



VERTIV WHITE PAPER

Complying With Fire Codes Governing Lithium-ion Battery Use

What You Should Know About NFPA 855, UL 9540A and UL 9540

Executive Summary

For several decades, governing bodies such as the International Fire Code (IFC), National Fire Protection Association (NFPA), and Underwriters Laboratory (UL) have released battery-related fire codes and standards to ensure and improve public health and safety by establishing minimum standards for fire prevention and protection. These codes are then enforced by the relevant Authority Having Jurisdiction (AHJ), who reviews facility plans, conducts on-site inspections and verifies compliance with all aspects of the code.

This process is more challenging than it seems, given that there are many roles involved in determining and maintaining fire safety from building architects and contractors to building owners and managers and the AHJ. In addition, businesses' drive for digital transformation and technology-enabled processes has given rise to a global network of data centers, each of which houses equipment governed by fire codes and standards. Thus, ensuring compliance with battery-related fire codes and standards is a responsibility that nearly all businesses now shoulder.

In recent years, companies have adopted lithium-ion battery energy storage systems (BESS) which provide an essential source of backup transitional power. UL and governing bodies have evolved their respective requirements, codes, and standards to match pace with these new technology developments.

Newer codes and standards such as NFPA 855 address size and energy requirements that building operators using these BESS solutions must meet. Some of the most notable requirements limit the maximum energy capacity of ESS groups or arrays to 50 kWh, 250 kWh per listed array, and 600 kWh per fire area. They also include the need for separation between adjacent ESS units and adjacent walls of at least three feet for groups and arrays unless the AHJ grants a waiver on spacing and capacity based upon data contained in a UL 9540A fire test, mentioned below. These requirements are designed to prevent the propagation of fire from one ESS unit to another.

A new fire test method, UL 9540A, can be used to address and potentially overcome these requirements. Specifically, manufacturers whose lithium-ion BESS complete the UL 9540A fire test demonstrate that any fire that originates in these units is limited to the cabinet or rack alone and does not propagate to another BESS. At the AHJ's discretion, the UL 9540A report can be used to provide a waiver for increased energy capacity of individual BESS units above 50 kWh for an array or above 250 kWh for a listed pre-engineered and prepackaged array and to reduce the 3-foot space requirements.

This waiver could provide your business with much needed power, capacity, and flexibility, provided you can meet these requirements. This white paper discusses these fire safety requirements further, so that you can make an informed decision for your business.

Understanding How to Manage the Fire Safety of Lithium-Ion Energy Storage Systems

Around the world, lithium-ion battery sales are soaring, with the market value projected to triple from \$36.7 billion USD in 2019 to \$129.3 billion USD in 2027. It's no wonder. These versatile performers are found in applications ranging from consumer mobile devices to database electronics and automotive and industrial applications.ⁱⁱ

In data centers and hosting facilities, lithium-ion BESS provide leap-ahead advantages over valve-regulated lead-acid (VRLA) batteries. Not only do they provide a highly reliable source of backup transitional power, but they also address issues data center operators have experienced for decades with managing and optimizing their uninterruptible power supplies (UPS). Lithium-ion BESS offer a longer operational life span; are smaller, lighter and easier to install; and provide more reliable performance at higher temperatures than VRLA batteries, justifying their higher initial purchase price.

While lithium-ion batteries offer all these benefits, it's important to remember that like all batteries, they can pose a fire risk. That's why batteries are governed by fire codes and standards, to ensure their safe and effective placement and use in applications such as data centers.

NFPA 855 is one such standard. This Standard for the Installation of Stationary Energy Storage Systems outlines requirements for mitigating hazards based on the technology used, the installation environment, the size and separation of the ESS installations, and the fire suppression and control systems that are in place. NFPA 855 refers to UL 9540A (large-scale fire testing) in the standard as a method used by manufacturers to prove fire performance of an ESS product. This reference to UL 9540A is also intended to aid AHJs with their evaluation of installations.

While many of these fire codes and standards have been around for years (or even decades), purchasing teams and data center operators should be aware that there have been two more recent developments governing the fire safety of data center equipment. Specifically, Underwriters Laboratory (UL) has released:

- **UL 9540A: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems** – UL 9540A is a fire test method performed by a third party to evaluate the fire safety of these systems.
- **UL 9540: Energy Storage Systems and Equipment** – UL 9540 is a certification that manufacturers can attain and use to advertise their ESS products.

What's New With UL 9540A and UL 9540

UL 9540A is a test method that a battery manufacturer can use to demonstrate the safety of its solutions. To complete the test, a testing agency will force the lithium-ion battery to catch on fire and then monitor the fire. The agency will evaluate whether the fire's flames move from one cabinet to another. To successfully complete the test, flames must be limited to the originating cabinet, and the fire must be able to be fully extinguished with water.

A successful UL 9540A report demonstrates that solutions have completed a critical fire test. Battery manufacturers can present the data in the report as evidence of the fire safety of their solutions.

BESS solutions that complete the UL 9540A test method have demonstrated that they have a lower fire propagation risk. This makes them suitable for use in all environments, but especially those that might be densely populated or mission-critical, such as a high-rise office building or a hospital.

UL 9540 is a certification that UPS manufacturers such as Vertiv may seek and obtain that attests that its lithium-ion BESS solutions meet specific safety criteria. Each combination of battery system and UPS that is UL 9540-certified has been tested and certified, making this a lengthy, involved and costly process.

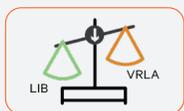
Lithium-ion UPS Battery Benefits Versus VRLA

Lower Total Cost of Ownership (TCO)



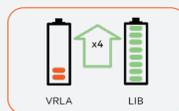
- Up to 50% savings over lifetime

Small and Lighter



- Easier to install
- Install flexibility
- More runtime in the same amount of space

Longer Life



- Last 10-15 years or more
- Fewer or no replacements
- Withstands higher temps without degradation

Longer Runtime



- Less than 4 hours for full recharge

As stated in UL 9540, the requirements cover ESS that are intended to receive and store energy in some form so that they can provide electrical energy to loads or to the local/area electric power system (EPS) when needed. The types of energy storage covered under this standard include electrochemical, chemical, mechanical and thermal. The energy storage system shall be constructed either as one unitary complete piece of equipment or as matched assemblies, that when connected, form the system.

This standard is a system standard, where an energy storage system consists of an energy storage mechanism, power conversion equipment, and balance of plant equipment. Individual parts of an energy storage system (e.g. power conversion system, battery system, etc.) are not considered an energy storage system on their own. This standard evaluates the compatibility and safety of these various components integrated into a system.

Summary of UL 9540A Test Hierarchy and Testing Process

Scope: The test methodology in the standard determines the capability of a battery technology to undergo thermal runaway and then evaluates the fire and explosion hazard characteristics of those BESS that have demonstrated a capability to undergo thermal runaway.

Cell level test: Forces a cell into thermal runaway. The vent gas composition is gathered and analyzed, and cell temperatures are monitored to determine the temperature when the cell vents and to verify that thermal runaway, as defined in the standard, has occurred.

Module level test: The number of cells within the module that are forced into thermal runaway can be one or multiple cells and is dependent upon the energy contained within the individual cells. A sufficient number of cells shall be forced into thermal runaway to create a condition of cell-to-cell propagation within the module.

Unit level test: An internal fire condition in accordance with the module level test shall be created within a single module in the initiating BESS unit.

Installation level test: The installation level test method assesses the effectiveness of the fire and explosion mitigation methods for the BESS in its intended installation. For example, sprinklers can be used to evaluate the effectiveness of sprinkler fire protection in accordance with code requirements.

Energy storage systems may include equipment for charging, discharging, control, protection, power conversion, communication, air circulation, fire detection and suppression, fuel or other fluid movement and containment, etc.

UL 9540 builds on prior certifications of products offered by Vertiv such as UL 1973: Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications and UL 1778: Standard for Safety Uninterruptible Power Systems and covers the gaps that exist between them.

UL 9540 certification was originally developed targeting grid storage BESS applications. The application of this standard to the UPS battery storage system, as well as the testing requirement, are still evolving and under development. However, review of the UL 9540A large-scale fire test report is an important part of the acceptance.

Fire Suppression Methods

Water is the preferred suppression method, both for the UL 9540A test method and all fires that originate within a BESS. Water can be used not only to extinguish flames, but also to reduce battery cell and module temperatures below a reignition point.

If you use other fire suppression methods at your site, as addressed in other fire codes and standards, you should be aware of their limitations. Dry chemicals can eliminate visible flames but lack the ability to cool burning components. Gaseous agents eliminate visible flames, but don't provide sufficient cooling to interrupt thermal runaway events. And finally, clean agent suppression systems can be used in addition to water but could create a hazardous situation if firefighters open doors and reintroduce oxygen into the room, which create flammable gasses.

Only water can be guaranteed to safely and securely suppress and extinguish any flames originating in a lithium-ion BESS and to reduce the cell and module temperatures below a reignition point.

Why UL 9540A Is Important

Potential to Waive Spacing and Capacity Requirements

International Fire Code (IFC) 2018 (code), National Fire Protection Association (NFPA) 1 2018, and NFPA 855 (standards) all require that a BESS be spaced three feet apart if a group or array is greater than 50 kWh. That translates to greater space constraints as your equipment will take up more space in your data center, potentially increasing your building and operational costs, while decreasing your capacity. Space and capacity requirements may be waived by an AHJ based on the findings of a UL 9540A report.

This will allow you to purchase and place equipment for maximum energy capacity and efficiency in your data center or hosting facility.

Vertiv Solutions Meet New Fire Code Requirements

Vertiv offers two solutions that have completed the UL 9540A test method:

- [Vertiv™ HPL 9540A Lithium-ion Battery Energy Storage System](#) -- The Vertiv HPL lithium-ion battery cabinet has successfully completed UL 9540A testing. The system provides safe, reliable and cost-effective high-power energy with improved performance over traditional valve-regulated lead-acid systems. Equipped with lithium-ion batteries using a nickel-manganese-cobalt (NMC) chemistry and Vertiv's own battery management system, Vertiv HPL provides a well-balanced, safe and powerful energy storage system with 38 kWh (207kW/cabinet). The cabinet works with most current and legacy Vertiv three-phase UPS systems. They are also compliant with UL 1642 and UL 1973.
- [Samsung 9540A Lithium-ion Battery Energy Storage System](#) – The Samsung SDI 128S and 136S energy storage systems for data center applications have successfully completed the UL 9540A test, making them qualified for immediate use with most current and legacy three-phase Vertiv UPS systems. They are also compliant with UL 1642 and UL 1973.

Both of these BESS can be used for:

- New data centers
- Cloud, colocation, and hosting facilities
- Enterprise data centers
- UPS energy storage
- Replacements for lead-acid batteries

Conclusion

Fire safety requirements can be extremely complex to navigate. However, addressing them proactively can yield significant business and technical benefits, while ensuring regulatory compliance and protecting public health and safety.

Whether you're building a new data center or hosting facility, or retrofitting one, we recommend consulting with a professional fire protection energy consultant who can analyze your site and make specific recommendations to minimize fire risk.

The consultant will consider the batteries you use; your stored energy capacity; the material used in the data center ceilings, walls and floors; the ventilation and fire suppression systems you have installed; fire alarm systems; and the time it takes for first responders to arrive on site when crafting site-specific recommendations.

Once you have those recommendations, it's likely that you'll have the information you need to design your data center space for maximum energy capacity and efficiency. Lithium-ion BESS that have completed the UL 9540A test, such as the Vertiv HPL Lithium-ion and Samsung 9540A Lithium-ion battery energy storage systems can help you accomplish this strategic goal, powering the business applications that drive your company and its customers forward. Since you'll likely be adding data center equipment on an ongoing basis to drive your business forward, you'll want to use every inch of space you can, while meeting critical fire safety requirements.

Vertiv is your partner in modernizing today's data centers and hosting facilities to meet the demands of digital transformation. We look forward to sharing our certification and test results with you, so that you can evaluate the data and make purchasing decisions with confidence, knowing that our solutions are fire-safe.

For additional information, please [contact your local Vertiv sales representative](#).

ⁱ Referenced Standards, Fact Sheet, National Fire Protection Association, , April 2018, <https://www.nfpa.org/-/media/Files/Code-or-topic-fact-sheets/ReferencedStandardsFactSheet.ashx>.

ⁱⁱ "Lithium-ion Battery Market by Component (Cathode, Anode, Electrolytic Solution, and Others), End-use Industry [Electrical & Electronics (Smartphones & Tablet/PC, UPS, and Others) and Automotive (Cars, Buses, & Trucks; Scooters & Bikes; and Trains & Aircraft), and Industrial (Cranes & Forklift, Mining Equipment, and Smart Grid & Renewable Energy Storage): Global Opportunity Analysis and Industry Forecast, 2019–2027," Report Synopsis, April 2020, <https://www.alliedmarketresearch.com/lithium-ion-battery-market#:~:text=The%20global%20lithium%20battery,18.0%25%20from%202020%20to%202027>.



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