Safe Operating Procedure

Lithium Battery Storage and Disposal

1. Introduction

The University is required to comply with legal obligations to minimise the risk of fire, damage, and injury because of storage and disposal of lithium batteries.

Every employer must ensure that all employees who handle lithium-ion batteries for their work or use equipment, or machines with batteries, have enough information to safely handle them under normal and emergency conditions. Caution must be taken in Li-ion battery storage, use, management, and disposal due to the potential for fire and injury if these batteries are misused or damage.

This SOP has been developed and reviewed by the university Health, Safety & Resilience and Sustainability Teams with input from the University Insurers and industry best practice. We continue to monitor the development of the Lithium-ion Battery Safety Act which is currently being consulted on at the House of Lords.

2. Definition

- **Lithium-Ion**: A lithium-ion battery (Li-ion) is a type of rechargeable battery in which lithium- ions move from the negative electrode to the positive electrode during discharge and back when charging.
- **Lithium-ion Polymer cells (LiPo)**: Same chemistry as lithium-ion cells but the electrolyte is made as a gel with a polymer host which reduces flammability and prevents leakage of liquid electrolyte from a damaged cell. However, these are more prone to impact damage, leading to fires from damaged cells.

Examples of where these may be found include drones, power tools, e-bikes/ scooter, etc. Smaller Li-ion are also found in mobile phones, power banks, e-cigarettes, and laptops.

- **Lithium Iron Phosphate (LiFe PO4)**: the chemistry of these batteries is much more stable and a lower fire risk than other lithium-based batteries. Danger still exists if these batteries overheat and release flammable gases.

Examples of LiFe battery use includes electric cars, emergency power supplies, or renewable energy storage.

3. Handling and Use

If the cells and batteries are correctly handled, the risk of fire developing from a lithium-ion battery from a reputable manufacturer is very low. Most incidents involving Li-ion batteries find a root cause in the mishandling or unintended abuse of such batteries. Possible causes of lithium-ion battery fires include, over charging or discharging, unbalanced cells, excessive

current discharge, short circuits, physical damage, excessively hot storage and, for multiple cells in a pack, poor electrical connections.

4. Best Practice

- Always purchase batteries from a reputable manufacturer or supplier. Cheap or counterfeit batteries may not undergo the same quality control processes and have a higher likelihood of failing. You must only use CE marked products (UKCA from 1st Jan 2023).
- All personnel authorised to use, change, or charge batteries should have adequate knowledge concerning the properties of the batteries and the safe use of chargers that may be involved. Be sure to read all documentation supplied with your battery.
- All batteries should be stored, charged, and used in accordance with the manufacturer's instructions.
- Never burn, overheat, disassemble, short-circuit, solder, puncture, crush or otherwise mutilate battery packs or cells.
- Do not put batteries in contact with conductive materials, water, seawater, strong oxidisers, and strong acids.
- Avoid excessively hot and humid conditions, especially when batteries are fully charged. Do not place batteries in direct sunlight, on hot surfaces or in hot locations.
- Always inspect batteries for any signs of damage before use, check for physical damage such as cracks/ bulges/ indentations. Any battery that has been damaged, dented, or pierced should be taken out of service immediately, segregated from other batteries and stored as set out below while awaiting safe disposal. Similarly, damaged goods containing batteries should also be segregated from other material and stored safely to await safe disposal.
- Lithium-ion batteries assembled to offer higher voltages (over 60v) may present electrical shock and arc hazards. Therefore, adherence to applicable electrical protection standards (terminal protection, shielding, PPE, etc.) is required to avoid exposure to electrical hazards.
- Do not reverse the polarity.
- Do not mix different types of batteries or mix new and old ones together (e.g. in a power pack).
- Do not open the battery system or modules unless you have a risk assessment, training, and permission.
- Do not use the unit without its electronic management system.
- Do not submit to static electricity risks to avoid damages to the Protecting Circuit Board.
- Immediately disconnect the batteries if, during operation or charging, they emit an unusual smell, develop heat, change shape/ geometry, or behave abnormally.
- Security or other responsible staff on site who may be called to act in an emergency, are to be made aware of the location of the charging area, the means for isolating the power and the action to take in an emergency.
- In premises that also provide sleeping accommodation, serious consideration should be given, wherever practicable, to using timers to control socket outlets used for

charging equipment.
- No charging should take place overnight.
- Batteries should not be carried in pockets as coins, keys and similar metal items can cause shorting leading to overheating, burns or ignition.
- Although protective electronics built into the battery should prevent overcharging, the battery management system can fail. For example, if the charger is not suitable, unattended charging is always a source of danger.

While this SOP focuses on larger/ higher risk Li-ion devices, the best practice still applies for everyday appliances such as mobile phones and laptops. For such devices, the following basic principles must be followed:

- If damaged – do not use and repair or replace.
- Only use manufacturers approved charging device.
- Dispose of via designated waste streams in this document.
- Do not charge in direct sunlight/ on hot surfaces.

5. Transporting Batteries

Take precautions to avoid dropping batteries during transport. When you need to transport a battery, protect the battery terminals and uninsulated connections from contact with other objects, use the original packaging or a suitably protected plastic container.

6. Storing Batteries

- Every time a battery is not used actively (e.g. for more than 3 days), it should be placed in the storage area to avoid being damaged and becoming unsafe.
- When not using your LiPo/ Li-ion battery pack, store it at 60-70% of the pack's rated capacity. Lithium-ion cells should never be stored fully charged. It is suggested to store them with a voltage around 3.8v. Most of the chargers have a "storage mode" that will either charge or discharge the cell to the proper storage voltage. Experts recommend putting the cells in storage mode after every run, this will help the battery to lengthen the usable life span.
- Store dust free and dry and protect from moisture.
- Store in a temperature protected area between 10oC and 25oC.
- Protect from the frost, and temperatures above 60oC. Batteries should never be in the sun or on hot surfaces.
- Stored and charged in 90-minute fire rated cabinets with RCD protection.
- Monitor storage by means of suitable fire alarm.
- Do not store together with fire accelerating products.
- Maintain safe distances (up to 5m from flammable materials).
- Store behind a fire door and where a fire alarm is situated.
- Never leave batteries unattended where someone can damage them.
- Must have a means of safely storing and segregating end of life/ damaged batteries from undamaged ones.

7. Disposal – End of Life (Standard) No Damage

- Ensure batteries are removed from devices and kept segregated before further material recovery.
- Insulate the battery terminals or wires to prevent short circuit.
- Faculties producing volumes of Li-ion and LiPo batteries from teaching and research activities, are required to identify and implement safe storage locations for used batteries until disposal of the batteries can be undertaken.
- Lithium Li-ion and LiPo batteries must be stored separately.
- The hazardous wastes stores at Singleton and Bay campuses have dedicated Li-ion/LiPo battery storage boxes filled with PyroBubbles® for safe storage of lithium batteries awaiting disposal.
- Disposal of batteries can be arranged by emailing estates-waste@swansea.ac.uk and following the chemical waste disposal procedure, clearly labelling and detailing the battery type.
- Faculties should look to develop local operational procedures to ensure all end-of-life Li-ion/ LiPo batteries are identified and placed into dedicated storage ready for disposal.
- For researchers producing coin and pouch cells, if disassembly is not possible, units can be disposed of via the chemical waste disposal route. It is recommended that damaged coin or pouch cells are placed into a safety pocket for disposal.

Do not:

- Dispose of Li-ion and LiPo batteries with ‘regular’ battery waste WMGN15.
- Crush, puncture, throw or do anything to the batteries that might result in electrodes touching and short-circuiting.
- Mix damaged and non-damaged batteries.
- Place large numbers of batteries together without proper segregation, as this presents an increased fire hazard.

8. Disposal – End of Life (Standard) No Damage

All lithium-ion cells users must be aware of and equipped to deal with the emergencies mentioned below.

8.1 Damaged Batteries

While all batteries need to be handled with caution, Li-ion/ LiPo batteries pose additional safety risks due to their high energy density and flammable electrolyte. When these batteries are poorly manufactured, overcharged or over discharged, incorrectly handled and/or connected or exposed to excessive mechanical and physical stress, conditions may arise and lead to thermal runaway that in turn may lead to the venting, leaking, explosion and/or fire of the battery cell or pack.

Procedure:

- After the impact/ accident, if the battery is not hot and/or leaking or smoking disconnect the battery.
- Remove the battery from the equipment wearing gloves, goggles/safety glasses, and lab coat (if available).
- To discharge the battery, move in a well-ventilated area and place the battery in a metal or hard plastic bucket.
- Email estates-waste@swnsea.ac.uk for further guidance on disposal. Alternatively, to discharge the battery use a resistor with resistance greater than ten times the rated internal resistance of the battery.
- Keep in mind that there may be no visible damage, a delayed fire can occur hours or days after the impact/ accident. It is safest to discharge the battery immediately.

8.2 Overheating, Venting and Leaking Cells

When a cell's internal temperature and pressure rise faster than the rate at which they can be dissipated, cell overheating will occur. This may be caused by electrical shorting, rapid discharge, overcharging, manufacturer defects, poor design, or mechanical damage, among many other causes. In series or parallel connected strings of batteries, high connection resistance from a poor electrical connection can lead to overheating. The overheating of a given cell may produce enough heat to cause adjacent cells to overheat in response. If the cell does not return to room temperature it may vent and catch fire or explode. Sounds like "clicks" and "puffs" may indicate a preliminary vent release.
Depending on the cell type and manufacturer, the critical temperature ranges around 120-300 °C (see manufacturer manual for details on the battery you are using).
Follow the emergency procedure below if you have overheating, venting, or leaking cells.

Procedure:

- If you notice hot cells, disconnect the charger and remove any external short circuit if present.
- If a cell is venting or smoking, evacuate all personnel from the area, closing doors behind you. The area should be secured to ensure that no unnecessary persons enter.
- If leaking material is present, do not touch it.
- Immediately dial 333 from any Swansea University (SU) landline, 01792 604271 from other phones or using the SafeZone app to initiate emergency assistance.
- Do not approach the cell until it reaches room temperature. The cell temperature can be checked using a remote device (i.e. infrared thermometer).
- If a remote device is not available, do not handle the cell for a period of at least 24 hours.
- As soon as the cell reaches room temperature, contact estates-waste@swansea.ac.uk to have the damaged battery removed from the working area as hazardous waste (see section 8.1).

8.3 Exploded Cell

Like a vented cell, an exploded cell is the result of an overheated or mechanically damaged cell. After the explosion of a lithium-ion battery, the room could fill quickly with dense white smoke that could cause severe irritation to the respiratory tract, eyes, and skin. All precautions must be taken to limit exposure to these fumes.

Procedure:

- If a cell has exploded, evacuate all personnel from the area closing door behind you. The area should be secured to ensure that no unnecessary personnel enter.
- Immediately dial 333 from any SU landline, 01792 604271 from other phones or using the SafeZone app to initiate emergency assistance.
- If a ventilation system is in place and it is safe to, turn it on, initiate ventilation and continue until the cell is removed from the area and the pungent odour is no longer detectable.
- Contact estates-waste@swansea.ac.uk for assistance in removal of the damaged battery cell as hazardous waste.

8.4 Lithium-ion Fire

Li-ion fires may occur because of thermal runaway, shorting and other conditions that result in increased temperatures. Once the battery begins to vent flammable vapours, it may quite easily catch fire. SU personnel are not required to fight fires. Trained fire extinguisher users should attempt to extinguish early stage (incipient) fires only if it is possible to do so safely. BS 5306-8:2023 states “For lithium-ion batteries, water or water-based extinguishers should be provided to cool individual small rechargeable devices that are no longer on charge.” There are specialist hand-held extinguishers such as Lith-Ex or LFX, but these should only be used for small batteries involved in fires due to the issue with the amounts of smoke produced in lithium-ion fires. Provision of specialist extinguishers should be on a risk assessment basis in consultation with the HS&R Team.

The high temperatures and self-oxidising reaction of a Li-ion battery's thermal runaway means that CO2 has no effect as the temperature is not reduced and the thermal runaway produces its own oxygen sufficient to sustain the reaction until the CO2 disperses.

Procedure for a Small-Scale Fire (for example is a small wastebasket fire)**:**

- Activate the nearest fire alarm. All personnel from the area are to evacuate.
- If you are trained in fire extinguishers and knowledgeable of the type of battery in use, use the closest water/ foam extinguisher.
- Make sure you are positioned between the fire and the nearest exit before attempting to extinguish the fire.
- If the use a portable fire extinguisher has little effect on extinguishing the fire, exit immediately. Do not initiate a second attempt.
- If you can put out the flames, pour water over the battery to cool it down, this will not create an electrical hazard. You might need 1 to 5 or more litres of water depending on the size of the battery in use.

- By-products of combustion may be toxic when inhaled. In the event of heavy smoke, exit the area immediately. Ensure others have left the area and close doors behind you as you leave.
- The HS&R Team will need to assess the situation for clean-up and waste management after the situation is under control.

Procedure for a Large-Scale Fire:
In the event of a "larger" fire that has been active for a time, and/or those involving furnishings, interior finishes, and structural building components, evacuate the area.

- Activate the nearest fire alarm. Do not attempt to extinguish the fire by using a portable fire extinguisher.
- Call Security and/or the Fire Service from a safe location. If you call the Fire Service direct, notify Security as soon as possible.
- Plan to be available for the Fire Service to provide information. This may include the size, location, and nature of the fire, as well as identifying any hazardous materials, especially in the event of a laboratory fire.
- the HS&R Team will need to assess the situation for clean-up and waste management after the situation is under control.

8.5 Disposal – Emergency

- Damaged, leaking, or swollen batteries are to be packed in plastic.
- Place the damaged Li-ion battery in clear plastic bag or wrap it in clear plastic foil; then place products in a clip top UN-approved 200l barrel with an inner plastic lining, on top of a layer of dry sand (fire sand). Then place a layer of sand over the ruptured battery.
- Label drum – Damaged Li-lo Battery, place outside in a secure, clear space just in case of ignition.
- Email estates-waste@swansea.ac.uk for disposal, contact your Faculty/ Department Health and Safety Representative and submit an Adverse Event Form for an investigation to be conducted.