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Lithium-Ion Batteries

Allianz Risk Consulting

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices. A battery may contain one or multiple cells that convert chemical energy into electrical energy. are a member of a family of rechargeable battery types in which lithium-ions move from the negative electrode to the positive electrode during discharge and back when charging. They are the most widely used type of rechargeable batteries today and are common in home electronics, mobile electronics, medical applications and industrial applications. Beyond consumer electronics, lithium-ion batteries are also growing in popularity for military and electric vehicles as well as aerospace and marine applications.

This risk bulletin is issued in support of raising the awareness of businesses involved in the manufacturing, packaging, transporting, usage and storage of these types of batteries, as well as products containing these types of batteries.

Lithium-ion batteries are popular for the following reasons:

- They are lighter than other types of rechargeable batteries of the same size, due to electrodes, which are made of lightweight lithium and carbon
- Because lithium is a highly reactive element, a lot of energy can be stored in its atomic bonds, thus lithium-ion batteries carry a very high energy density
- They have a low self-discharge over time compared to other batteries
- They have a small memory effect there is no need to completely discharge the battery before recharging, as required by some rechargeable batteries
- They can handle hundreds of charge/discharge cycles over their lifetime

Despite the huge advantages of lithium-ion batteries, there are disadvantages that should be noted:

- Lithium-ion batteries begin degrading soon after being manufactured and will typically last 2 to 3-years from the date of manufacture, whether used or not
- Heat causes lithium-ion batteries to break down faster than normal, so their sensitivity to high temperatures must be considered. Storage in a cool place slows the aging process of lithium-ion batteries. Manufacturers recommend storage temperatures of 15°C (59°F)
- A lithium-ion battery pack requires an on-board computer (battery charge state monitor) that handles the entire charging process to make sure the batteries charge as quickly and fully as possible. This on-board computer draws power from the batteries, causing the

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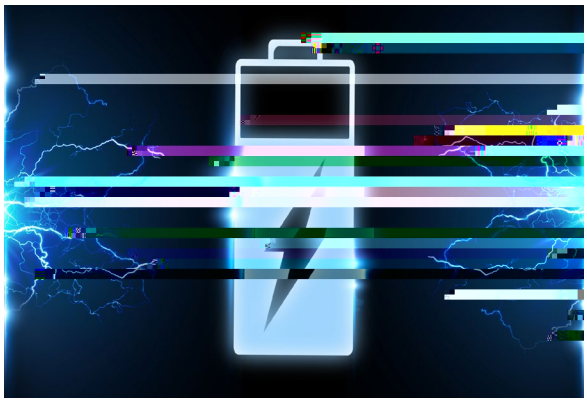
- If completely discharged, a lithium-ion battery is ruined
- If a lithium-ion battery pack should fail or be damaged, it could ignite or explode, due to the flammable electrolyte contained and pressurized in these batteries. Over the past several years, in response to reported accidents and failures, there have been several lithium-ion battery-related recalls

amended as additional research is completed (providing more knowledge about the hazards associated with transporting these batteries) and, unfortunately, as new incidents come to light. Within the US, the regulations governing the transportation of lithium-ion batteries can be found in Title 49 of the Code of Federal Regulations (CFR), which governs shipping.



Source: iStock

Although it is not within the scope of this risk bulletin to go into all of the detailed requirements found within those regulations (in order to be in compliance with the hazardous materials (hazmat) regulations), it is within this bulletin's scope to provide the following general information:

- Formal training and record keeping is required of all employers who are involved in the transportation of hazardous materials, including lithium-ion batteries, whether being shipped as standalone batteries, or contained or packed in equipment
- Hazmat regulations also apply to lithium-ion batteries used in battery-powered vehicles, such as wheelchairs, golf carts, lawn vehicles, motor scoove to scnobatteren0 -1.474 TD(hazards sh)Tasso 0.293 0.577 scn/Span<</ActualText<FEFF25F hazar in TitleSc tatte38.3he detaiUniith Ns
- Specific exceptions or exemptions may apply to certain shipments

Manufacturing and packaging processes are keys to keeping lithium-ion batteries safe during transportation. Lithium-ion batteries may become a source of ignition if overcharged, mishandled, short circuited, heated to high temperatures or if produced with manufacturing defects. If damaged during transportation some lithium-ion batteries may release a flammable electrolyte mixed with other flammable gas compounds. It is for these reasons that importers as well as shippers of lithium-ion batteries must be keenly aware of these compliance issues and ensure that their shipments meet all regulations that apply.

As lithium-ion batteries continue to grow in their usage and evolve to suit the demands of our society, so will the need for continued research and development.

We have already begun to see an increase in the application of this energy resource in the maritime industry from an engineering point of view on both large commercial vessels as well as small private vessels. According to a recent US Coast Guard (USCG) article[2] the Marine Safety Center has reviewed plans for vessels having all-electric and hybrid-electric propulsion systems.

With these systems comes the need to store the electrical power and lithium-ion batteries are among the quickly advancing energy storage system options. There are various reasons for the growth in popularity in the marine industry as previously discussed, however the USCG feel that the safety margins have not kept up with the rapid growth and changes in their application. The thermal runaway event which led to a lithium-ion battery fire on a US flagged hybrid-electric towing vessel in the port of Los Angeles in 2012 is an example of the lack of safety of Lithium-ion batteries.

2. LT Stephen Lewis, Lithium-ion Batteries are Heating Up, Marine Safety Engineering, Dec. 2016.

Another strategy is that lithium-ion batteries should be isolated from other battery chemistries and commodities (storage, transport, etc.). They should be stored (shipped) in environments that would effectively contain fires and toxic burn by-products. This is essential to health, safety, and preservation of property. Close attention should be paid to isolating batteries from general facilities by developing external storage or "satellite" storage. Battery storage farms would allow for storage off-site with just-in-time (JIT) delivery of batteries to a facility when needed. Batteries should be partially charged during storage. Most manufacturers recommend a 40% charge.

The storage of equipment that incorporates lithium-ion batteries (power tools. cell phones, laptops, etc.) does not present the same hazard as battery storage because the equipment that typically encases the batteries significantly delays their involvement in a fire incident. Therefore, protection for the storage of these items can usually be based on the commodity classification of the product. This will typically be driven by the housing of the product, the packaging and the pallet.

2.

Since lithium-ion batteries present critical challenges to facilities that possess them, it is recommended that training be included in any risk management strategy. Facilities and individuals alike should be aware of the unique hazards that these batteries present.

Companies that possess lithium-ion batteries in high quantities should work with experts to develop training that seeks to mitigate the fire issues and ensures additional layers of safety. Training might address issues like battery awareness or include more detailed situational training such as battery fire behavior, emergency response procedures and fire extinguisher use (lithium-ion battery focus). This type of training lends itself well to the preservation of property, as well as life.

Effective lithium-ion battery standard operating procedures (SOP's) should include processes that guide shipping and receiving, handling, daily use, storage and other functions involving the batteries. Proper SOP's should address every facet of the battery life cycle. Businesses that are involved in the storage and transportation of lithium-ion batteries would be well advised to develop a unique SOP.

Lithium-ion battery fires shouldn't be treated like common fires as the burn characteristics and toxic by-products released are different than fires involving other materials. The level of risk should be determined through proper assessment and businesses should create emergency response procedures based on sound response and battery handling data.

Close attention should be paid to Safety Data Sheets (SDS, formerly MSDS) and other suggestions from manufacturers and distributors. These documents prescribe possible methodologies for proper storage, handling and emergency response. It should be noted that SDS recommendations can sometimes vary widely and at times are quite different, ultimately adding to some confusion, although some of the suggestions can be used to develop a strong lithium-ion battery management process.

It should be noted that as this bulletin was being prepared, the US Public Broadcasting System (PBS) aired an episode of the popular science-based television program called "NOVA" entitled "Search for the Super Battery[5]" which discusses the rapidly evolving field and explores a new technology (solid plastic electrolyte) which may eliminate the common hazards and risks associated with Lithium-ion batteries.

Lithium-ion battery on bike luggage carrier
Source: iStock

5. Search for the Super Battery, NOVA, Feb. 1, 2017 - http://www.pbs.org/wgbh/nova/tech/super-battery.html