes to apply and bind.		
4	Check the ABS warning light.		
5	Check that the retarder is working properly.		
6	Check for any alarms or alerts on the instrument panel, if in doubt seek advice on what the issue is.		
C	***End of Shift Checks***		
1	Record any problems in the vehicle's defect card/sheet.		
2	Tell a mechanic or the next driver if there are problems that require attention.		

References

References

Addendum 106: Regulation No. 107 Revision 3 18 October 2011.

Ahrens, M, 2010, *U.S. Vehicle Fire Trends and Patterns*, National Fire Protection Association.

American Public Transportation Association, 2010, TS 40.1.6 *Master Battery Switch Standard Bus Procurement Guidelines*, Washington, DC.

American Public Transport Association, 2009, *Recommended Practice for Installation of Transit Vehicle Fire Protection Systems*, APTA Document Number BTS-BS-RP-003-08.

American Public Transport Association, 2010, *Standard Bus Procurement Guidelines RFP*, Washington, DC.

Australian Bureau of Statistics, 2011, *Census of Motor Vehicle Use, Australian* Government, Canberra.

Australian Design Rules 44/00 and 58/00.

Australian Design Rule 58/00, 2006, *Requirements for Omnibuses* Designed for Hire and Reward.

Australian Standards 3791, 1991, *Hydraulic Hoses* (Amended 1995).

Australian Standards 2444, 2001, *Portable fire extinguishers and fire blankets* - Selection and location. pp.19.

Australian Standards 5062, 2006, *Fire Protection for Mobile and Transportable Equipment*.

Bureau of Infrastructure, Transport and Regional Economics and CSIRO, 2009, *Modelling the Road Transport Sector*, Treasury, Canberra.

Bus Industry Confederation, 2010, *Industry Survey*.

Bus Industry Confederation, 2011, Based on bus sales data recorded in Australasian Bus and Coach Magazine.

Cosgrove, D. 2011, *Long Term Patterns of Australian Public Transport Use,* Australasian Transport Research Forum 2011 Proceedings 28 - 30 September 2011, Adelaide, Australia Publication website: http://www.patrec.org/atrf.aspx.

Crescenzo, RA 2012, *Bus Fires in the United States: Statistics, Causes and Prevention*, Proceedings from 2nd International Conference on Fires in Vehicles – FIVE 2012, Chicago, USA, p.13.

Fire Protection Association of Australia Tasmanian Branch, 2007, *Guide to the Selection and Location of Portable Fire Extinguishers and Fire Blankets.*

Hardy, L, 2013 *Collated Insurance Data*, Bus Industry Confederation, Canberra.

Hardy, L, 2013, *Collated Media and Published Data*, Bus Industry Confederation, Canberra.

http://www.csiro.au/Outcomes/Safeguarding-Australia/FireTriangle.aspx.

Insurance Data from interviews with various Australian Insurers 2012. (See Figures 1-4 for results).

Johansson, E. and Yang, J., 2011, *Motorcoach Flammability Project Final Report: Tire Fires – Passenger Compartment Penetration, Tenability, Mitigation, and Material Performance.* Technical Note 1705.

Insurance Data from interviews with various Australian Insurers 2012. (See Figures 1-4 for results).

Liu, Y., et al, 2007, *Road Tunnel Fire and Life Safety Issues*, Fire Science and Technology Laboratory CSIRO, Manufacturing and Infrastructure Technology.

Meltzer, N., Ayres, G. Truong, M., 2008, *Motorcoach Fire Safety Analysis*, Federal Motor Carrier Safety Administration.

Metropolitan Fire & Emergency Services Board Community Safety Directorate, 2009, *Guideline No: GL-16.*

Office of Transport Safety Investigations, 2011, *Report on the Hillsdale bus Fire bus fire Involving STA bus Mo4878*, NSW Government, Sydney.

Office of Transport Safety Investigations, 2013, *Bus Fire Information tabulated by OTSI for Jul 2012 to Sep 2013*. NSW Government, Sydney.

OTSI Bus Safety Investigation Report: An Investigation into bus fires in NSW 2005-2012.

Minister for Infrastructure and Transport the Hon. Anthony Albanese MP, 2012, *Bus Industry – Keeping the Nation Moving*. Speech to Bus Industry Confederation Annual Dinner, Canberra, March 2012.

Roads and Maritime Services NSW, 2013, *Information Alert 20 Coolant Leaks Roads & Maritime Services - Compliance and Regulation*, NSW Government Sydney.

Safety Data Sheet, Air1® pdf and AdBlue® Product safety information sheet according to Regulation (EC) No. 1907/2006, Article 32 Aqueous Urea Solution.

Smyth, S. and Dillon, S. 2012. *Common Causes of bus Fires,* SAE International, August 2012 (2012-01-0989).

TCRP, Synthesis 12: *Transit bus Service and Cleaning Functions*, pp.19.

The West Australian, Monday 10 April 1950.

Tourism Research Australia, 2008, Transport Fact Sheet, Department of Resources, Energy and Tourism, Canberra.

Transportation Research Board of the National Academies Washington, D.C. (2011). *NCHRP SYNTHESIS 415, Design Fires in Road Tunnels A Synthesis of Highway Practice*, Washington, D.C.

Verband Deutscher, V. 2005. *Fire Protection in Vehicles and Tunnels for Public Transport*, VDV-Forderkreis, ISBN 3-87094-664-4 Dusseldorf, Germany, pp. 503.

Vehicle Standard Australian Design Rule 58/00, Requirements for Omnibuses Designed for Hire and Reward 2006.

Vehicle Standard Australian Design Rule *Definitions and Vehicle Categories 2005*, Compilation Date: 31/05/2012.

Vehicle Standards Instruction, 2003, *Fire Extinguishers in Buses*, Public Passenger Vehicles Inspection Number P 5.0.

Wormald Portable Fire Equipment Solutions www.wormald.com.au.

BIC
Bus Industry Confederation
moving people

BUS INDUSTRY CONFEDERATION
PO Box 6171, KINGSTON ACT 2604

Tel: +61 2 6247 5990
Fax: +61 2 6273 1035

Email: enquiries@bic.asn.au
Web: www.ozebus.com.au

Bus Australia Network

BIC Bus Industry Confederation moving people

busnsw

BusSA Bus & Coach Association SA

BusVic Bus Association Victoria

QBIC

TasBus

WARTA BUS WA