

Insight: Lithium-Based Battery Exposure for Recyclers

Recognizing the Risk

Trending in conversations across the recycling, material recovery and waste facility communities is the involvement of lithium batteries in fires. This Insight provides information about the different types of lithium batteries. It also speaks to where they can be found, what they look like, their associated risks and how the different types behave in a fire situation. Emerging best practices are touched upon to provide you with a start point to consider as you manage the lithium-based battery risks at your facility.

Background

Lithium-based batteries used today can be categorized in several ways such as by materials (lithium-metal, lithium-ion, etc.), single-use or rechargeable, cell configuration, size and associated use, specific energy, power, and composition.

Lithium coin batteries | originally developed in the 1970s. As electronics have evolved, their high energy density and long shelf life made them well suited for applications that are low drain and utilize very fast high-rate pulses (for example sensors).^{1,2}

Lithium AA batteries | originally developed in the 1980s. These batteries are higher powered with longer duration, needed for the increasingly demanding consumer electronics being developed.

Lithium-ion batteries (LIBs) | first introduced in consumer electronics in 1991. These energy dense batteries pack a lot of energy in a small space, can be charged without being discharged and effectively retain charge relative to other current technologies. Today, they are in everything from e-cigarettes to electric cars with the demand projected to increase 50-fold by 2030.¹

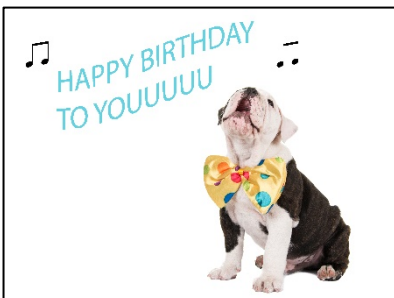
Keeping up with this demand has its challenges. Presently it's cheaper to produce the batteries from raw materials but the metals used to construct these batteries are limited. Geographic availability and the unprecedented supply chain challenges have driven prices by up to 80% over what it was just a few years ago.¹

For recyclers this means extracting the metal and components from the 11 million tons of spent lithium-ion batteries projected to flood the market by 2025 could become economically viable.¹

The Risks

Lithium-based batteries can pose a significant fire risk and the damage is often severe.

Scenario 1:



A consumer thinks a greeting card is recyclable and into the recycling bin it goes. The card plays music, powered by a small, single-use, button cell lithium battery. These small batteries can ignite when run over by standard recycling facility machinery and the large quantities of paper at the recycling facility becomes the fuel that can lead to a large fire and a total loss. While the investigation is still ongoing, such is thought to be the case for a recycling facility in Passaic, New Jersey where it's reported the fire started in a bale of paper. Unlike other common fire threats such as propane tanks, aerosol cans, and discarded fireworks these small batteries are impossible to filter out or spot but contain enough energy to spark a flame.

Scenario 2:



Another consumer knows that LIBs used in tools are required to be recycled and drops one into a designated store recycle bin, unknowingly damaging the battery’s outer protective case. Due to this damage a fire starts in the battery a few days later at the recycling facility, which quickly spreads across an entire lot of LIBs waiting to enter the battery grinding machine. Due to the challenges with this type of fire, the fire department fights the fire for days. In the end, the facility is a total loss. Similar scenarios can be found in the U.S. Environmental Protection Agency’s “Analysis of Lithium-Ion Battery Fires in Waste Management and Recycling”.³

Lithium-metal and Li-ion Batteries Explained



The first step is being able to identify what a typical lithium-metal and lithium-ion battery might look like.

Lithium-metal batteries are single use batteries that contain free lithium metal and are highly combustible. They are commonly found as the small-sized coin/button batteries in watches, laser pointers, computer motherboards, and other electronic devices that require a power source of small size. “AA” and “AAA” lithium batteries are also commercially available and can be found in the high drain devices becoming more prevalent among consumers e.g., radio-controlled toys. Lithium batteries are non-rechargeable and contain lithium, a water reactive alkali metal. Water from sprinklers can cause an explosion when exposed to the lithium in these batteries.



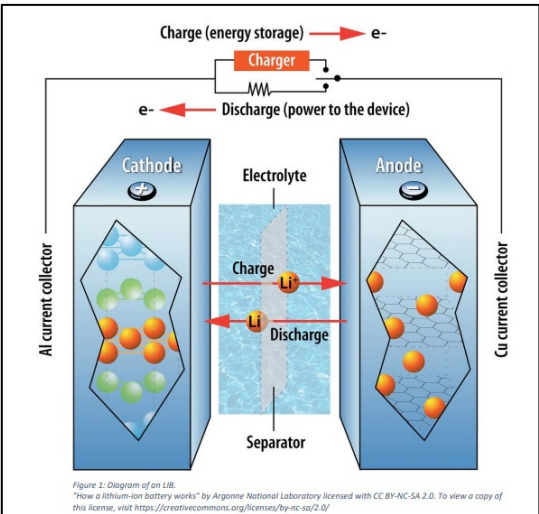
Lithium-ion are rechargeable batteries commonly found in electric cars, forklifts, laptops, tools and cell phones. Part of the risk at recycling facilities stems from what makes these batteries so popular: they pack a lot of power for their size. They do not contain the flammable lithium metal. They do contain flammable electrolytes.

How the Popular Li-ion Battery Works

LIBs are chemical energy storage units that release their charge in the form of electrical energy through electrochemical reaction.

Inside the battery, lithium ions travel through the electrolyte between a cathode and an anode. When the battery is charged, positively charged lithium ions travel through the electrolyte from the positive electrode (the cathode) to the negative anode, while the charged current carriers the electrons through the external circuit. When the battery is discharged, the ions travel through the separator from the anode, where they embed themselves in a carbon matrix during the charging process, to the cathode.

You can also watch an animation of how a lithium-ion battery works and find more information on the U.S. Department of Energy website.⁴



Risk Exposure

Each category, along with manufacturing quality, bring inherent risks.

At a recycling facility, the coin, AA etc. batteries are highly combustible. When the lithium in these batteries encounters water/moisture, almost certainly an explosive-like reaction can take place. The other challenge is that these batteries are small and often “hidden”.

LIBs enter the recycling system at the point of collection and from that point, any of numerous touch points can result in a damaged LIB that can short circuit, catch on fire and spread rapidly at high heat via thermal runaway.

They behave differently than other battery types in critical ways that increase their risk of fire:

Lithium Batteries are easily damaged in the Residential Refuse and Recycling System

 Collection	 Material Recovery Operations
• Dropping • Blade Scraping • Crushing +1,800# PSI compression ram • Puncturing by sharp objects, glass, metal • Unloading and running over with tires • Push material with container bodies	• Pushing into piles • Scraping with Blade • Puncturing by sharp objects and metal • Running over with tires • Loading onto conveyor belt • Dropping through screens • Dropping to storage

- They are less stable and easily damaged, resulting in shorts and explosive failures
- Electrolyte materials are typically flammable
- If the batteries short-circuit, they can overheat and create a chain reaction known as “thermal runaway,” a cascading effect in which they reach very high temperatures and emit smoke and toxic gasses that can further fuel fire and explosion, especially when stored closely with other lithium batteries
- LIB fires can be smoky and emit toxic gases
- LIB fires can re-ignite

Li-ion batteries do not contain the water reactive lithium metal but rather the lithium-ion fire require sprinklers delivering large amounts of water that have been found to be effective in mitigating the fire. However, the risk doesn’t necessarily end when the fire is “extinguished”. 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.

Lithium batteries are currently regulated as a class 9 hazardous material under 49 CFR § 173.185 [4] in the U.S and internationally under dangerous materials.

Managing the Risk

Controlling a fire initiating from a LIB or involving thermal runaway can be challenging.

Guidelines and best practices are emerging and evolving on how best to manage the risks associated with LIBs. Here are a few we have gathered. Keep in mind that battery design and technology is also changing where safety is a prime consideration, as are the regulations that govern their design and transport worldwide.

Public Education | Educating the public on safe disposal of LIB can be instrumental in reducing the risk of fire. Organizations worldwide are working on this initiative as just one component of a larger lithium-battery/metal recovery recycle strategy. A few tips to share with customers are listed below.

- Do not put these into the routine household trash
- Keep them away from each other and other metal that could cause shorts (plastic bag, cover leads with tape)
- Take them to the recycle facility directly
- Take them to a designated drop off point

Employee Education | Employee education is a critical step to reducing the risk associated with Lithium-Ion Battery handling and fire safety.

- **Labels:** Implement an employee lithium-ion and label identification program, communicate hazards and process steps to ensure safety and management of the fire risks
- **Products:** Educate employees to separate consumer items that may contain LIB or lithium-based batteries so the batteries can be removed prior to the crushing action at the plant. Crushing the batteries in the consumer items can damage the battery and lead to a fire.
 - Battery Operated Toys
 - Computers & Cellular Telephones
 - Electric Scooters
 - Baby Monitors
 - E-Cigarettes
 - Large Electric Vehicle Batteries⁷
- **Response:** Ensure incident response procedures are in place and communicated with employees, including instructions for responding to battery failures including fires or explosions

Processing | Safe handling of the Lithium or LIBs from collection to smelter is a critical step. As noted above, there are numerous points where an LIB can be damaged, short/leak and start a fire.

- Safe transport can be done in containers filled with sand or steel containers specific for li-ion batteries
- Separate lithium-metal from lithium-ion batteries
 - Lithium-metal = NO water! Danger of explosion
 - Lithium-ion + water = YES, can cool and assist in containing the fire
- Keep the separated batteries away from metal in other waste, high humidity, water and flammables
- Once battery packs are in the smelter, the flammable electrolytes pose little hazard

Storage | The type of battery, temperature and storage configuration/containers are all considerations.

- Create a lithium or LIB battery only storage area, with no heat source within the space

Li-ion battery manufacturers can be a valuable source of information with some providing storage instructions

Control the temperature – 10°C to 45°C⁸

Fire Protection & Fire Fighting | While small fires may happen often at the recycling or waste facility, a fire involving a lithium-based battery is different. There are a few key steps you can take in advance to help minimize loss, should a fire from a LIB occur.

- NFPA* 855 Standard for the Installation of Stationary Energy Storage Systems (ESS) offers guidance for an ESS that can be helpful and relevant for li-ion batteries at a recycling facility based on the types of batteries arriving for recycle
- Consider novel approaches e.g. installing a thermal camera to look for ignition points on the waste floor
- Consider heat activated ceiling venting – successfully used by Rethinkwaste at their Shoreline facility³
 - When triggered by the fire, these vents opened to create a chimney-like effect that was designed to limit the fire's horizontal spread. Eventually, the blaze was extinguished by numerous local fire departments.
- Evaluate the conveyor belt for appropriate fire protection and ensure easy access placement cut-off switches
- Ensure high-value equipment is adequately protected
- Collaborate with the local fire department, offer tours and ensure there is a response plan in place
- Take the fire outside when possible. Larimer County Landfill's Recycling Center did this using their heavy equipment and possibly saved the facility in its entirety³

- Facilities should have fast-acting automatic fire detection in place such as very early warning aspirating smoke detection type systems
- Alarm systems should have 24/7 remote monitoring to ensure that no alarm goes unnoticed

Conclusion

While fires at waste and recycling facilities may be common, the risks involving li-based batteries can be much greater.

- There are millions of batteries that will need recycling, the problem is only growing
- The public does not always know how best to dispose of the different types of batteries – lithium based or otherwise
- These batteries often arrive “hidden” in the products they used to power, buried in the stream of incoming waste.
- There are different types – lithium and lithium-ion, each based on very different technology and each contributing to fires in very different ways
- Lithium-ion batteries should be kept in a li-ion only area and consider that these batteries can reignite
- Water is not good for lithium batteries, much needed for li-ion batteries
- The waste industries are only starting to recognize the challenges and opportunities these lithium batteries pose with guidelines and best practices for safe handling similarly emerging

References & Resources

References:

¹ [Producing batteries for green technology harms the environment. Here's what needs to change | World Economic Forum \(weforum.org\)](https://www.weforum.org) accessed November 17, 2021

² [Firefighters Could Spend Days Putting Out Hot Spots After New Jersey Recycling Center Fire, Officials Say – CBS New York \(cbslocal.com\)](https://www.cbslocal.com) accessed November 17, 2021

³ [An Analysis of Lithium-ion Battery Fires in Waste Management and Recycling \(epa.gov\)](https://www.epa.gov), July 2021, accessed November 17, 2021

⁴ [How Lithium-ion Batteries Work | Department of Energy https://www.energy.gov/eere/maps/how-lithium-ion-batteries-work](https://www.energy.gov/eere/maps/how-lithium-ion-batteries-work), accessed March 2021

⁵ [Federal Register :: Hazardous Materials: Transportation of Lithium Batteries](https://www.federalregister.gov), accessed November 15, 2021

⁶ U.S. Environmental Protection Agency, “EPA Reaches Agreement with Superior Battery to Begin Cleanup in Morris, Illinois | US EPA” (<https://www.epa.gov/newsreleases/epa-reaches-agreement-superior-battery-begin-cleanup-morris-illinois>), accessed November 04, 2021)

⁷ [Batteries | CPSC.gov](https://www.cpsc.gov/th/Regulations-Laws--Standards/Voluntary-Standards/Topics/Batteries) U.S. Consumer Product Safety Board, <https://www.cpsc.gov/th/Regulations-Laws--Standards/Voluntary-Standards/Topics/Batteries> accessed November 22, 2021

⁸ [Lithium ion Battery Storage - Lithium ion Battery Manufacturer and Supplier in China-DNK Power https://www.dnkpower.com/lithium-ion-battery-storage/](https://www.dnkpower.com/lithium-ion-battery-storage/), accessed November 8, 2021

Resources:

[Microsoft Word - Issued TIA 855-20-1 Final \(nfpa.org\)](https://www.nfpa.org) accessed November 22, 2021

United Nations, “UN Manual of Tests 1915377_E_ST_SG_AC.10_11_Rev.7” (https://unece.org/fileadmin/DAM/trans/danger/publi/manual/Rev7/Manual_Rev7_E.pdf, accessed November 4, 2021.)

[Microsoft Word - Lithium Coin 0318 \(energizer.com\)](https://www.energizer.com)

Call2Recycle | United States

Insight: Lithium-Based Battery Exposure for Recyclers

International Lithium Association

FEAD - European Waste Management Association

Latin American Battery Association

The Battery Association of Japan

EUROBAT

Electro-Federation Canada

RECHARGE

Recycling Laws By State | Call2Recycle | United States

*While NFPA documents are the global standard used by AIG, international equivalents may be acceptable.

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