Lithium-Ion Battery Exposures in Recycling Industries

The inherent hazards associated with Lithium-Ion batteries in recycling industries and steps to consider in mitigating the risk

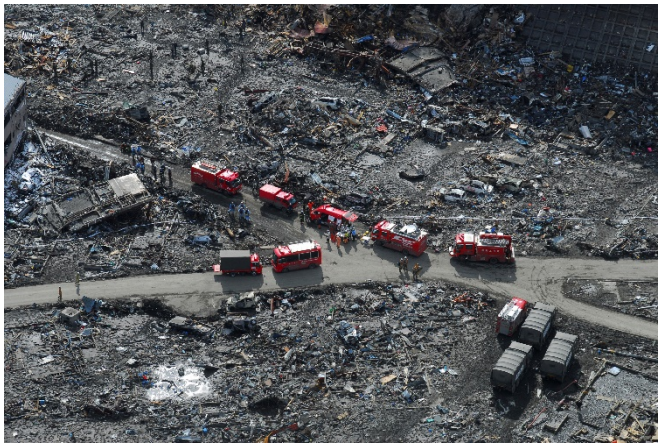
Background

Lithium has been used as an important component in batteries since the first-time battery technology was introduced at the end of the 19th century, due to its features of having the largest electrochemical potential yet is one of the lightest elements in the periodic table. Thus, Lithium can produce some of the highest possible voltages in the most compact and lightest volume. [1]

There are two types of batteries that are often confused with one another: Lithium batteries and Lithium-ion (Li-ion) batteries. The first type is considered a primary battery which are single use and incapable of recharge. They contain free lithium metal and are highly combustible. When a burning lithium metal part encounters water, it will react vigorously and release an abundant amount of flammable hydrogen gas. The gas will burn, intensifying the fire, resulting in a rapid heat rise and an explosion-like reaction. Lithium batteries are used where recharge isn't necessary or feasible, such as military war fighter applications, medical equipment and certain consumer electronics applications, to name a few.

Lithium-ion (Li-ion) batteries on the other hand, are considered secondary batteries which are rechargeable. This type of battery does not contain lithium in metal form, but rather in the form of electrolyte ions. While li-ions are still considered flammable and pose fire hazards associated with thermal runaway reactions, the use of water sprinklers have been found to be the one of the most effective firefighting efforts. [2] Application of water in these cases would not create an explosion-like reaction due to the absence of lithium metal. Common applications of Li-ion batteries include laptops, cell-phones, electric vehicles, and energy storage systems (ESS). The demand for Li-ion batteries is expected to increase today's use by 7 times by the year 2024. Extensive research has yet to be completed on the perils associated with the storage, recycling, and fire protection of Li-ion batteries.

One of the most concerning features of Li-ion battery fires is that they can seemingly ignite or reignite days or weeks after they were thought to be extinguished. A study completed by the California Products Stewardship Council (CPSC), based on 347 reported fires in the US and Canada over a year period, found that the source of 40% of fires at waste management facilities is Li-ion batteries. [3] The distinctive danger of Li-ion batteries combined with the rapid increase in demand creates a need for facilities to focus on mitigating and preventing Li-ion sourced fires, especially at recycling operations. Under United States regulations, Lithium-ion batteries are classified as Class 9 miscellaneous hazardous materials. [4] The different risks presented by Li-ion can be categorized as chemical, mechanical, and electrical.



Risk Exposure

Chemical and mechanical risks result from a battery sustaining mechanical abuse such as poor handling (batteries being dropped, falling, or being punctured by forklifts) which causes internal shorting of the battery and can liberate corrosive and flammable electrolyte from the battery unit. The loss of an individual battery can rapidly cascade to nearby batteries and potentially result in a large-scale fire. Electrical risks include issues associated with current flow in the battery, such as inadvertent over charging, over discharge, and short circuit events which will generate unwanted chemical reactions which are more exothermic than normal. [1]

A significant risk for Li-ion batteries is thermal runaway which is a cycle where battery cells produce an excessive and rapid self-heating from an exothermic reaction and may cause a chain reaction with other surrounding battery cells. Thermal runaway can occur with batteries of almost any chemistry, not only Li-ion batteries. It is mostly caused by a battery having internal cell defects, mechanical failures/damage or overvoltage. These lead to high temperatures, gas build-up and potential explosive rupture of the battery cell and release of the flammable electrolyte, resulting in fire. The more energy a cell has stored, the more energetic the thermal runaway reaction. Without disconnection, thermal runaway can also spread from one cell to the next, causing further damage. [1]

Fires caused by Li-ion batteries can be very intense and challenging to control. The immediate fire and electrical risks, as well as toxic fumes that are expelled, can be extremely dangerous to employees, visitors, fire fighters and first responders. [4]

General Recycling Process

The first step is to separate the lithium and Li-ion batteries from others. Unless there is a machine on site specifically designed to sort batteries, this must be done by hand. Batteries are labelled by the manufacturer and state the chemical make-up. However, it is critically important to train employees in the methods to recognize the difference between lithium batteries, and Li-ion battery, and ensure that they are separated from others and stored properly prior to it being received into the building.

Defective batteries must be isolated from the rest in a bucket of sand to guarantee an inert reaction. Lithium batteries should also be stored in a bucket of sand to avoid short circuit and placed in an area away from any water sources including water-based fire sprinkler systems. [6] Li-ion batteries on the other hand, can and should be stored in an area covered by active fire protection system including water-based sprinkler systems.

Education

Educating the public on the importance of proper recycling will likely decrease the number of Li-ion fires. It is important that people know how to properly dispose of Li-ion batteries. In 2017, a Li-ion battery that was put in the trash caused an explosion in a garbage truck in NYC. This could have been prevented if the battery was place in a plastic bag so that it could not come in contact with any metal. Another option would be to wrap the battery in electrical or duct tape to cover over the terminal. [7]

Facilities should have automatic fire detection in place, with early warning smoke detection and highly sensitive smoke detection (using devices such as VESDA) when storing large amounts of Li-ion batteries. All of the above systems should have 24/7 remote monitoring to ensure that no alarm goes unnoticed. It is recommended that they are stored in a place that is cool (dry ventilated and kept between 40°F – 80°F or 4°C – 25°C), and isolated from any water as well as heat sources including direct sunlight. It has been an industry standard to use 33-feet / 10-m as a safe separation distance, knowing that sparks and other hot emissions can commonly spread across that horizontal distance from the source.

As for active fire protection, testing and research is just beginning. Initial fire testing suggests that automatic fire sprinkler protection based upon protection schemas used for rack storage of cartoned, non-expanded Group A plastics, may offer adequate protection where the system suppresses the fire prior to the time of significant Li-ion battery involvement. While there is yet no defined standards for organizations about what kind of protection to install, it is apparent that inert gas and foam suppression systems seem unable to control thermal runaway. This then leaves the two best main options likely to be automatic fire sprinklers and water mist

If Li-ion batteries must be stacked on pallets during storage, extra measures should be taken to assure the stacks are stable and will not be bumped, knocked over or otherwise damaged. When wraps are introduced to help increase stack stability, an anti-static shrink wrap is highly recommended to prevent explosions.

Employees need proper training before they are cleared to work with Li-ion batteries. A few key points to remember are [6]:

1. Separate lithium batteries from Li-ion batteries as fire-fighting methods are very different. The former cannot be controlled with water, while the later can.
2. Do not use metal products that can potentially puncture the battery shell.
3. Most batteries are packed and attached together via super adhesive(s) which require gentle to mild heat to remove.
4. Only accept handheld batteries that are wrapped in plastic bags, so they do not come in contact with other metal that can create short circuit events.
5. Do not store batteries in a pile as they will likely short and burn. If Li-ion batteries must be stacked on pallets, they should be stable, arranged so as not to be bumped or knocked over, and may only be wrapped with anti-static wraps.
6. Lithium batteries and defective batteries must be isolated from the rest in a bucket of sand to guarantee inert reaction and avoid short circuit between cells.
7. Develop a well-thought-out SOP for handling batteries, which should include important first responder contacts. Work with the local fire department or brigade and make sure they know the different areas where the lithium batteries, and Li-ion batteries exposures are located.
8. It is highly recommended to set up staging and temporary storage of Li-ion batteries, outside of the structure and away from the nearest building and equipment. Ensure a minimum safe distance of 33-feet (10-m) when it concerns a non-combustible building or 66-feet (20-m) when a combustible building is exposed.

Conclusion

The use of Li-ion batteries is growing rapidly across the world and the dangers associated with them are becoming more apparent. Solutions are being developed through new standards development, testing procedures, training, etc. As such, careful attention to risk mitigation recommendations is critical to safe use of this technology.

For more Information

For further information contact your local AIG Property Risk Engineer or e-mail CRS@AIG.com.

References

1. "The history and development of batteries", Jose Alarco and Peter Talbot, 2015. (https://phys.org/news/2015-04-history-batteries.html)
2. The Fire Protection Research Foundation, "Lithium-Ion Batteries Hazard and Use Assessment", Celina Mikolajczak, PE; Michael Kahn, PhD; Kevin White, PhD; Richard Thomas Long, PE.
3. International Fire Protection Issue 74 (June 2018)
4. ScienceDirect, "Opportunities to Improve Recycling of Automotive Lithium Ion Batteries", Alexandru Sonoc and Jack Jeswiet, 2015 (https://ac.els-cdn.com/S2212827115000797/1-s2.0-S2212827115000797-main.pdf?_tid=19fe6ba6-1a50-44c2-ba4e-82d6112a93b2&acdnat=1529935434_201dbd104612de55e0495331d3bf391d)
5. Sustainable Materials and Technologies "The Future of Automotive Lithium-ion Battery Recycling: Charting a sustainable course", Linda Gaines, November 2014. (https://www.sciencedirect.com/science/article/pii/S2214993714000037)
6. ISRI – Institute of Scrap Recycling Industries, Inc. (https://www.isri.org/safety/explosive-safety)
7. "Lithium-ion Battery Energy Storage Systems", AIG. (https://www.aig.co.uk/insights/lithium-ion-battery-storage)