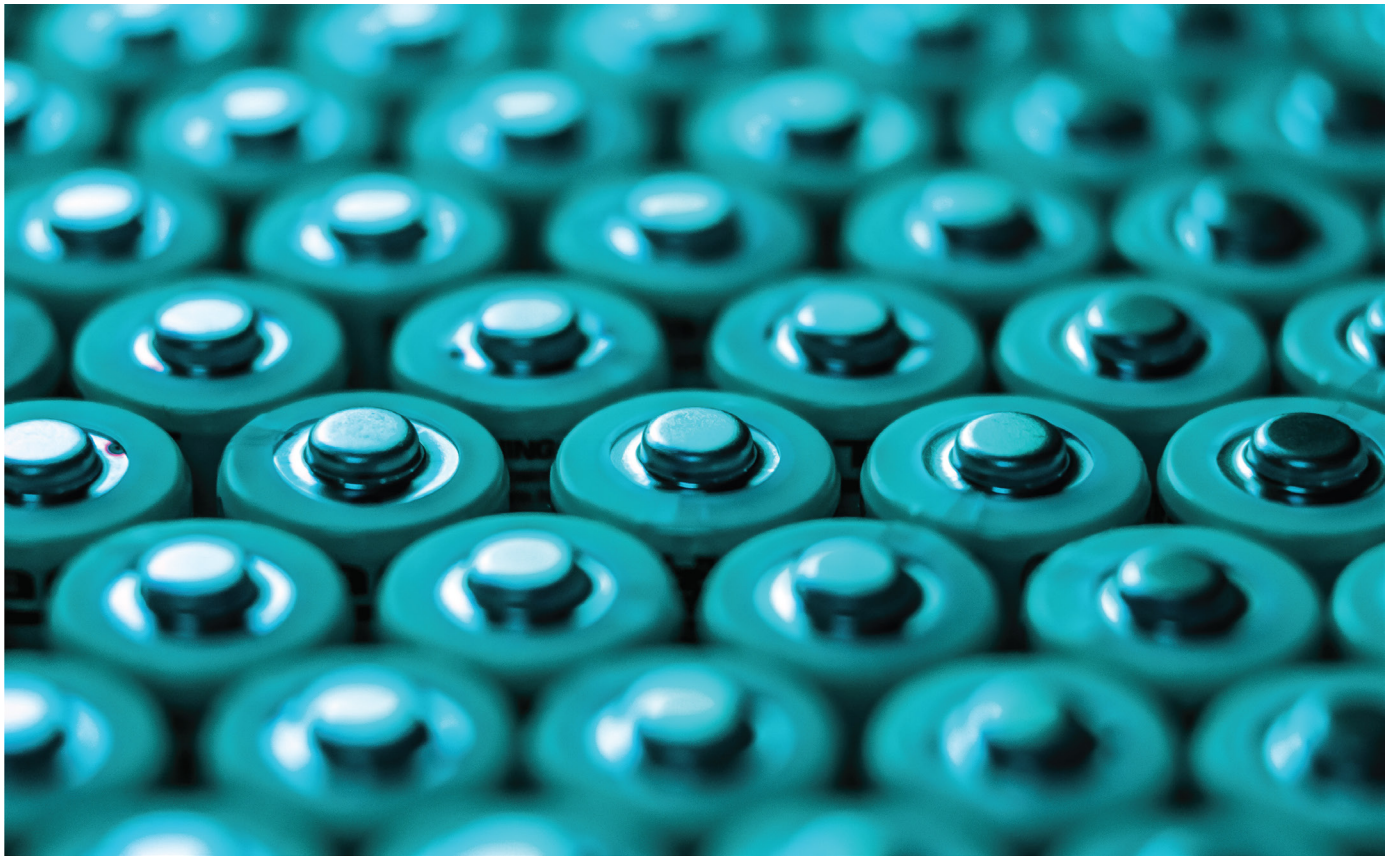
Lithium vs Lithium-ion batteries: the differences matter when fighting a fire



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Batteries are everywhere. They can power everything from toys and smart phones to pacemakers, smoke alarms, and autonomous vehicles. The focus of this article is on two batteries – lithium and lithium-ion batteries – that are often confused because of the similarity in their names.

Both come in all shapes and sizes. However, there are differences between the batteries. Differences that are extremely important to firefighters. When mixtures of lithium and lithium-ion batteries do occur – such as at a recycling plant – the two types of batteries should be totally segregated because extinguishing strategies for the batteries are not compatible.

Know your batteries

All batteries are made up of the same three basic components: the anode (negative side), the cathode (positive side), and some sort of electrolyte. When the cathode and anode of a battery are connected, a chemical reaction occurs between them and the electrolyte. Electrons flow through the circuit from the anode, and then enter back through the cathode, prompting a chemical reaction. These reactions continue until the materials are consumed, at which point no more electricity is produced by the battery.

Both lithium and lithium-ion batteries produce portable electricity in this manner. The metal lithium used in the lithium battery has unique properties which make it highly suitable as a negative electrode. It is one of the lightest metals in the

periodic table and it also has the greatest electrochemical reduction potential, providing the largest energy density per weight. In lithium-ion batteries, pure metallic lithium is not used. Instead, it is blended with other materials.

Lithium batteries are primary cell batteries. The batteries have a high charge density, allowing them to hold more power and to last much longer than other batteries. The shelf life of a lithium battery is up to four times longer than that of lithium-ion batteries They are also easy to make and much cheaper than lithium-ion batteries. Lithium batteries, however, cannot safely and easily be recharged, which eventually led to the invention of lithium-ion batteries.

Lithium-ion batteries are secondary cell batteries. The battery's electrodes are made from lithium combined with many other materials, meaning they are not metallic lithium. They are also great at holding a charge and do not need to be completely discharged before recharging. The batteries are highly complex compared to the simplicity of the lithium battery. Within a lithium-ion battery, there are multiple lithium-ion cells which store and provide the power. The cathode and anode are separated by a thin sheet of "microperforated" plastic that keeps the two electrodes from touching. Within the battery unit, a small computer monitors and regulates the temperature, voltage, and state of battery charge. This tiny system keeps the battery functioning. While rare, lithium-ion batteries are vulnerable to fires and explosions which can lead to a venting of flammable gases.

Morris, Illinois Industrial Fire

On June 30, 2021, a massive industrial fire broke out at an abandoned warehouse in Morris, Illinois. Clouds of black, toxic smoke could be seen spewing into the air from miles away. When firefighters arrived, they were not aware of what was being stored in the warehouse. They started pumping water onto the fire, resulting in an increased intensity in the fire and occasional large explosions from inside the warehouse.

When the building's owner arrived, he said he had no insurance on the building and that he was storing supplies in the 70,000-square-foot warehouse. He planned on opening a solar power business at the end of the year. He also mentioned that he had intended to repair the roof at the end of the week. He thought water dripping from the roof onto the batteries could have sparked the fire. To the surprise of firefighters and town officials, no one knew that the abandoned warehouse was being used to store hundreds of batteries. After learning about the batteries, the firefighters chose not to use water or foam on fire and instead decided to let it burn.

With the fire continuing to burn, nearly 1,000 residents had to be evacuated due to the toxic fumes and smoke being spewed into the air. Fire officials and other governmental entities began reaching out to the EPA and other firefighting agencies for additional advice on how to put out the growing fire. They applied 1,000 pounds of a dry chemical called Purple-K (potassium bicarbonate, trademarked Ansul) to the fire hoping it would smother it. According to officials onsite at the time, the "lithium fire laughed" at the Purple-K. Next, officials pumped 28 tons of dry cement into the warehouse to cover the burning batteries. The "trouble spot" itself was about 3 feet deep, covering an area of about 30 feet by 40 feet. The fire was eventually put out, but the EPA continued to monitor the air quality in the area for about 3 to 4 days. News sources later reported that nearly 200,000 "lithium batteries", ranging in size from cellphone batteries to large car batteries, were stored in the warehouse.

Summary

Most lithium-ion battery fires and explosions come down to a problem of short circuiting. This happens when the plastic separator fails, letting the anode and cathode touch. Once they get together, the battery will start to overheat. Once one cell overheats, a domino effect called "thermal runaway" can happen. For batteries with hundreds of cells, thermal runaway has the potential to be a big problem. Until all potentially damaged lithium-ion batteries are removed from the area following a fire, a fire watch must be present 24/7 as lithium-ion battery fires have been known to reignite any time from minutes to days after the initial event.

In chemical fires, smoke pollution versus water pollution in the form of aggressive water or foam use is a major issue. That's why sprinklers are so important. Where sprinklers cannot be used such as on large quantities of metallic lithium, fixed in place special extinguishing systems are used instead. Either way, the fixed systems control the fire quickly, and by not using a lot of water, the runoff and ground contamination problem is lessened. Water from a firefighting hose is used for the final knockdown or other special agents for metallic lithium. Sometimes, water immersion tanks are used to prevent the lithium-ion battery from reigniting. This is obviously done outside. Some fire departments in Europe use a crane to immerse a car in a dumpster-size immersion tank to put out a thermal runaway fire. Class D agents are not needed for lithium-ion battery fires. While other agents may control a fire, they don't cool the cells, which is key to putting out the fire. Class D agents are only needed for large quantities of metallic lithium. This cannot be just any Class D agent. It

must be specifically listed for lithium. Because the potassium bicarbonate mentioned earlier is much more readily available than other powders for lithium fires, it is often tried as a substitute with results like those obtained at the Morris fire.

Sprinklers are generally effective with lithium batteries packaged for consumer point of sale (think AAA -D cells). Lithium batteries are usually smaller and when packaged with other consumer goods or in a retail display, the amount present is small enough that sprinklers and standard water hoses can still be used to put out a fire. In manufacturing plants, special agents such argon are needed to protect the metallic lithium in the lithium battery. An agent called Lith-X (trademark of Ansul) can be used for primary lithium fires or dry inert material (like cement) can be used if available.

With the increased popularity of rechargeable lithium-ion batteries, they are now being used in Energy Storage Systems (ESS). The NFPA (National Fire Protection Association) with the assistance of FM Global released a **fact sheet** addressing the issues around using lithium-ion batteries in ESS, including thermal runaway, stranded energy – the ability for a fire to reignite, toxic and flammable gas generation, and the need for large amounts of water to effectively dissipate the heat generated from ESS fires since cooling the hottest part of the fire is often difficult.

Knowing your batteries can make all the difference in fighting a battery fire.