Lithium-Ion Battery Storage & Handling

Protecting Your Facility From Lithium-Ion Battery-Related Fires & Explosions

Global Risk Consultants®

White paper

Abstract

While the development of lithium-ion batteries has advanced innovation and technology in the past several decades, they have also presented a new range of fire and explosion risks. Deficiencies in quality, incorrect assembly, and damage can result in overheating and explosions that present hazards to life safety and property. For commercial and industrial environments, proper storage and risk management are critical in avoiding lithium-ion battery malfunctions. This whitepaper will discuss the hazards that industrial facilities face, examine recent case studies involving lithium-ion battery incidents, and risk mitigation techniques that facilities can adopt to ensure safety.

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About the TÜV SÜD GRC expert



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As Chief Engineer for TÜV SÜD GRC, Mr. Macaulay serves in a variety of functions including developing tools to improve the quality, consistency, and effectiveness of services, provides technical support to clients, supports internal technical training, and works with the marketing team to develop new services and improvements to meet client expectations and add value. In addition to those duties, he also serves as Account Manager and Account Engineer for various clients, providing a true holistic approach to risk management. In addition, he conducts standard surveys and special engineering projects.

1. Introduction

It's no exaggeration to say that lithium-ion batteries power our world. Invented just 40 years ago as a result of research by three Nobel Prize-winning scientists, lithium-ion batteries today are found in virtually all types of electrical and electronic devices, from consumer products like smart phones and laptop computers to wearable medical devices to automobiles and even advanced industrial equipment. Without lithium-ion batteries, our ability to stay in touch and get things done would be very limited indeed.

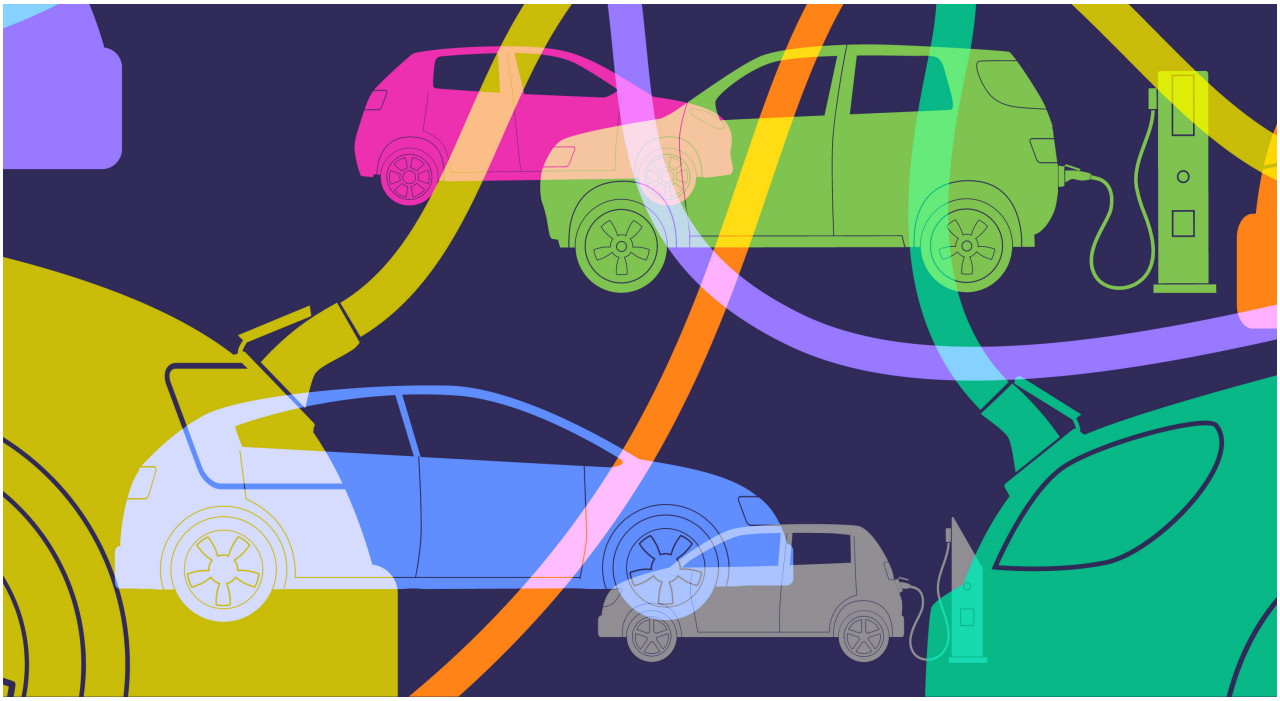
However, the widespread use of lithium-ion batteries has also brought to the forefront concerns about their safety. While normally safe under most use conditions, lithium-ion batteries that are poorly designed or which consist of low-quality materials or have been assembled incorrectly or have been damaged can overheat and even explode, potentially resulting in catastrophic consequences involving life and property. This problem is only magnified when large quantities of lithium-ion batteries are stored on-site or transported between industrial facilities.

In this white paper, we'll explore the hazards specific to lithium-ion battery storage in commercial and industrial environments and discuss fundamental strategies that building owners and operators of commercial and industrial facilities can implement to reduce the potential risks associated with battery-related fires and explosions.

There are three major configurations for Lithium-ion batteries:

- The small format, batteries we are used to seeing in electronic devices and hand tools
- Larger batteries that are used in mobile equipment such as lift trucks and automobiles
- Very large scale Energy Storage Systems (ESS), typically used for uninterruptible power supplies (UPS) or for electric power grid storage, often in conjunction with renewable power generation equipment.

While all of these types of batteries function similarly, this white paper address issues with small and medium format batteries only. Users of large scale ESS should consult NFPA 855, Standard for the Installation of Stationary Energy Storage Systems, for specific loss control approaches.



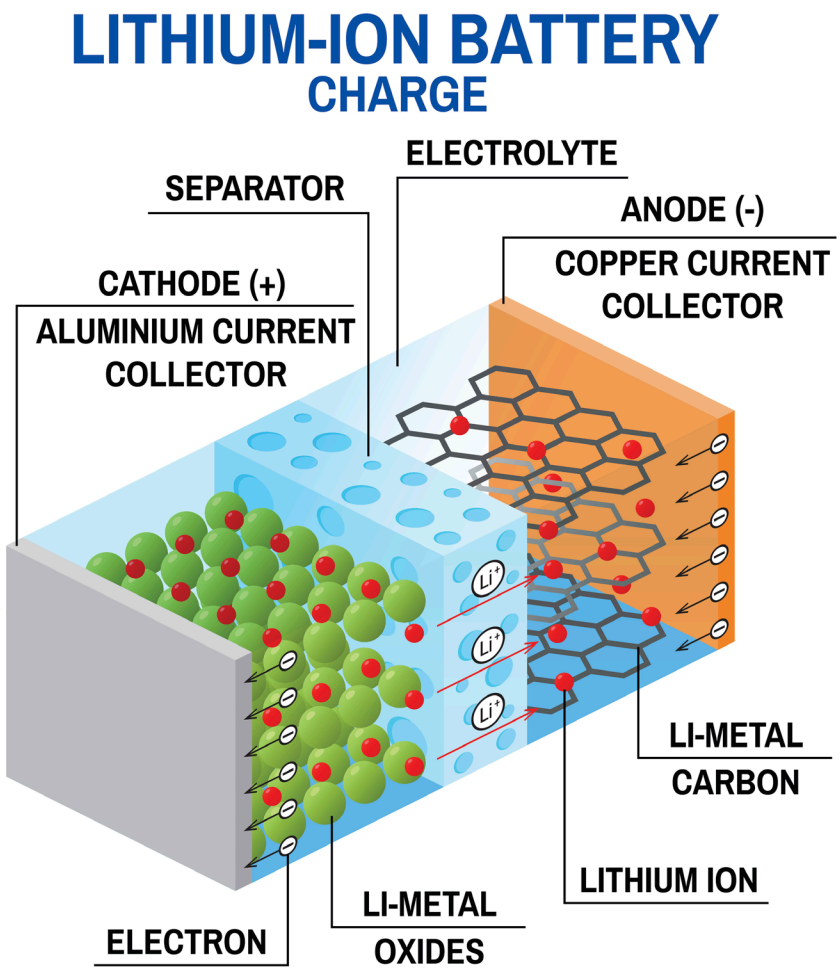
2. How battery design and materials impact safety

Each lithium-ion battery consists of cells in which lithium serves as the agent for an electrochemical reaction that produces energy. When discharging, lithium ions in the battery cell move from the anode (the negative electrode) to the cathode (the positive electrode) through an electrolytic substance, typically a liquid or gel, resulting in the release of energy from the battery. The process is reversed when the battery is being charged, with ions moving from the cathode to the anode.

The basic design of lithium-ion batteries offers a number of advantages over conventional batteries, including greater energy density and cell voltage and, in the case of rechargeable (secondary) lithium batteries, little loss of charging capacity over time. But these benefits also introduce a number of potential safety risks related to thermal stability and internal short circuits. The most important added risk is that, unlike most other batteries, the electrolyte used in lithium-ion batteries is flammable. Excessive heat from very high internal currents (most often from short circuits) can ignite the electrolyte. Even in lithium-ion batteries with integrated safety features, an unanticipated breach in the battery separator material can result in high current that overheats the battery's electrolyte, quickly leading to thermal runaway and fire or even explosion.

Further, as the demand for smaller, more robust lithium-ion batteries increases, battery manufacturers and developers are continuously exploring design and material options that can lead to improved battery performance, such as changes in lithium chemistry or thinner battery separator materials. While such changes can contribute to a significant increase in energy density, they can also make lithium ion batteries more vulnerable to small manufacturing defects or internal damage from physical impact with another object.

Finally, variations in battery design and quality of materials and manufacture can contribute to potential safety risks. Defects in the design of the battery itself, the use of low- or poor- quality materials, or the incorrect assembly of battery components can individually or collectively increase the likelihood of battery overheating or failure.



3. Recent incidents involving lithium-ion battery overheating and explosions

In recent years, public attention regarding the safety of lithium-ion batteries has focused primarily on incidents involving consumer products. The U.S. Consumer Product Safety Commission (CPSC) reports that there were more than 25,000 instances of overheating or fires involving more than 400 types of lithium battery-powered consumer products from 2014 through 2017 (1). And high-profile cases, such as those involving Samsung's Galaxy Note 7 smartphone in 2016 or widespread reports in 2016 and 2017 of battery-powered hoverboards catching fire or exploding, have helped increase general awareness regarding the risks associated with poorly design or manufactured lithium-ion batteries.

In the recycling industry, one operator of materials recovery facilities (MRFs) in California reports that their company has experienced an average of two fires a month directly attributable to lithium-ion batteries, with one 2016 incident costing the company an estimated $8.5 million (2). The potential threat that disposed lithium-ion batteries pose to MRFs is significant enough that the U.S. Environmental Protection Agency (EPA) has developed a number of on-demand webinars on the proper handling of lithium-ion batteries by electronics recycling facilities (3).

These and other examples illustrate the very real risks posed by the improper use, storage and handling of lithium-ion batteries in industrial settings. Fires and explosions associated with lithium-ion batteries have potentially significant consequences for workers, facility operators and the communities surrounding such facilities. Such incidents can also lead to an extended shutdown of a facility's operation with the attendent financial impact.





4. Facility protection fundamentals and strategies for minimizing the risk associated with lithium-ion batteries

Fortunately, there are important steps that operators of industrial facilities and MRFs can take to reduce the risks associated with the use, storage and recycling of bulk quantities of lithium-ion batteries. These fundamental protection steps should be taken, regardless of the facility or installation in which lithium-ion batteries are found, and include:

Ensure that the facility is equipped with sprinklers conforming with NFPA standards for plastic materials: Idle battery storage is not typically subject to internal ignition (see next bullet). Large scale testing (6) has shown that lithium-ion batteries behave similarly to unexpanded plastic commodities in a fire. Therefore, sprinkler protection should be provided as detailed in NFPA 13, Standard for the Installation of Sprinkler Systems, for cartoned unexpanded plastic commodities (if the batteries are in cardboard cartons) and for exposed unexpanded plastics (if there is no cardboard packaging material).



Make sure that lithium-ion batteries held in storage are changed at levels not exceeding 50% of their charge capacity: Fully charged lithium-ion batteries have a higher energy density and are at greater risk of generating significant heat from short circuiting related to internal defects. Therefore, batteries intended for longer-term storage should be charged at levels not exceeding 50% of their total charge capacity and kept at temperatures between 40-80° F (4-27° C) to help minimize the risk of thermal runaway from manufacturing defects or internal failures.

Establish minimum distances between battery charging stations and any combustible materials: While generally safe, the process of charging lithium-ion batteries can present safety concerns. Therefore, stations designated for the charging of large format batteries should be separated from other combustible materials by at least three feet. Stations intended for the charging of small format batteries (such as those used in hand tools) should be set on a firm, non-combustible surface and be separated from other combustible materials by at least one foot.

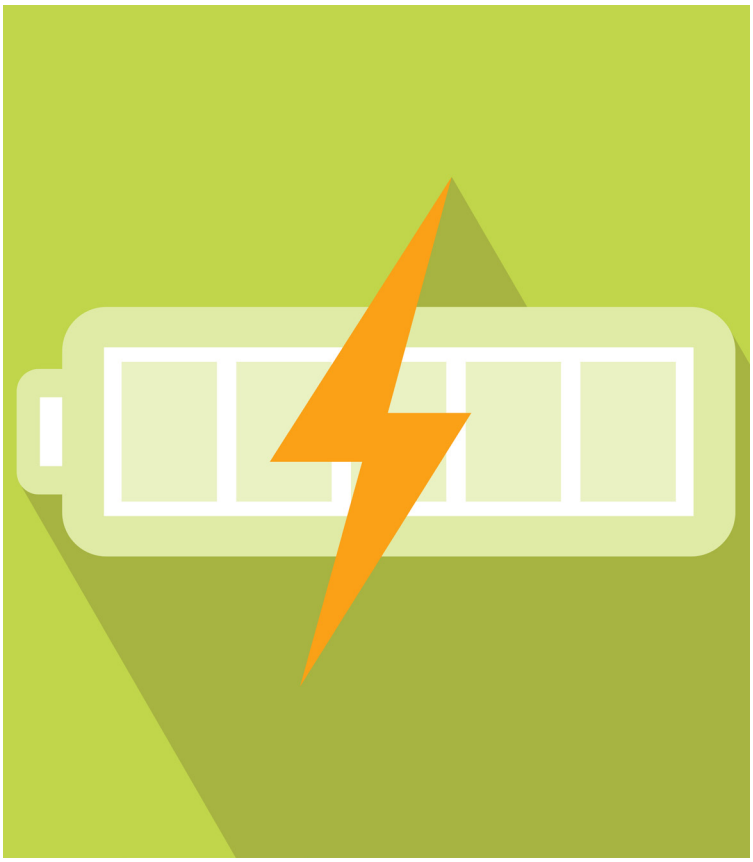
Isolate battery terminals prior to placing lithium-ion batteries in waste bins or disposing of them: Lithium-ion batteries that are damaged, or which have been designated as waste should have their battery terminals covered with insulating material. Taking this step helps to ensure that the terminals don't accidentally come in contact with metal or other battery contacts that could close the battery circuit and result in an unintended energy discharge.

Provide sufficient separation between bins holding damaged, discarded or waste batteries and storage holding other combustible materials: Bins holding damaged or discarded batteries should be separated by at least 10 feet (3m) from all other storage areas and bins holding other potentially combustible materials. This separation helps to reduce the risk of spreading a fire originating among discarded or waste batteries. In addition, these bins should be metal and equipped with metal lids whenever practical.

Discard lithium-ion batteries that show evidence of physical or mechanical damage separately from other waste batteries: Internal components and mechanisms in lithium-ion batteries are highly susceptible to damage when the battery is subject to a severe external force or when it is dropped on a hard surface. Any external evidence of damage should trigger concerns about the internal integrity of the battery and result in its disposal in bins intended solely for damaged batteries.

For larger format batteries (mobile equipment batteries): Ensure battery chargers and batteries (equipment) being charged are separated from other combustible contents by at least 10 ft (3 m).

As noted previously, the design of lithium-ion batteries continues to evolve as manufacturers seek new ways to increase battery density while also reducing size. Therefore, the safety of lithium-ion battery technology will continue to be investigated to address unexpected hazards that emerge from the advancement of this important technology. As we learn more about the risks associated with the use, bulk storage and recycling of lithium-ion batteries, changes in standards and best practices can be expected to change as well.



Did you know?

The U.S. Consumer Product Safety Commission (CPSC) reports that there were more than

25,000

instances of overheating or fires involving more than 400 types of lithium battery-powered consumer products during the period from 2014 through 2017.

6. How TÜV SÜD Global Risk Consultants Work to Support Lithium-Ion Battery Safety

Acquired by TÜV SÜD in 2010, Global Risk Consultants is the leading unbundled property loss control provider worldwide, and offers comprehensive risk analysis and risk prevention services for owners and operators of facilities that use large scale lithium-ion batteries in industrial applications, or that bulk store or recycle lithium-ion batteries.

Since our founding in the late 1950s, Global Risk Consultants has gone beyond the parameters of traditional property loss control services and continuously strives to provide our clients with solutions to help achieve and maintain a highly protected status. We provide our clients customized and comprehensive reports permitting them to make informed, practical business decisions.

Our other risk consulting and prevention services include:

- **Fire Protection Engineering**
- **Boiler and Machinery Engineering**
- **Infrared Thermographic Surveys**
- **Jurisdictional Boiler and Pressure Vessel Inspections**
- **Natural Hazards Analysis**
- **Customized Loss Control Training**
- **Arc Flash Analysis**
- **Process Safety & DHA**
- **Business Continuity Planning**
- **Code & Project Services**
- **Property Valuation Services**

With more than 400 employees worldwide, including risk control engineers and consultants, we can respond to your property risk control needs effectively.

For more information about how TÜV SÜD Global Risk Consultants can help protect your facility from the risks of lithium-ion battery usage, storage and recycling, contact us at contact-grc@tuvsud.com. Or visit our website at www.tuvsud.com/en-us/services/risk-management.





GLOSSARY OF ACRONYMS

GRC – Global Risk Consultants
LI – Lithium
US – United States
CPSC – US Consumer Product Safety Commission
UPS – Uncorruptable power systems
MRF– Materials recovery facility
EPA – US Environmental Protection Agency
NFPA – National Fire Protection Association
ESS – Energy storage system
DHA – Dust hazard analysis

ENDNOTES

[1] "Status Report on High Energy Density Batteries Project," report by the U.S. Consumer Product Safety Commission, February 12, 2018. Available at https://www.cpsc.gov/s3fs-public/High_Energy_Density_Batteries_Status_Report_2_12_18.pdf?UksG80UJqGY0q4pfVBkbCuUQ5sNHqtwO (as of November 7, 2019).

[2] "Battery fires an 'existential threat' for industry," posted on the website of Resource Recycling, April 10, 2018. Available at https://resource-recycling.com/recycling/2018/04/10/battery-fires-an-existential-threat-for-industry/ (as of November 7, 2019).

[3] See, for example, "Sustainable Materials Management (SMM) Web Academy Webinar: An Introduction to Lithium Batteries and the Challenges that they Post to the Waste and Recycling Industry," an on-demand webinar produced by the U.S. Environmental Protection Agency, March 22, 2018. Available at https://www.epa.gov/smm/sustainable-materials-management-smm-web-academy-webinar-introduction-lithium-batteries-and (as of November 7, 2019).

[4] "Lithium Ion Batteries Hazard and Use Assessment – Phase III," R. Thomas Long, Jr, Andrew Blum, for the Fire Research Foundation, November 2016

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