Insight: Lithium Battery Storage and Safety at Distribution Centers and Warehouses

The global demand for lithium-ion batteries (LIB's) is expected to increase from 185 GWh (185 million kWh) in 2020 to over 2,000 GWh (2 billion kWh) by 2030, mainly due to the electrification of transport. The prevalence of (LIB's) to power consumer electronics such as phones, tools, e-cigarettes, medical equipment, robotics, warehousing equipment, and battery energy storage systems is also growing at a very rapid pace.[1]

The purpose of this Insight is to provide information relative to the safe warehouse storage of lithium-ion cells, packs, modules and full batteries. The identification and determination for safe transit of these batteries are topics not covered; however, understanding aspects of handling LIB's may be helpful overall in determining the appropriate protection needed to mitigate inherent risks while they are in storage.

Similarly, the storage of batteries associated with Energy Storage Systems (ESS) is outside the scope of this document.

Recognizing the Risk

For warehousing operations, storing LIB's of all types and the products that contain them poses the risk of fire.

Spontaneous Ignition:

Spontaneous ignition can result from flaws introduced during manufacturing or design leading to a short-circuit, the use of low-quality components, or damage to the battery from improper handling e.g. a puncture, being dropped, or exposure to excessive heat.[2] If a LIB short-circuits, it can overheat and create a chain reaction known as "thermal runaway," a cascading effect in which the batteries reach very high temperatures and emit smoke and flammable gasses that can further fuel fire and explosion.[3]

Unique Fire Characteristics:

Fires involving LIB's, especially larger ones like those used in electric vehicles (EV) stored in proximity, can be very difficult to extinguish. To put into context the amounts of water needed by firefighters to extinguish an EV fire started by vehicle self-ignition took over 30,000 gallons (113,562 liters) of water and 4 hours.[4]

Lithium batteries have one of the highest energy densities of any battery technology today. Following a fault, residual energy remains in the battery which can contribute to delayed re-ignition of the batteries after apparent extinguishment. Reliable observation has revealed that re-ignition can occur up to several weeks after an initial fire event.

Quantities and Storage Arrangements:

Warehouses and distribution centers keep getting bigger, up into the millions of square feet, increasing the exposure simply by the quantity of goods being stored. Whether a large or smaller storage facility, common factors that can contribute to the increased risk include:

- The types and quantity of goods/batteries being stored
- Whether the batteries are stand-alone packaged or in electronics
- The amount of plastic in the packaging
- Whether the storage is on floor, palletized or in racks
- Height of the storage and building roof or storage area ceiling height
- Whether an Automated Storage Retrieval System (ASRS) is being used.

Warehousing Equipment:

ASRS and other robotics used in warehouses also use LIB's, which have the potential to self-ignite or even explode if they become damaged or malfunction. This can occur in part through an ASRS arm that has become worn, giving off sparks and potentially catching fire itself, exposing the LIB to heat and ignition.[6] Increased exposure can also exist if large quantities of batteries for these robots are maintained on site.

Controlling the Hazard

As with any hazardous material, starting with a thorough risk assessment is critical. While studies to model thermal runaway and fully understand this phenomenon are just emerging and global safety standards are not yet established, industry knowledge is increasing. Applying the Hierarchy of Controls to the unique hazards of LIB's may be helpful. Consider the following controls to mitigate the risk:

- Store products/batteries in cool, dry conditions.
- Maintain a storage temperature not less than, 32°F (0°C), optimally around, 50°F (10°C).
- When storing batteries (standalone or in packages), in racks with ASRS, contact your AIG Risk Engineer for added protection recommendations.
- Isolate and contain stand-alone and packaged battery storage away from the general operations and ensure the area is equipped with appropriate suppression systems (with the ability to deliver copious amounts of water).
- Use thermography to help identify stressed or damaged batteries and potential thermal runaway situations by detecting heat.
- Manage End-of-Life batteries as follows:
  - Send old, end-of-life batteries immediately to a qualified, third-party battery recycling firm.
  - When old or end-of-life batteries cannot be immediately sent to a qualified recycling firm, store outside buildings in a weather tight intermodal containers or trailers (lorries) with minimum of 50 ft (15.2 m) detachment from building exterior walls.
  - Dispose of damaged LIB's by packing them in plastic bags and storing outside in containers of sand or other inert material at least 50 ft (15.2m) from all facility buildings. Cover the terminals of the damaged batteries to prevent accidental shorting.
- Develop and implement Standard Operating Procedures (SOPs) for shipping, receiving, handling, daily inspection and use of batteries.
- Conduct training on topics such as battery fire behavior, emergency response procedures, fire-fighting strategies, safe battery disposal and personnel protection.
- Consult with local firefighting authorities to create emergency response plans.
- For sprinkler design criteria, contact your AIG Risk Engineer.
- Routine inspection, maintenance, and test intervals should be specified and documented in procedures. This should include batteries, electrical alarms and fire detection systems. Test and maintenance intervals should be based on appropriate industry standards and manufacturer instruction manual guidance.

References & Resources

[1] Statista, "Projected battery demand worldwide by application 2020-2030", S. O'Dea, Jan 5, 2023, https://www.statista.com/statistics/1103218/global-battery-demand-forecast/

[2] Australian Competition and Consumer Commission, "Lithium-ion Batteries" https://www.productsafety.gov.au/products/electronics-technology/lithium-ion-batteries

[3] Journal of Power Sources, “Thermal runaway caused fire and explosion of lithium ion battery”, Qingsong,Wanga Ping,Pinga, Xuejuan et.al
https://www.sciencedirect.com/science/article/abs/pii/S0378775312003989

[4] The Washington Post, A Tesla was in a junkyard for three weeks. Then it burst into flames. By Julian Mark, June 2022
https://www.washingtonpost.com/nation/2022/06/22/tesla-fire-sacramento/

NFPA 13

UN Transportation Guidelines

https://spj.science.org/doi/full/10.34133/energymatadv.0008

Lithium Ion Battery: University of Washington Clean Energy Institute, https://www.cei.washington.edu/education/science-of-solar/battery-technology/#:~:text=They%20have%20one%20of%20the,%2DCd%20or%20Ni%2DMH.

Lithium Ion Fire Protection http://fmj.ifma.org/publication/?i=712769&article_id=4069875&view=articleBrowser

For more information, contact your local AIG Risk Engineer.