To The Point
Lithium-ion Batteries Storage Considerations

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Lithium-ion (Li-ion) batteries capitalize on their ability to deliver high energy density, longer shelf life, and lower environmental impact than traditional technologies. As a result, Li-ion batteries have become the energy storage technology of choice for most electronic devices and equipment, small and large.

While billions of these batteries operate safely on a daily basis, as we know from media reports and even personal experiences, these batteries present a risk of thermal runaway. This document aims to provide businesses with information about the various levels of risk associated with Li-ion batteries, as well as mitigation strategies to consider when managing such risk.

For Li-ion batteries, thermal runaway events generally begin with a single cell overheating; this ignites the electrolyte within that cell, which ignites adjacent cells. Causes of thermal runaway can range from inferior quality cells, manufacturing defects, mechanical and physical abuse, and overcharging.

Because lithium reacts exothermically with water, these fires are incredibly challenging to control and extinguish. Certain lithium-ion battery chemistries can also release heavy metals and toxic smoke, which are costly to clean up and remediate when involved in a fire, especially in sensitive environments.

Below are the four stages of thermal runaway:

Stage 1: Abuse Factor

Stage 2: Off-Gas Generation

Stage 3: Smoke Generation

Stage 4: Fire Generation

Thermal runaway events in Li-ion batteries have resulted in the recall of millions of laptop batteries due to

overheating reports and fires involving the batteries and chargers for "hoverboard" scooters and, more recently, e-bikes. While these events might be small in number compared to the billions of units in use with no reported adverse events, they reinforce the need for a robust risk assessment.

The loss examples in commercial and industrial settings are growing. For example, the Morris Lithium Battery Fire on June 29, 2021, was one of the biggest Li-ion battery fires in American history.[1] This event helped highlight how challenging it is to protect against and extinguish a fire involving Li-ion batteries in bulk storage. It also reinforced how critical hazard communication and fire department planning is to battle such a blaze. In 2018, another large fire occurred in Jamaica, New York, after a Li-ion battery was improperly disposed of, sparking a fire that brought the nearby Long Island Railroad to a halt. The fire grew rapidly due to nearby trash, piles of paper, cardboard recycling, and windy conditions. It took close to a full day to extinguish the fire.[2]

Battery Storage

The severity of fire risk associated with the storage of Li-ion batteries is dependent upon the quantity of batteries, battery chemistry, physical form, energy rating (ampere-hours), state of charge (SOC), storage spacing and arrangement, and product packaging. Also, there is evidence of increased fire hazard due to rough handling and breach of battery integrity, such as puncture, with resultant thermal runaway – as lithium chemistries are reactive with oxygen. Inventory handling methods to ensure batteries are not damaged and identifying and isolating stock that may be damaged – is also key.

Keep only incidental storage quantities to protect Li-ion battery storage in high (extra) hazard sprinklered properties. Incidental storage is accomplished by limiting the battery storage footprint to 200 ft^2 (20m^2) and height to 6 ft. (1.8 m) while keeping 10 ft (3 m) of open space in between each pile and from other nearby combustibles. The goal is to spread out and lower the risk so that it is limited to one pallet in the event of a fire.

For most other occupancies, studies have shown that even a single pallet of Li-ion batteries can spread uncontrolled fire quickly. Consider relocating the storage offsite or outside and away from the structure, such as within a temperature-controlled storage container or at a secure third-party location.

Li-ion batteries may be stored in limited quantities in specially designed storage cabinets. Market options today include storage cabinets with integrated fire extinguishing systems, off-gas, and pressure relief designs to mitigate the smoke and fumes from a thermal runaway event.

Special sprinkler systems are necessary for bulk battery storage, such as warehousing. Often, this may include segregating storage into dedicated areas and sprinkler upgrades such as in-rack sprinklers and more robust ceiling storage sprinklers.

Material Handling Equipment Using Li-ion Batteries

Material handling equipment (e.g., forklifts, pallet jacks, etc.) is quickly transitioning from traditional lead-acid to Li-ion batteries. Li-ion battery-powered material handling equipment relies on "opportunity charging," meaning the charging stations are decentralized throughout the storage area, allowing quick recharging.

Below are examples of the desired level of certification(s) for such battery systems when used in material handling equipment:

- Class 1 and 2 forklifts – UL 2580 “Batteries for Use in Electric Vehicles," a standard for testing batteries for large electric vehicles.
- Class 3 forklifts (pallet jacks) – Either UL 2271,"Batteries for Use in Light Electric Vehicle (LEV) Applications," or UL 2580.
- Look for UL-E and UL-EE Certifications for forklift applications (best practice). UL 583: “UL Standard for Safety for Electric Battery-Powered Industrial Trucks.”
- Battery management software – UL 1998 "Standard for Safety for Software in Programmable Components."
- Firmware/hardware evaluation and test – UL 991 "Standard for Tests for Safety-Related Controls Employing Solid-State Devices."

Other common marks include CE, CSA, and IEC. If the batteries, BMS (Battery Management System), and charging system are not UL Listed, they should meet an equivalent level of testing and approval.

Make sure you have an emergency response plan to address the fire exposure. Train your operators to identify the first signs of thermal runaway for a quick response – and give them formal training on actions to take in the event of a fire or thermal runaway involving the equipment.

Any physical damage to the forklift battery or its enclosure should be reported. Also, consider installing accessible incident response kits near the equipment – such as fire-rated blankets, heat-resistant gloves, noncombustible containment drums, and fire suppression media.

Business Considerations

Below are some best practices to initiate within your facility:

- Strongly consider ways to minimize storage of Li-ion batteries within your facility, including outdoor or protected third-party storage options.
- Protect stored batteries from physical damage.

- Store batteries at a charge level between 30-50%.
- Maintain a consistent temperature between 50-80 °F (10-27 °C) in the storage area.
- Establish guidelines for identifying and handling damaged or overheating Li-ion batteries.
- Consider keeping a noncombustible container filled with water 25 ft (8 m) from your building to place any batteries or containers with evidence of physical or mechanical damage.
- Consider storing Li-ion batteries within a specially designed Li-ion battery safety storage cabinet(s), designed for Li-ion batteries. If you plan to use multiple storage cabinets, space them at least 10 ft (3 m) apart from each other and nearby combustibles.
- Pile/floor storage of Li-ion batteries in high (extra) hazard, sprinklered properties should be in designated areas with at least 10 ft (3 m) of separation distances between individual piles and limited storage footprint and heights.
- A Chubb Risk Engineer should review any bulk warehousing fire sprinkler protection to ensure adequate protection. Li-ion batteries need robust sprinkler designs with strong water supplies to control fire.
- Ensure Li-ion battery-powered material handling equipment is listed/approved by a nationally recognized testing laboratory (NRTL) – such as Underwriters Laboratories (UL). Other common marks include CE, CSA, and IEC.
- Have an emergency response plan in place to address Li-ion battery fire exposure. Train your employees and operators on the signs of thermal runaway – and have formal procedures about what they need to do in the event of a fire and thermal runaway involving the material handling equipment.
- Consider installing incident response kits near the batteries – such as fire-rated blankets, gloves, noncombustible containment drums, and fire suppression media – as it may not be possible to relocate the batteries once involved in a fire event.

Importance of Battery Precautions

Li-ion batteries are helping transition our energy needs today towards a more sustainable future away from carbon-based sources. However, Li-ion batteries present a unique and challenging fire risk, especially from thermal runaway. Battery form, chemistry, energy rating (Ah), listings/approvals, and manufacturing quality will all impact the unique risk profile of the batteries.

As these batteries continue to pervade businesses through bulk storage, integration, assembly, or even into newer material handling equipment, please reach out to Chubb Risk Consulting Services to explore options for safe use, handling, storage, and emergency planning and response best practices.

References:

1. **Morris Lithium Battery Fire,** response.epa.gov/site/site_profile.aspx?site_id=15259
2. **Royal Waste Fire,** qns.com/2018/03/huge-trash-fire-jamaica-shut-service-long-island-rail-road-branches/
3. **UL 2580,** "Standard for Safety for Batteries for Use in Electric Vehicles"
4. **UL 2271,** " Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications"
5. **UL 1998,** "Standard for Safety for Software in Programmable Components"
6. **UL 991,** "Standard for tests for Safety-Related Controls Employing Solid-State Devices"
7. **UL 583,** "Standard for Safety for Electric Battery-Powered Industrial Trucks"

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