PROCEDURE

Energy storage systems

IS4-SOPb

Introduction

When to use	This document describes the procedures to follow when dealing with a fire or physical damage to energy storage systems (ESS). These systems are modern storage batteries usually with a lithium or nickel base. These procedures must be followed for any incident which results in an emergency response by Fire and Emergency New Zealand. ESS systems can be found in: • electric vehicles • residential or commercial installations, or • electricity supply authority installations, (substations) This procedure must be read alongside the guidance in the IS4 suite of policy and guidance, as well as the training modules on Learning Station: • Electricity 1: How electricity works • Electricity 2: Working safely around electricity
Vehicles Background	There has been an increasing number of incidents involving these systems of batteries, resulting in property damage and a potential safety hazard to responding crews. Electric vehicles are becoming more common, and the range is extending to heavier vehicles, (busses and trucks). Lithium or nickel based batteries are found in three types of vehicles: • hybrid electric (HEV) • plug-in hybrid (PHEV) and • electric vehicles (EV), increasingly seen on New Zealand roads. These vehicles may operate on a combination of petrol/diesel engine plus electric motor, or be 100% electric. The high voltage electric component can be between 200 and 800 volts DC.
Static battery background	Energy storage systems made up of lithium or nickel based batteries can also be found in buildings. These installations support electricity supply in part or wholly “off-grid” installations. These can be part of solar/wind and water generated power storage systems. ESS are also used as storage for off-peak (cheaper) power. This is then used as peak power supply support. These can be very large installations and can be found in: • residential housing • commercial/industrial buildings • electricity supply authority infrastructure (substations). **Note:** There is also an increasing number of lithium or nickel based batteries in small appliances, electric toys, mobility scooters and electric bikes. The hazards are the same for these size batteries.

Hazards	Lithium and nickel based batteries present a hazard when damaged physically or electrically. A situation involving chemical breakdown inside the battery, called **thermal runaway,** can occur. This causes the battery cells to overheat, releasing toxic and volatile fumes, and sometimes igniting and/or causing vapour explosion. Once thermal runaway occurs, damaged cells can induce failure in other cells within the battery. The heat and vapour pressure created as the batteries break down means battery casings can rupture violently. This is not the battery content exploding, but the vapours creating an overpressure rupture. These vapours are highly toxic and flammable. Vapour build-up can create a potentially explosive situation. Level two and breathing apparatus will be required if there is any suspicion of battery failure in motor vehicle accidents, and for any fire scenario involving any size lithium or nickel based battery. There is a risk of PPE and respiratory protection equipment (BA) contamination, requiring decontamination. The mix of contaminants cannot be reliably defined, but one possible vapour and liquid contaminant is **hydrofluoric acid**. This acid has very toxic and corrosive properties. See Post incident considerations/requirements below. **Note:** The lack of industry standards makes it impossible to reliably determine what toxic and hazardous substances may be present during battery breakdown. Using the possibility of hydrofluoric acid as the default contaminant will give sufficient guidance for PPE and hazard management.

Pre-incident planning

Fixed battery installations	Uninterruptable power supplies (UPS) are used in many business and some residential locations, to avoid computer and control equipment failing in power outage situations. Where operational plans are being developed for a location, knowledge of any battery storage is to be recorded in the hazards section of the Site Report. Tactical Plan scenarios should consider issues if the installation is damaged, threatened or involved in fire, flooding or other damage. Increasingly, power supply retailers are considering local suburb based battery support in the form of battery substations for peak power demand management. This uses off peak power stored in the batteries to balance the peak load demand on a daily basis. **Note:** Where power suppliers are using peak demand management with battery installations, areas are to ensure stations have at least a generic site report for managing the situation.
Mobile battery installations	Battery storage is lithium or nickel based, and this presents a hazard when attending motor vehicle accidents where the batteries can be damaged by impact or fire. Damaged batteries may not show any visual sign of damage, but may already be in a thermal runaway event. Early monitoring with thermal imaging and/or gas detection is desirable, but may not be achievable. Vigilance is required if monitoring equipment cannot be deployed on the first response vehicles.

Operational considerations

Assessing the situation

On arrival, crews approaching the incident should be mindful of the potential for a lithium or nickel based battery to be onsite, or on-board, and possibly involved in the incident.

Where the presence of large storage batteries is suspected or known, and damage has or is likely to have occurred, breathing apparatus (BA) should be worn from the start of scene assessment through all phases of stabilising the incident.

Residential and commercial installations of batteries can also be charged by:

- solar panels (photovoltaic cells/PVs)
- wind turbines
- an electric vehicle (i.e. homes-back-fed from the charge in the vehicle).

Power for charging batteries may not be from a reticulated mains power supply. Crews need to be aware of the continuous supply from any non-reticulated power generation, for example solar, wind, or small hydro power.

Any battery involved in an incident will still have stranded energy (power) in it, depending on the state of charge the battery was in at the time of the incident. There is also a risk of electrocution on any battery storage system, be it a fixed installation or in a motor vehicle, even after the incident is contained.

There may be a requirement to evacuate the area surrounding the vehicle or installation. These large battery installations can, if in a thermal runaway, release toxic and volatile fumes. Once they are venting, there is no way of predicting if or when fire may develop, and there is the risk of vapour explosion.

Initial actions

Water is currently the medium used for fire suppression.

Thermal runaway either pre-fire, or during a fire, can only be halted by cooling with copious amounts of water. Temperatures of up to 100°C can be generated, at which point the battery may start to vent and the vapours ignite.

Larger batteries systems will require large quantities of water to reduce the heat as quickly as possible, and pre-planning will dictate whether direct attack on an installation or exposure protection is the preferred approach.

Gas detectors will trigger on the carbon monoxide, which is a signature gas emitted by batteries in breakdown. Repeated monitoring may be required.

A thermal imaging camera (TIC) should be used and the battery should be continuously monitored to check stability. If temperature starts to rise, further water should be applied to reduce the heat.

Note: See the Hazards section for notes on PPE.

Monitoring

Any lithium or nickel based battery has the potential to reignite after initial fire suppression.

Gas detectors should be used to monitor carbon monoxide (CO) levels. Increased CO is a signature indicator of battery failure. A rise in CO values may indicate that the battery is failing.

Thermal imaging cameras (TIC) should be used to check and monitor battery stability.

Cooling may be required if temperatures start to rise. Monitoring (up to 5 days) may be required after the incident is contained. See Handover considerations below.

Handover considerations

When fire suppression has been completed, a handover to the owner or other agency needs to include safety information about:

- the risk of thermal runaway and possible ignition/re-ignition. This can be up to five days
- stranded energy still in the battery and the risk of electrocution from any damaged cabling
- the battery being stored outside, and kept at least 15 metres away from any other combustible material.

Safety considerations

Crew	• Identify if batteries are involved • Level 2 PPE and BA to be worn until scene is contained • TIC to be used to check and monitor battery stability • Approach from up wind to reduce risk of contamination.
People	• Public safety from toxic fumes • Risk of electrocution • Risk of re-ignition after initial fire suppression • Consider evacuation of area surrounding incident.
Environment	• Location of incident and surrounding properties • Downwind contamination risks from smoke • Contaminated run off from fire suppression may need to be contained • Pollution control notifications to be made.

Post-incident considerations/requirements

Decontamination	After the incident, decontamination will be required by G7-1 SOP Post fire decontamination procedure for Chemical fire. **Note:** The lack of industry standards makes it impossible to reliably determine what toxic and hazardous substances may be present during battery breakdown. Using the possibility of hydrofluoric acid as the default contaminant will give sufficient controls for decontamination.

Related information

Also refer to the following

Policy

- G7-POP Decontamination

Procedures

- G7-SOP Decontamination
- G7-1-SOP Post fire decontamination
- IS4 Working near electrical hazardss

References

- 022/2019: Response to lithium-ion battery fires
- Lithium battery in thermal runaway (https://www.youtube.com/watch?v=24fYrV2vCPk)

Document information

Owner	National Operations Manager
Last reviewed	14 November 2019
Review period	Every second year

Record of amendments

Date	Brief description of amendment
November 2019	Related information updated

August 2018	Created