Storage of Lithium-ion Batteries

Risk Control Guide RCG101

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Scope

The purpose of this document is to provide guidance on the storage of Lithium-ion (Li-ion) cells, batteries, modules and finished products containing Li-ion batteries.

It does not include Li-ion Battery Energy Storage Systems (BESS).

Its primary scope is the potential fire and explosion risks and associated risk control measures with Li-ion batteries at storage locations.

Introduction

Li-ion batteries are the rechargeable batteries that are found in many electrical devices in common use from phones, laptops, mobility scooters to e-cigarettes, and are used extensively every day.

The Li-ion batteries can be a safety hazard if not properly engineered and manufactured, as cells contain flammable electrolytes. If damaged or incorrectly charged, this can result in a thermal runaway event, potentially leading to fire, explosion and the release of toxic gases, for which fire extinguishment can be very difficult.

Overview

Hazard

Thermal runaway is a phenomenon in which the Li-ion cell enters an uncontrolled, self-heating state. It can be caused by a manufacturing defect, overcharging, over-discharging, mechanical damage or exposure to heat from an external source.

Thermal runaway can lead to an energetic and prolonged battery fire that can last for many hours. A fire or explosion involving the batteries could subsequently spread to nearby combustible materials or construction. This can result in a significant property fire and period of business interruption.

Risk Control Measures

Storage Location

It is suggested, in order of preference, that Li-ion batteries are:

1) Stored externally in a non-combustible building or container.

   The building or enclosure should be positioned at least 10 metres from other buildings, structures, external equipment and storage.

2) Stored internally within compartments separated from other areas of the building by a minimum 120-minute fire rated construction. Ideally the compartment should be accessible from the outside of the building. If this is not feasible or practical, then the internal opening is to be fitted with 120-minute fire rated doors.

In addition, it is suggested the store is: -

- Only used for Li-ion battery storage or products containing Li-ion batteries;
- Not exposed to direct sunlight or at risk of flooding;
- Provided with natural air circulation;
- Maintained at an ambient temperature below 30°C;
- Provided with suitable security, due to the high values at risk of theft.

Management Controls

It is suggested that the following management controls are implemented:

1) Introduce a formal inspection procedure for incoming batteries and /or products containing Li-ion batteries to identify any damage or evidence of heating or swelling.

2) Avoid charging of Li-ion batteries and ensure the State of Charge (SOC) is retained at or less than 60%. The preferable SOC for storage is 30 to 60% at which the batteries are relatively benign.

3) Provide staff awareness training on the hazards of Li-ion batteries.

   - Include battery storage arrangements within the Site Emergency Plan.
   - Develop a safe working procedure to handle products when moving internally to avoid puncturing cartons and damaging batteries, or products containing batteries.

- Introduce an emergency procedure for batteries or products that are dropped, damaged, or punctured.

- Remove and safely dispose of any Li-ion batteries from any defective returned goods.

- Develop pre and post incident plans in consultation with the local fire brigade.

  Include reference to :
  - removal and disposal of any damaged or impacted batteries or products
  - potential for reignition of batteries
  - provision and use of sandbox or water trough
  - introduction of a fire watch until the incident has been cleared

Battery Charging

Under normal use, the greatest risk of fire can occur when Li-ion batteries are being charged/discharged and this risk may be enhanced if a cell is defective or damaged.

It is suggested that charging at storage locations is avoided.

If charging is absolutely necessary it is suggested that the below precautions, in order of preference, are considered:

1) Undertaken in a detached dedicated outbuilding at least 10 metres from other buildings, structures, external equipment and storage.

2) If charging is undertaken inside occupied premises, it must be within compartments separated from other areas of the building by minimum 120-minute fire rated construction. Ideally the compartment should be accessible from the outside of the building only. If this is not feasible or practical, then the internal opening is to be fitted with 120-minute fire rated doors.
   - Such room(s) should be located at ground floor level with an external door for fire brigade access
   - Heating, Ventilation and Air Conditioning (HVAC) provided to maintain an ambient temperature between 15-18 degrees C
   - Provide mechanical ventilation, or have sufficient high level natural ventilation to an outside area

Fire Detection

Consider providing smoke and gas detection systems (ideally combined smoke and carbon monoxide detection) for all Li-ion batteries storage rooms, charging areas and compartments.

Automatic Sprinkler Protection

There are currently no specific UK or European guidelines for fire protection of Li-ion batteries storage. However, practical guidance is available in the following FM Global documents: -

- FM DS 3-26 Fire protection for non-storage occupancies (Section 3.3 Lithium-ion batteries), 2021
- FM DS 8.1 Commodity classification (Section 2.4.2 Lithium-ion batteries), 2021

Gaseous and Condensed Aerosol Fire Extinguishing Systems

In the scenario where the Li-ion batteries have entered an advanced thermal runaway, traditional extinguishing gases may not have the capacity to remove sufficient heat to extinguish the fire. In addition to this, the fire is not always dependent on an oxygen supply, so protecting storage compartments, even with high concentrations of any gaseous agent, may not extinguish the fire.

Other fire protection solutions are being explored and developed against Li-ion fires including, aerosols, water mist, Aqueous Vermiculite Dispersions and the use of various wetting agents.

Aqueous Vermiculite Dispersion (AVD) extinguishers are available, but are currently non-compliant under BS 5306.

Dealing with Defective or Damaged Batteries

It is suggested that defective or damaged Li-ion batteries or products containing Li-ion batteries that are awaiting removal from a site, should be packed in compliance with the Carriage of Dangerous Goods Regulations, ready for safe shipping.

This is essentially a strong and leak-proof outer packaging constructed of a suitable material, and of adequate strength in relation to the packaging's capacity and its intended use. Internally packed with a non-conductive and non-combustible cushioning material (typically vermiculite).

Cells and batteries shall be designed or packed to prevent short circuits and the dangerous evolution of heat, with individual protection of the battery terminals. The cushioning material is to fill spaces between the batteries in order to reduce vibration and shocks during transit and also to protect against any heat release that might occur.

It is suggested that these shipping boxes are stored in a detached dedicated outbuilding of 120-minute fire rating. This should be at least 10 metres from other buildings, structures, external equipment and storage, pending removal.

Consider appropriate frequency of removal by a licensed carrier to avoid excessive accumulations of damaged or defective batteries on site.

Technical Information / Glossary of Terms

Thermal Runaway

Batteries can fail in an uncontrolled manner leading to thermal runaway. Thermal runaway is rapid self-heating caused by exothermic reactions between battery components, normally following short circuiting between electrodes.

The high energy density of battery cells and presence of combustible electrolyte mean a thermal runaway event can be very energetic and difficult to extinguish.

During thermal runaway, internal degradation and oxidization processes can keep cell temperatures above 500 degrees C, with the possibility of igniting secondary combustibles. This could possibly lead to leakage of flammable electrolytes, explosion and fire. Toxic and flammable gasses (such as hydrogen fluoride (HF) and Carbon Monoxide (CO) may also be emitted, which can ignite resulting in a rapid fire/explosion.

Different Chemical Compositions

Li-ion batteries come in multiple chemical compositions such as:

- LCO (Lithium Cobalt Oxide)
- NCA (Lithium Nickel Cobalt Oxide)
- NMC (Lithium Nickel Manganese Cobalt Oxide)
- LMO (Lithium Manganese Oxide
- LFP (Lithium Ferrous Phosphate, but known as Lithium Iron Phosphate)
- LTO (Lithium Titanate Oxide)
- LiPo (Lithium Polymer) also known as LIP or Li-Poly

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