Addressing Safety Concerns for Lithium-Ion Batteries in UPS Applications

Addressing common misconceptions about the risk of overheating and fire caused by Lithium-Ion Batteries in Data Center and UPS Applications.

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- *What causes thermal runaway*
- *How safety features prevent thermal runaway*
- *Lithium-ion battery chemistries*
- *Battery Management systems*

EXECUTIVE SUMMARY:

Review of the misconceptions about Lithium-ion battery safety, as well as regulations for lithium-ion batteries and their safety features. The different

lithium-ion battery chemistries will be discussed and how they affect safety.

It was unfortunate timing. Right around the time battery manufacturers had engineered solutions that addressed safety concerns for lithium-ion batteries in UPS applications, the news was filled with stories of the batteries in electric vehicles and consumer electronic devices overheating. The UPS industry was in the process of launching and promoting their long-awaited 3-Phase UPS systems with Lithium-Ion Batteries (LIB) and was already facing an uphill battle to prove to data center designers and operators that LIB was a safe and effective battery option that ultimately reduces the UPS total cost of ownership.

But the viral videos of cellphones randomly catching fire on airplanes couldn't be ignored and the negative press about lithium-ion batteries complicated the UPS and battery manufacturers' ability to make the case that LIB are as safe as VRLA in UPS applications. Adding fuel to the fire, some major US cities passed laws limiting or even prohibiting the use of lithium-ion batteries in large energy storage applications and small electric vehicles such as scooters and e-bikes.

Lithium-Ion batteries for UPS applications got a bad rap from the beginning.

Prevent thermal runaway through proper installation and utilization of the type of lithium-ion battery recommended by the manufacturer.

If thermal runaway in cellphone batteries was causing fires in handheld devices, imagine how catastrophic a fire in the data center could be. Lithium-ion car batteries, also frequently criticized for their ability to easily ignite and continue to feed a fire. If it's difficult to put out a fire in an electric vehicle, how hard will it be to extinguish a data center fire with dozens of batteries before there's a complete loss? And, what about those laws prohibiting the use of lithium-ion in large energy storage applications? If they're not safe as far as local fire departments and governments are concerned, why would data center operators feel comfortable using them in their UPS? These are questions commonly asked when discussing safety concerns for Lithium-ion batteries in UPS applications.

Addressing common misconceptions about the risk of overheating and fire caused by Lithium-Ion Batteries in Data Center and UPS Applications starts with understanding the safety features of Lithium-Ion batteries for UPS and how they prevent thermal runaway or fire. To start, it's helpful to know what causes thermal runaway in the first place. When a battery is damaged or misused, it can cause a short circuit in a battery cell. From there, a rapid chain reaction occurs producing a large amount of heat. This chain reaction may continue into neighboring cells causing them to break down and release hot flammable gases.

The primary ways to prevent thermal runaway are to ensure proper installation and protection for the battery cells to minimize the risk of damage that would cause the short-circuit. Similarly, it is important to use the lithium-ion batteries in accordance with the manufacturer's recommendations. If a short-circuit still manages to occur, it's critical to have the safety mechanisms in place to minimize the heat produced by the thermal runaway. These mechanisms include battery monitoring systems, safety fuses, and other features we discuss later, to isolate the damaged cell so the chain reaction doesn't spread to other cells.

It's all about the chemistry.

The term 'li-ion' refers to an entire class of batteries whose electrochemistry varies widely. The actual chemistry of a lithium-ion battery is the single most determining factor in how heat-sensitive and therefore, safe, or stable, a lithium-ion battery is. Without asking you to refer to the Periodic Table of the Elements, suffice it to say that lithium-ion battery chemistries vary by application. For example, the Lithium-ion batteries in cellphones need to provide high density power for as long as possible in as little space as possible. That demands a certain kind of compound be included in the battery – Lithium Cobalt Oxide (LCO). This chemistry offers high energy density, but sacrifices stability, particularly if the battery is damaged. In UPS applications where there is a greater emphasis on safety, more stable compounds that include nickel (NMC), manganese (LMO),

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and iron phosphate (LFP) are used. These other compounds offer lower energy density, but longer life creating a more stable battery.

But what if there is an overheating event or fire? It depends on the chemistry. The compounds used in lithium-ion batteries for consumer electronics and electric vehicles produce oxygen when they overheat, thus increasing the chance a fire will start and, once it does, making it extraordinarily difficult to put out. Data center fire suppression systems are typically designed to extinguish fires by limiting oxygen. The compounds used for LIB in UPS and data center applications do not produce oxygen when overheating and are therefore compliant with National Fire Protection Agency (NFPA) codes.

Standards and safety features significantly reduce the risk of thermal runaway.

Many standards and testing protocols have been developed over the years by both Underwriters Laboratories (UL) and the National Fire Protection Agency (NFPA). The 2018 NFPA Fire Code 1, Section 52.3 discusses how to safely deploy LIB in data centers and the standards for the fire suppression system. UL 1973 outlines the standards for LIB used in data center applications and is included in the NFPA Fire Code. The individual battery cells are covered under UL 1642. This listing includes both the cell construction and the battery monitoring system (BMS) and mandates that the LIB and BMS must come as a package from the OEM. The UL listing also includes parameters for the battery cabinet. It must be noncombustible and locked, for example. Spacing and layout is also addressed in the UL listing to manage the power density and capacity of the installation.

Battery Management Systems monitor each battery at the cell level and has the capability to shut down any cells that stray outside the pre-determined parameters.

Another important distinction between batteries used in small consumer electronics where space and weight are at a high premium versus data center applications where footprint is measured in square feet rather than millimeters, is that LIB for UPS applications come with a Battery Management System (BMS) embedded in the battery modules. The BMS monitors each battery at the cell level and has the capability to shut down any cells that

stray outside the pre-determined parameters. This ability to isolate potentially problematic cells allows the battery system to stay online even after the BMS takes a cell offline. Most LIB manufacturers include additional bult-in safety features such as safety fuses inside each battery module, overload, overcharge, and short-circuit protections, hardened material layers and thermal dissipation measures to minimize the chance of thermal runaway.

What about those laws prohibiting li-ion batteries in some cities?

It's a common misunderstanding that lithium-ion batteries for data center and UPS applications are prohibited in some large cities such as San Diego and New York City. The current laws permit stationary storage battery systems, which applies to UPS, provided they are UL listed and meet the applicable sections of the NFPA fire codes. In other words, LIB for UPS is permitted provided they are genuine OEM battery systems installed and maintained in accordance with the manufacturer's specifications. The laws are mostly in place to regulate two growing applications of lithium-ion batteries in urban settings.

The first is outdoor energy storage systems that store power generated by solar panels and other non-fossil fuels that are tied to the electrical grid. Those rules limit the size and application of any single energy storage system in addition to mandating compliance with current codes relating to Lithium-ion battery safety. Secondly, the laws aim to regulate e-vehicles, such as electric bikes and scooters, within cities to make sure that the batteries used in those are UL listed and NFPA compliant. This is in direct response to a growing after-market for used lithium-ion batteries and is an effort to protect consumer safety by requiring e-vehicle rental companies only use new OEM batteries in their fleets.

It's worth pointing out here that the chemistries of both applications – large energy storage and e-vehicles are not the same as the chemistry used in data center and UPS applications. So, it really is, all about the chemistry.

Conclusion

The special chemistries and robust safety features unique to LIB were engineered and developed specifically to address the safety concerns for Lithium-ion batteries in UPS applications. For this reason, it is important that the Lithium-Ion Battery be approved by the UPS manufacturer for use in stationary storage battery systems. The safety features of the UPS and LIB must be compatible to ensure safe operation. Substituting or replacing Lithium-ion batteries from unapproved manufacturers can put your facility at risk. Similarly, we recommend factory assembly and start-up services for LIB systems for UPS and regular factory preventive maintenance services. When the time comes to replace aging Lithium-ion batteries for UPS, it is important to use brand new factory parts and service.

The development of chemistries specific to LIB in data center and UPS applications coupled with the advanced safety features embedded in each battery cell, module, and string allows the UPS OEMs to offer a lower total cost of ownership for lithium-ion batteries versus VRLA in UPS applications. With more power in less space and at a fraction of the weight, LIBs are emerging as a safe, best-in-class choice for standby emergency power for critical applications. With the UL 1973 listing and compliance to NFPA fire codes, most existing data centers can be retrofitted to a LIB solution without requiring the reconfiguration of the fire suppression and HVAC systems.

For more information about lithium-ion batteries for UPS applications, read our white paper on the Benefits of Lithium-Ion Batteries for UPS. For a side by side comparison of Lithium-ion batteries versus VRLA, please see our article, 'Lithium-Ion Batteries versus VRLA Batteries in 3-Phase UPS Systems'. If you would like to review a sampling of single-phase and 3-Phase UPS Systems that come with Lithium-Ion batteries please visit our website. For more details including configuration assistance and pricing, send me an email, or call 800-876-9373 ext. 711.

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