TECHNICAL INFORMATION

Fire safety in electric bus depots

1 Purpose

This technical information sheet details Fire and Rescue NSW (FRNSW) recommendations to mitigate the risk of fires in electric vehicle bus (EV bus) depots and provide measures that assist intervention activities and firefighting operations during a fire emergency.

2 Scope

This technical information sheet details:

(a) specific risks of EV buses to consider in the planning and design of bus depots

(b) fire safety measures adequate to the specific hazards of EV bus depots

(c) additional requirements that will facilitate fire brigade intervention

(d) requirements for open air parking and the charging of EV buses, and

(e) workplace fire safety and emergency planning in case of an EV bus fire or emergency.

3 Application

This document applies to any new and existing facility proposed to be used as an operating base for electric-powered passenger omnibuses (i.e. EV buses), including for the parking, repairing, maintaining and charging of EV buses, among other functions (i.e. a bus depot).

Note: The bus depot may also hold other energy powered buses, such as diesel, hydrogen and compressed natural gas (CNG).

This document does not apply to any stationary energy storage systems and power-generating system, such as photovoltaic (PV) arrays installed at the bus depot.

Note: The fire safety of these systems should be in accordance with relevant national, state, or local government requirements.

This document is based on known hazards of current electric vehicle battery technology. When a new battery type or technology is proposed, the existing fire safety measures must be reviewed.

Unless stated otherwise, the considerations within this document do not overrule any other national, state, or local government requirement.

4 Background

As the NSW government transitions the state's bus fleet to Zero Emission Buses (ZEB) to achieve net zero emissions by 2050, the development and refurbishment of supporting infrastructure is necessary to manage the new hazards associated with EV buses. EV buses are primarily powered by lithium-ion batteries that present unique fire safety risks and challenges for firefighting.

Although the total fire load for EV buses may not differ significantly from that of internal combustion engine buses, the presence of lithium-ion battery packs and their charging processes introduces additional fire hazards in parking and charging facilities and during operation including collisions.

One significant risk associated with lithium-ion battery packs is thermal runaway, a self-sustaining exothermic chain reaction within the battery pack triggered by thermal abuse (e.g. exposure to heat), mechanical abuse (e.g. impact or collision damage), or electrical abuse (e.g. overcharging, battery fault). This can occur while driving, charging, or when the bus is parked.

Thermal runaway causes an uncontrollable temperature rise within battery cells and emission of large volumes of toxic and flammable gases, potentially resulting in a battery fire, toxic cloud, and gas explosion. Fires involving EV buses therefore can generate higher heat and smoke output and directional jet like flames. Large lithium-ion battery packs will burn for longer periods and require significantly more water to cool and protect exposures compared to more conventional bus fires.

When fire involves a lithium-ion battery, firefighters will take a defensive strategy of containing fire while the battery self-consumes. While fire sprinklers help control fire, thermal runaway is difficult to control due to being a chemical reaction. Prolonged cooling of the batteries is necessary but challenging due to their location and enclosed design (i.e. pack containing individual battery cells). Re-ignition can occur hours, days, or even weeks after initial extinguishment.

5 Planning and design requirements

5.1 General principles

5.1.1 All new bus depot sites are to comply with the *National Construction Code* (NCC). FRNSW consider EV buses to be a special hazard under E1D17 and E2D21 of the NCC.

5.1.2 FRNSW should be consulted in the planning and design of all bus depots intended to serve EV buses regardless of whether formal referral to FRNSW is required or not.

Note: The unique risks associated with EV buses should be addressed through fire engineering assessment.

5.1.3 Existing bus depot sites proposed to serve EV buses may not have been designed for the specific risks associated with EV bus fires, therefore existing fire safety measures must be evaluated against these new and specific risks for the site.

5.1.4 The EV bus depot should be open-to-air and only contain buildings required for operations (e.g. office, workshops), preferably having full perimeter vehicular access.

5.1.5 FRNSW does not support any over-site development (OSD), or integrated site/depot development (ISD/IDD) being connected to the EV bus depot.

5.1.6 A fire engineering assessment should be used to identify potential hazards and risks to on-site staff, firefighters, neighbouring sites and the public including fire, explosion, electric hazards, and toxic gas impact.

Note: This assessment should form the basis for potential fire scenarios and to identify required fire safety measures.

5.1.7 Supporting analysis and evidence are required to be provided to demonstrate that the fire safety measures proposed for new or existing workshops are adequate to manage the fire risks resulting from fires involving EV buses and any other hazardous storages.

Note: Any information and inputs relied upon in the fire engineering assessment should be current and published by reputable sources.

5.2 Fuel loads and fire source features

5.2.1 The bus depot must include measures to limit the risk of fire spread between buses and to other combustibles. For any bus depot having limited separation to fire-source features, a quantitative assessment of the potential risk for fire to spread off site is to be undertaken.

Note: The assessment should identify measures to prevent fire spread and mitigate impact from any deflagration or explosion of a vapour cloud within an enclosed space.

5.2.2 The bus depot should manage buses to be parked into clusters that provide sufficient separation distances between each bus cluster to prevent fire spread.

5.2.3 The maximum number of buses and overall dimensions of each cluster must be appropriately determined considering such factors as, but not limited to:

(a) how close buses, and bus clusters, are parked together

(b) specific fire hazard posed by each bus type (e.g. combustion, electric or CNG)

(c) proximity to other storage areas and combustible fuel loads

(d) installed fire safety systems (e.g. ability of system to limit fire spread)

(e) occupant egress pathways and final exits (both occupants and vehicles)

(f) premises allotment boundaries (i.e. fire source features)

(g) fire brigade access (e.g. for emergency vehicles and to firefighting equipment).

Note: A quantitative and deterministic analysis of each factor should demonstrate suitable separation distances under the worst credible fire scenario, including consideration of wind impact, jet flames, EV battery explosion, etc.

5.2.4 Where possible, buses having different engine types (e.g. combustion, electric or CNG) should be parked into separate clusters and in segregated parking areas.

Note: Segregated parking will enable prompt identification of the bus type and allow firefighters to undertake fire brigade intervention specific to the risk.

5.2.5 Each bus cluster must have suitable separation from other fuel sources (e.g. diesel tanks, battery storage, stationary energy storage system, hazardous chemicals etc.), such as fire rated walls or sufficient separation distance that prevents fire spread.

Note: A quantitative assessment should be undertaken to demonstrate that fire will not spread from bus clusters to other fuel sources, and vice versa.

5.3 Designated isolation area

5.3.1 Any damaged or faulty EV battery, whether being an individual battery pack or an EV bus containing the damaged battery, is to be separated within a designated isolation area located away from other vehicles, buildings and exposures.

Note: A quantitative assessment should be undertaken to demonstrate that the separation provided is adequate.

5.3.2 The isolation area should be open to air and provide means for fire brigade intervention (e.g. access, fire hydrants, containment) should an EV battery go into thermal runaway.

Note: Damaged EV batteries should not be stored in any under-ventilated enclosed space due to the risk of the EV battery exploding.

5.3.3 Any damaged or faulty EV battery is to be kept within the isolation area until there is little likelihood of re-ignition or delayed ignition occurring from thermal runaway.

6 Fire safety measures

6.1 Fire hydrant system

6.1.1 FRNSW requires an AS 2419.1 fire hydrant system be installed and provide coverage for the whole bus depot, including coverage to all outdoor parking and charging areas.

Note: Clause 3.9 of AS 2419.1:2021 details requirements for open-yard protection of any protected area that contain special hazards.

6.1.2 The fire hydrant system must have a water supply (flow and volume) suitable for extended duration firefighting operations. This is to be determined through assessment of the worst credible fire scenario, which includes prolonged cooling of EV batteries in thermal runaway.

Note: Large quantities of water are needed to contain, extinguish and cool fire damaged lithium-ion batteries over an extended duration.

6.1.3 The water source, adequacy and quality available for firefighting operations must be in accordance with AS2419.1 (i.e. clean, non-recirculated water).

Note: The fire hydrant system cannot (re)use any contained fire water run-off as a source of firefighting water.

6.2 Automatic fire suppression system

6.2.1 FRNSW recommends an AS 2118 automatic fire suppression system be installed within any maintenance or workshop buildings (i.e. any building which may occupy EV buses) and have a minimum floor area of 1,000 m^2.

6.2.2 The design of any fire sprinkler system should be appropriate to the hazard class (e.g. 'high hazard' class) and have a minimum level of performance that will minimise fire spread and reduce the likelihood of any structural damage.

6.3 Smoke hazard management

6.3.1 FRNSW recommends smoke hazard management be installed in buildings to ensure tenable conditions for safe evacuation of occupants and facilitate fire brigade intervention.

6.3.2 Automatic smoke/heat vents or smoke exhaust system should be provided and direct toxic smoke and gases away from areas where firefighters will likely be operating, and away from locations where any other air handling system might be drawing fresh air from.

6.3.3 An automatic fire detection and alarm system must be installed to provide early warning of fire, whether triggered from any detection device or fire sprinkler system installed within buildings or any suitable external detectors.

6.3.4 Where possible, the EV bus battery management system (BMS), the charging device's intellectual response system, or CCTV cameras should be utilised to investigate and provide early warning of any abnormal conditions.

6.4 Fire safety schedule

6.4.1 The layouts, arrangements and hazard profiles for the bus depot should be detailed in a fire engineering report that is listed on the fire safety schedule for the depot as an essential fire safety measure.

6.4.2 Any proposed changes to the bus depot, such as increase in EV bus numbers, change of battery chemistry, alternate fuelled buses, change in cluster size, new or modified buildings etc., will require a reassessment of the fire engineering report to be undertaken.

7 Fire brigade intervention

7.1 Fire brigade access

7.1.1 The bus depot must provide safe, efficient and effective access to fire brigades as detailed in FRNSW guideline *Access for fire brigade vehicles and firefighters*.

7.1.2 Where possible, the bus depot should provide full perimeter emergency vehicle access around the site.

Note: If not possible, a quantitative assessment should be undertaken to demonstrate that an uncontrolled fire will not spread off site to an adjacent premises.

7.1.3 During fire, buses may need to be relocated away from the fire-affected zone and/or evacuated from the depot site if safe to do so, therefore:

(a) vehicle exits and entrances to the depot must accommodate both the evacuation of buses and fire brigade access at the same time (e.g. a fire brigade booster hardstand must not block an exit/entrance),

(b) the bus depot must detail within the site's emergency plan procedures for relocating buses, including to not obstruct fire brigade access (e.g. access for emergency vehicles and/or firefighter access to any installed firefighting equipment).

7.2 Fire water run-off containment

7.2.1 The bus depot must include provision to contain a large amount of contaminated fire water run-off in the event of fire.

Note: Calculations should demonstrate the adequacy of proposed containment, including net water discharge from both the fire hydrant and fire sprinkler systems over the expected duration of the worst credible fire scenario.

7.2.2 Any fire water containment system must ensure that contaminated run-off water is not able to enter any local water course or groundwater.

7.2.3 Where a containment system is proposed to be connected to the reticulated stormwater, provision must be made for isolation of the system by way of automatically operated valve that closes upon activation by a relevant fire safety system.

7.3 Emergency shutdown equipment

7.3.1 A master emergency shutdown switch must be provided at the fire control centre (FCC) located at the main entrance to the bus depot.

Note: The master emergency shutdown switch should enable firefighters to isolate power to all EV bus chargers within the depot in single action.

7.3.2 An additional emergency shutdown switch should be provided at any other fire brigade panel (FBP) that is installed (e.g. at any alternate site or building entrance point).

Note: The emergency shutdown switch should isolate all EV bus chargers only.

7.3.3 Local emergency shutdown switches or break glass units must be provided within proximity of EV bus charging bays and must isolate power to all EV bus chargers.

Note: Local shutdown switches should activate the fire alarm system and automatically notify the fire brigade.

8 Outdoor parking and charging areas

8.1 General requirements

8.1.1 Outdoor parking and charging areas must remain clear of all egress pathways and not be located near any final exit, whether occupant or vehicle, from the bus depot site.

8.1.2 Outdoor parking and charging areas must have clear separation from installed firefighting equipment (e.g. fire hydrants, fire brigade booster) or other emergency equipment.

Note: If there exists any potential for fire spread, a quantitative assessment should be undertaken to demonstrate what measures need to be provided in order that fire spread will not occur.

8.1.3 Outdoor parking and charging areas should include automatic early fire detection, such as flame detectors, and trigger a fire alarm system which automatically calls the fire brigade.

8.1.4 Outdoor parking and charging areas must have adequate lighting to aid visual identification of fire (i.e. smoke being visible) and to assist with firefighting intervention at night.

8.2 Charging bays

8.2.1 EV bus charging bays must be located outdoors in well-ventilated areas to reduce the risk of an EV bus battery pack going into thermal runaway and potentially result in an explosion.

Note: Any EV battery explosion confined within a building will likely result in severe structural damage and possible collapse of the building.

8.2.2 All charging bays should include real-time 24/7 monitoring of charging faults or other abnormal events, particularly when charging occurs overnight, which may include:

(a) CCTV cameras being positioned around the perimeter and monitored by security or other staff for any indications of fire or other incident.

(b) continuous monitoring of each charging bay while in use, either through the BMS of the EV bus on charge or via monitoring of the charging system, to ensure:

- fully charged buses are immediately disconnected from the charging system, and
- the charging system is isolated or disconnected, and an alarm sent to operators and maintenance staff when a fault is detected in an EV battery.

(c) an intelligent response system (e.g. response to overcurrent, short circuit, over voltage, over temperature protection etc.) being incorporated into each charging system.

8.2.3 All charging bays must be provided with bollards located to protect the charging equipment from mechanical damage from vehicle impact.

9 Fire risk management

9.1 Management in-use (MIU) plan

9.1.1 A management in-use (MIU) plan must be implemented for the depot to identify and minimize fire risks including, but not limited to, the following:

(a) a battery management plan, documenting procedures to manage EV batteries through their full life cycle (e.g. charging, replenishment, repair/replacement and disposal)

(b) an operations plan, documenting procedures for movements between parking, maintenance and refuelling, including charging of EV buses at charging bays

(c) a parking plan, documenting the maximum number of buses permitted to park in each cluster, engine type of cluster (if applied), and maximum dimensions of each cluster.

9.1.2 The MIU plan should outline procedures for responding to a charging fault or other abnormal event being detected (refer to clause **Error! Reference source not found.**).

Note: The procedures should specify conditions in which to notify the fire brigade should it not yet be activated by an automatic fire detection and alarm system.

9.2 Emergency plan

9.2.1 Clause 43 of the *Work Health and Safety Regulation 2025* requires any person conducting a business or undertaking (PCBU) to provide an emergency plan for their workplace, detailing emergency procedures for staff and occupants of the premises.

9.2.2 An emergency plan must be developed for the bus depot in accordance with *AS 3745–2010 Planning for emergencies in facilities.*

9.2.3 The emergency plan must identify training for staff (including drivers) on their roles and responsibilities in responding to an emergency event, which includes an EV bus fire.

9.3 Emergency services information

9.3.1 An emergency services information package (ESIP) should be developed for the bus depot, as detailed in FRNSW guideline *Emergency services information package and tactical fire plans*.

9.3.2 The ESIP should include, but not limited to, the following specific information:

(a) a site plan identifying bus parking layout (including bus types if separated), charging bays, buildings, high-risk areas (e.g. combustible storage), vehicular access points and travel paths, and installed firefighting equipment.

(b) details of installed firefighting equipment including a copy of the fire hydrant system block plan, fire sprinkler system block plan, water supply details (e.g. water capacity, flows and pressures)

(c) details of emergency shutdown equipment including type, activation conditions, system overrides, and any other relevant procedures (e.g. system resetting).

(d) details of fire water run-off containment including relevant procedures, isolation valve locations, capture capacity, drainage catchment mapping (showing terrain fall).

(e) details of any other hazards that may impact upon fire brigade intervention, such as combustible storage, hazardous chemicals, electrical substations, high-risk exposures (protection of), environmental risk, transport infrastructure in close proximity.

(f) contact details of a site representative available 24/7 who can liaise with firefighters and assist with locating the EV bus involved and identify the model of EV bus.

9.3.3 If available from the vehicle manufacturer, a copy of the Australasian New Car Assessment Program (ANCAP) 'rescue sheet' should be provided for each make and model of EV bus being housed at the bus depot.

Note: The ANCAP rescue sheet provides critical information to firefighters on the locations and chemistry of batteries, high voltage components and cables, power isolation, etc. Copies can be provided in either hard copy, hyperlink or QR code format.

9.3.4 The ESIP should identify any strategy for relocating buses away from a fire-affected area, such as identifying any nearby off-site temporary parking. If safe to do so, buses may be moved off premises under direction of the incident controller as part of the firefighting strategy.

Note: Under no circumstance should drivers attempt to relocate any bus in the event of any fire, especially any EV bus involved in or adjacent to the fire.

9.3.5 The bus depot should have appropriate signage and markings, including warning signs (e.g. no smoking, electrical hazards and hazardous chemicals), parking and charging bay markings, fire safety system signage, hardstand markings, egress pathway markings etc.).

10 Contact us

For further information contact the Fire Safety Branch on (02) 9742 7434 or email firesafety@fire.nsw.gov.au.