10.28 Lithium-Ion Batteries Undergoing Thermal Runaway SOP

Section 1 - Purpose and Objectives

(1) To provide information, hazards and tactics when undertaking operational activities involving lithium-ion batteries undergoing thermal runaway.

Section 2 - Scope

(2) This procedure applies to all CFA members.

Section 3 - Procedure

Background

(3) Thermal runaway is an uncontrolled chemical reaction within the battery cell. This causes a rapid discharge of the cells energy, resulting in an uncontrolled temperature rise, which results in a fire or 'off gassing'. The cause of thermal runaway to a lithium-ion battery can be as a result of:

a. Physical damage – being impacted by an external force, submerged in water, short circuit; or
b. Over heating/loading or charging.

(4) When in thermal runaway, lithium-ion batteries can behave in two distinct ways and produce different hazards:

a. Catch fire:
    i. smoke; and/or
    ii. blow torch-type flame behaviour.
b. Off gas (with no fire):
    i. pressurised toxic vapour/gasses released (including volatile organic compounds (VOCs)); and/or
    ii. vapour cloud explosion (VCE).

(5) Thermal runaway can produce other common hazards, including, electrocution, secondary ignition, burns and projectiles.

Suppression Strategies

(6) Where lithium-ion batteries are either on fire or off gassing, Incident Controllers should consider the following three suppression/control strategies:

a. Cooling.
b. Submerging.

c. Controlled burn out.

(7) With all three strategies ventilation and monitoring should be considered.

(8) The size and location of the lithium-ion battery will help determine the appropriate suppression strategy. (see table two).

(9) The Incident Controller,(where possible and available)should seek specialist advice from the relevant manufacturer, distribution companies, and other relevant agencies/organisations, when determining control strategies. This may include site information, books and manuals.

(10) A single strategy may be used or a combination of the three. All have different strengths and weaknesses the Incident Controller should consider:

Table One

Options	Actions	Strengths	Weaknesses
Cooling/Suppress (Water) Water is the best extinguishing agent. Note – foam use may not assist in cooling and may inhibit use of a thermal imaging camera (TIC) to assess/monitor the battery.	Water is continually applied to extinguish the fire and to cool the battery pack/cells to ambient temperature.	1. May (in some instance) reduce time on scene. 2. May reduce the production of vapour and smoke. 3. Limits fire spread.	1. Large amounts of water and constant supply is required. 2. Large scale water run off and environmental protection measures are often required. 3. Can be difficult to get water into the battery pack and the seat of the fire/heat.
Submerge (Water)	The battery pack (and/or the item its attached to) is submerged in a body of water.	1. As per cooling (above). 2. Contains battery and limits fire spread to exposures. 3. The likelihood of secondary ignition is reduced.	1. Obtaining a water container of suitable size and type. 2. Safety to firefighters during submersion operations of the battery. 3. Large scale water run off and environmental protection measures are often required. 4. Even when underwater, gases can continue to be emitted (leading to VCE).
Controlled burn out	The battery pack (and/or the item it's attached to) is allowed to burn out in a controlled manner. Firefighting operations focus on protecting exposures. Note – Beware of explosion risk (VCE), if off gassing in an enclosed structure e.g. car passenger compartment, garage or room/building.	1. Water usage is focused on protecting adjoining assets. E.g. other batteries preventing further thermal runaway. 2. May be better for enviromental protection and water run off where these cannot be otherwise mitigated.	1. Potential fire spread to exposures if not appropriately mitigated. 2. Continued smoke and vapour will be produced including potential for VCE. 3. Duration will depend on battery size.

(11) Further guidance can be found in the 2021 Australian and New Zealand Emergency Response Guide Book (this guide provides emergency response information for dealing with accidents, spills, leaks or fires involving dangerous goods).

Actions for the Incident Controller

(12) Set up an exclusion zone. Be aware that projectiles may be released (explode) from the battery. Refer to the 2021 Australian and New Zealand Emergency Response Guide Book for further information. The size of the exclusion zone will vary according to the type of lithium-ion battery.

(13) Conduct a 'size up' of the fire or incident and apply the dynamic risk assessment process.

(14) Ensure a thermal imaging camera (TIC)is used to locate the hottest area of the battery pack.

(15) Apply the principles of RECEO. See SOP 9.28 Strategy and Tactics for further information.

(16) Consider public messaging refer 9.42 Requesting and Issuing Community Warnings SOP.

(17) Ensure a thermal imaging camera (TIC)is used to monitor battery temperature.

(18) Prepare for thermal runaway (secondary ignition) if battery temperature increases (above ambient).

(19) Once suppressed and battery is at ambient temperature, consider monitoring for a further 60 minutes.

Post Incident

(20) The following relevant details of the lithium-ion batteries and charging equipment where possible are to be recorded and included in the fire report (FIRS):

a. brand, make, model, serial number and year of manufacture;
b. charging status of the lithium-ion batteries prior to the fire occurring;
c. whether the lithium-ion batteries were on charge at the time of the fire; and
d. what appliance, battery storage system, equipment, mobility device, power tool or portable device the lithium-ion battery was being utilised to supply power for.

(21) Incident Controllers are to ensure Energy Safe Victoria (ESV) is notified of electrical fires that have been determined to originate and have been caused by lithium-ion batteries or associated charging equipment (via District Duty Officer or State Duty Officer).

(22) CFA members are not to collect, store or transport any lithium-ion batteries or associated charging equipment that has been damaged or impacted by heat or fire from the scene of an incident.

Handover of scene

(23) The Incident Controller is to ensure, where reasonably practicable, information on potential hazards (e.g. secondary ignition) and how to identify signs of thermal runaway are provided to appropriate person.
Suggested advice is outlined in Table Two.

Table Two

Categories/types of lithium-Ion batteries	Small/Portable devices	Light mobility devices	Light (utility) vehicles	Road registered electric vehicles	BESS

Categories/types of lithium-Ion batteries	Small/Portable devices	Light mobility devices	Light (utility) vehicles	Road registered electric vehicles	BESS
Description	Mobile phones, laptop computers, Cordless tools etc	eBikes, eScooters, eSkateboards	Golf buggies, ATVs, Powered wheelchairs, Mobility scooters	Bikes, cars, buses and trucks	Residential to commercial, large grid
Handover message	Damaged device is to be stored away from any exposures and not to be returned inside a structure. Recommend to the owner to contact local Council/Shire or EPA for disposal options.			Damaged vehicle must be quarantined or isolated from exposures or stored for a minimum of 15 metres from other exposures due to the risk of re-ignition (secondary ignition/fire) of the battery, which could occur at any time. Have the vehicle inspected by a suitably qualified person.	
General handover information for all categories	Secondary ignition is a subsequent thermal runaway event (fire) resulting from damage to the battery cells that has occurred during the initial incident. This secondary ignition may occur regardless of fire brigade intervention and may happen sometime after the initial incident. Signs of secondary ignition are popping, hissing, whistling, projectiles, and dark and light coloured vapour cloud coming from the battery. If thermal runaway is suspected call triple 000 immediately. Secondary ignition can occur at any time and may occur many weeks after the initial fire.				

Safety Notes

(24) Do not transport or carry on person affected lithium-ion batteries.

(25) Follow the principles of 'DANGER' where applicable – refer to SOP 10.09 HAZMAT Response.

Environmental Notes

(26) Members should consider and attempt to contain contaminated fire water run-off where operationally practicable.

Definitions

(27) Commonly defined terms are located in the CFA centralised glossary.

Section 4 - Related Documents

(28) SOP 10.29 Electric Vehicles

(29) SOP 9.28 Strategy and Tactics

(30) 2021 Australian and New Zealand Emergency Response Guide Book

(31) EV Fire Safe

(32) AFAC: Incidents Involving Electric Vehicles

Status and Details

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Effective Date	To Be Advised
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Approval Authority	
Approval Date	To Be Advised
Expiry Date	Not Applicable
Accountable Officer	Jason Heffernan Chief Officer
Responsible Officer	Garry Cook Deputy Chief Officer Operational Response & Coordination
Author	Tracey Parkhill
Enquiries Contact	Safety Compliance

Glossary Terms and Definitions

"CFA member" - Refers to all CFA volunteers, volunteer auxiliary workers, officers, employees and secondees.

"Incident Controller" - The individual designated by the control agency to have overall management of the incident and who is responsible for all incident activities.

"FIRS" - Fire and Incident Reporting System.

"Thermal runaway" - Thermal runaway is an uncontrolled chemical reaction within the cell. This causes a rapid discharge of the cells energy, resulting in an uncontrolled temperature rise. In Lithium batteries this can create a flammable and toxic vapour. Temperatures can exceed 1000°C, igniting vapours can be violent and explosive in nature. Common signs of thermal runaway Popping, Hiss/whistle - gases venting, Projectiles, Dark & light-coloured vapour cloud coming from the battery pack (BESS).

"RECEO" - Rescue, Exposures, Containment, Extinguishment and Overhaul.