NEW ENERGY IN THE BATTERY INFRASTRUCTURE

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Abstract

Over the past several years, there has been a significant effort to address energy storage system (ESS) safety especially those systems that utilize batteries as their source of energy. New technologies that do not have a long history of use in the built infrastructure are being utilized. Based on this, there is concern from regulators, fire marshals, electrical inspectors, building owners and other industry stakeholders with the safety of these systems and how to best integrate them into facilities. Development of product safety standards and product installation standards, and updating of building codes to address these concerns have been ongoing. This work has culminated in the publication of UL 9540 to evaluate the safety of energy storage systems as well as the ongoing development of the NFPA 855 standard for energy storage system installation; publication of Article 706 and updates to Article 480 of the NEC; updates to NFPA 1 and the ICC IFC fire codes, which are having an impact on the industry. Included in the fire codes and installation standard are exceptions that require large scale fire testing. UL 9540A is a new test method that UL developed to address this large-scale fire testing for energy storage systems. UL 1974 is a UL standard under development to address the process for determining the safety of used batteries for repurposing in applications such as energy storage. All of this work will have a direct impact on the industry, and it is important to know what to expect when trying to site these systems.

This paper and the associated presentation will provide an overview of how an ESS product is evaluated for safety using UL 9540 and include information on how the traditional technology lead acid systems used in Uninterruptible Power Supply (UPS) being evaluated to UL 1778 is impacted when they are part of an ESS. It will also present an overview of various code developments impacting the industry, including limitations on size and siting and exceptions allowed based upon large scale fire testing. Included is an overview of the UL 9540A large scale fire test method developed by UL with input from industry and the fire safety community, and the new UL 1974 repurposing standard as there is interest in utilizing repurposed electric vehicle batteries in stationary applications and concern regarding the safety of these used batteries.

Attendees will gain a better understanding of safety assessments of energy storage systems and battery systems. Attendees will also gain insight into the code developments impacting battery energy storage systems whether they are using newer technologies or traditional lead acid technologies, options available to them for large scale fire testing and the use of repurposed batteries, and anticipated future code work.

Introduction

In the topic of energy storage systems, it is important to understand first what is an energy storage system and how does this differ from a traditional UPS system. As defined in UL 9540. Energy Storage Systems (ESSs) and Equipment, an energy storage system is essentially a device that can store energy in some form such as battery energy storage and provide usable electrical energy as a standalone source to a local grid or in parallel with an electric utility grid or both. The energy storage system may have capability to provide backup power as a UPS when utility power goes out, but it is not used exclusively for that purpose. Essentially, the difference between an energy storage system a UPS is that the energy storage system is providing electrical energy during normal operation as part of the normal energy sources, whereas a UPS operates only when the normal source is not available. Also, a UPS provides AC power only and energy storage systems can be designed to provide AC or DC power or both, depending upon their design and the grid being supplied. Figure 1 is an example of an ESS.

Energy storage systems are being utilized for grid support, transmission support, support for renewable energy sources and arbitrage and other cost savings measures as well as for power quality and reliability. Energy storage systems are being installed in front of the utility meter, but also behind the meter in areas where they are closer to the user such as in and around commercial and residential buildings. They are also using a number of newer technologies of batteries where there is not a lot of field data on their safety, which concerns the authorities having jurisdiction (AHJs) such as fire marshals and building inspectors. To address the concern of various stakeholders, new safety standards, new installation standards and updates to current model codes have developed over the past few years to address energy storage system safety.

US Safety Standards Impacting Energy Storage

Battery energy storage systems are essentially an assembly of major components such as the battery system with its BMS, the power conditioning system, an overall system control, and HVAC and other balance of plant components that are required for the energy storage system to operate as intended. Each of these major components may have its own safety standards addressing the safety of that individual component. The energy storage system standard, UL 9540, like the UPS standard, UL 1778 addresses the safety of the overall assembly while referencing major component standards. UL 9540 and UL 1778 reference critical component standards and then include testing and construction criteria to address the safety of the overall device. See Figure 2 and 3 for component battery standards used to evaluate batteries for these standards.

Figure 1 – NEC's Lithium ion Battery Energy Storage System Installed in Sterling, MA

UL 9540 Overview

ANSI/CAN UL 9540, Energy Storage System and Equipment, is a bi-national safety standard for the USA and Canada, whose scope covers energy storage systems, and includes electrochemical, chemical, mechanical and thermal type storage technologies. It was published on November 21, 2016 and includes construction criteria and both type and routine (production) test criteria with which to evaluate the safety of an energy storage system. A critical aspect of UL 9540 approach is the safety analysis, which can be in the form of a FMEA or similar type of safety analysis that considers potential risks associated with the system design, the potential for risk to occur and its severity, and the protections used to mitigate the risk. This analysis should guide the level and type of safety controls that need to be employed in the system. Identified critical components are required to be evaluated for reliability.

In addition to the safety analysis, another important feature of the UL 9540 standard is that major components are required to comply with their applicable safety standard. For the power conditioning system, this would be UL 1741, Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources; and for battery systems, UL 1973, Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications.

UL 9540 is referenced in the model codes such as NFPA 70, National Electrical Code (NEC), and NFPA 1 Fire Code and ICC International Fire Code (IFC), which are the basis for municipal and regional electrical and fire codes. In addition, UL 9540 is currently referenced in the second draft of NFPA 855, Standard for Installation of Energy Storage Systems that is under development. Establishing compliance for an energy storage system to UL 9540 will help to ease restrictions on installations at sites subject to AHJ approval.

So, what does an evaluation to UL 9540 look like? What are critical steps to determining compliance to UL 9540? Similar to other product safety standards, UL 9540 has two major areas of criteria: construction criteria and testing criteria, noted in the standard as performance. Like many safety standards, UL 9540 also references critical component safety standards such as UL 1973, the UL safety standard for stationary batteries which battery systems would need to comply with. As noted above, a critical aspect of the UL 9540 evaluation is the safety analysis. This safety analysis analyzes how the various parts of the energy storage system work together to maintain the system components within their intended operating specifications; and it should consider single fault conditions, or identify performance or integrity levels of safety of critical components and parts depending upon the approach taken. Any electronics circuits and software determined to be critical safety components will require an evaluation for functional safety in accordance with several suitable standards that are referenced. An entity submitting their product for certification to UL 9540 would have to conduct this type of analysis, such as an FMEA on their energy storage system, in advance and provide it for review as part of the certification investigation.

UL 9540 construction criteria also includes electrical component and safety criteria and refers to criteria in the NEC for wiring connections and electrical installation criteria. UL 9540 also refers to both the NEC and NFPA 70E for worker safety criteria, such as adequate work space, electrical shock and arc flash considerations, as energy storage systems utilizing batteries may require workers to conduct maintenance on or in close proximity to hazardous live circuits. Many energy storage systems are being enclosed within ISO type containers or enclosures that allow staff to enter the container to conduct maintenance and repairs. Although maintenance staff would only enter these container systems as needed, UL 9540 addresses important worker safety requirements such as safe egress, lighting needs, and ventilation.

Utility grid interaction is also addressed in UL 9540, since energy storage systems, by their definition, are intended to supply energy to a local or utility grid or both. UL 9540 refers to UL 1741 for power conditioning systems, and its recent supplement SA of UL 1741 is intended to address grid support utility interactive inverters that may be employed in an energy storage system.

Fire detection and suppression are a critical consideration for energy storage systems, especially those that utilize battery energy storage. UL 9540 currently requires that a fire safety analysis be conducted to determine the need for, and type of detection and suppression system to be provided either as components installed within the energy storage system or to be identified and described in sufficient detail in the installation instructions. These devices are to be installed in accordance with the applicable fire code regulations. The next edition of UL 9540 will make further reference to the fire codes, which have been updated to better address energy storage systems and will reference the new large-scale fire test method developed by UL in UL 9540A.

In addition to construction criteria, there are testing criteria in UL 9540 that are essentially a check of the safe operation of the system. A majority of the testing criteria are located within the major component references, such as UL 1973 for the stationary batteries. However, UL 9540 does have a variety of electrical tests such as operation/temperature check, grounding, dielectric voltage withstand and impulse testing, mechanical tests covering fluid containment of systems and moving parts tests for flywheel systems, and environmental tests that consider anticipated environment of the installation site. To get a better understanding of the tests that the battery system portion is required to comply with, a review of UL 1973 is necessary.

UL 1973 Overview

UL 1973 is UL's standard for stationary batteries and has been recently revised to the 2nd edition, which has been renamed and is now a bi-national standard for the USA and Canada just like UL 9540. A UL 1973 battery system is a component of a UL 9540 energy storage system and can also be a component of a UL 1778 UPS system. UL 1973 is non-technology specific but has a number of specific criteria for different technologies of batteries, including lithium ion, sodium high temperature (referred to as sodium beta) batteries, and flow batteries.

UL 1973 is structured in a similar manner to UL 9540 as it contains both construction criteria and testing. As with UL 9540, UL 1973 has requirements for a safety analysis of the battery system, to ensure that the battery management system and other protections provided with the battery maintain the battery system in a safe state including ensuring that the battery cells do not operate outside of their specified operating regions for voltage, current and temperature under charging, discharging and other conditions of use. As with UL 9540, electronic and software controls identified as critical to safety are evaluated for reliability and functional safety. Depending upon the approach taken, the evaluation considers single fault conditions or determines the necessary safety level that the components need to meet based upon the standards used.

UL 1973 is the standard that can be used for most battery technologies and for capacitor and hybrid capacitor and battery systems. UL 1973 references several battery standards for cell and capacitor criteria, and also contains quite a bit of technology-specific criteria that include cell test programs for secondary lithium cells that have a choice between a UL 1642 approach or an IEC approach to testing. UL 1973 also has several appendices that have specific criteria for sodium beta technologies, such as sodium sulfur and sodium nickel chloride, and flow batteries, such as vanadium redox and zinc bromine. All technologies have to meet the general construction criteria and go through a similar set of tests when it comes to the testing of the complete system.

The battery tests in UL 1973 are grouped into electrical, mechanical, environmental, and the new category for single cell failure tolerance, which is essentially a fire propagation test. The electrical tests consist of what would be expected to evaluate the safety of a battery, including short circuit, overcharge, overdischarge, imbalanced charging, a temperature test conducted under charging and discharging, a cooling/thermal stability system failure test, dielectric voltage withstand and continuity tests. The mechanical tests consist of evaluation of the battery system enclosure as well as drop tests for modules/packs that may be installed in the field. The environmental test program includes a moisture resistance test, salt fog and external fire. The single cell failure design tolerance test is essentially a propagation test where a single cell is failed in whatever manner to try to drive it to thermal runaway to see if there is an explosion or fire propagating to the outside of the enclosure. This propagation test is important because the FMEA analysis looks at the robustness of the safety controls and their ability to prevent out of specification conditions, but it does not look at the ability of the design to withstand a thermal runaway condition due to a latent cell defect or other reason.

Figure 2 – Hierarchy of UL Battery Standards for Energy Storage Systems (UL 9540)

Energy Storage Component	Technology	Standard No. and Title
Cell	Lithium ion and Lithium metal solid state	UL 1642, Lithium Batteries
	"	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications, 5.11.2 or Appendix E
Cell	High Temperature Sodium (Sodium Beta)	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications, Appendix B
Cell	Nickel, sealed cell types	UL 2054, Household and Commercial Batteries
Monobloc battery with relief valve and/or flame arrestors	Lead Acid or Nickel	UL 1989, Standby batteries
Stack	Flow Battery – All types	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications, Appendix C
Capacitor	Electrochemical	UL 810A, Electrochemical Capacitors
Module	Battery module	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications
Module	Capacitor module	UL 810A, Electrochemical Capacitors
Battery or Capacitor System	All types	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications
Battery system **–** a complete battery consisting of one or more modules with its battery management system and other protection components for the battery Module – battery pack that is a component of a battery system		

Figure 3 – Hierarchy of UL Battery Standards for UPS Applications (UL 1778)		
Energy Storage Component	**Technology**	**Standard No. and Title**
Cell	Lithium ion and Lithium metal solid state	UL 1642, Lithium Batteries
Cell	"	UL 62133, Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes - Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made from Them, for Use in Portable Applications
Cell	"	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications, 11.2 or Appendix E
Cell	High Temperature Sodium (Sodium Beta)	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications, Appendix B
Cell	Nickel, sealed cell types	UL 2054, Household and Commercial Batteries
Cell	"	UL 62133
Monobloc battery with relief valve and/or flame arrestors	Lead Acid or Nickel	UL 1989, Standby batteries
Stack	Flow Battery – All types	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications, Appendix C
Capacitor	Electrochemical	UL 810A, Electrochemical Capacitors
Module	Battery module	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications
Module	Battery modules	UL 2054, Household and Commercial Batteries
Module	Capacitor module	UL 810A, Electrochemical Capacitors
Battery or Capacitor System	All types	UL 1973, Batteries for Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications
Battery system **–** a complete battery consisting of one or more modules with its battery management system and other protection components for the battery Module – battery or capacitor pack that is a component of a battery or capacitor system		

UL 9540A Overview
UL 9540A, "Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems" was developed by the UL fire research group to address a requirement in the ICC International Fire Code and a similar anticipated requirement in the installation standard, NFPA 855, Installation of Energy Storage Systems,

for large scale fire testing. Both the fire code and NFPA 855 have placed strict limitations on the size and quantity of energy storage systems as well as separation distances between systems and structures that can be installed in mixed use occupancies. These limitations on size are based upon energy limits and are technology-dependent. The large-scale fire testing can be used to reduce separation distances, increase size (energy) of systems, and show effectiveness of fire suppression systems.

The results from the UL 9540A test method is intended to address the following key areas of concern identified by building code and fire code officials: 1) the appropriateness of the battery energy storage system (BESS) installation instructions with regard to separation distances and location of cabling to and from the system, 2) installation ventilation requirements, 3) effectiveness of fire protection and deflagration mitigation strategies, and 4) information necessary for fire service strategy and tactics in the event of a fire involving the BESS.

The test method has several different levels of testing. The first level is the cell level testing, whose purpose is to determine a method for consistently creating a thermal runaway condition in a cell and for collecting temperature, to venting and collecting and identifying gases vented from the cell. The module level testing is conducted upon completion of the cell level testing. The module level testing is also an information-gathering step. One or more cells in a module are driven into thermal runaway, and the effects of fire propagation in the module are evaluated. In addition, the gases coming off the module are monitored, as well as voltage and temperatures on the cells being failed; and surrounding cells are monitored for information purposes. The same procedure for failing cells at the module level is then replicated at the unit level using one of the modules located within the energy storage system where there is the potential for worse case conditions. For the unit level tests, the initiating BESS unit is representative of what is to be installed in the field and contains the module to be failed. The initiating BESS is surrounded by target BESS as intended in the planned installation, and are populated with the BESS components with the exception of the cells. The initiating BESS unit and the target BESS units are outfitted with thermocouples and installed in proximity to a wall surface (painted black) that is a distance anticipated in the BESS installation. The black walls are provided with thermocouples to measure the temperatures from the initiating BESS unit. This part of the testing determines whether propagation in the initiating BESS will lead to fire propagation outside the BESS, explosions, hazardous heat level on surroundings systems and structures, and to determine what sort of ventilation is required to mitigate flammable gas accumulation. If the unit level testing does not result in fire propagation, explosion or excessive heat on surrounding systems and walls, the testing may be completed at this stage.

Should there be fire emanating from the BESS, explosions, flammable gas accumulation or excessive heat generated on target units or surrounding walls, the installation level test is conducted, which is essentially the unit level test repeated with proposed fire suppression and mitigation systems and overhead cabling system in place to evaluate the effectiveness of the installation protection. This level of testing is a means to establish the effectiveness of proposed fire suppression systems for the BESS installation and to ensure that there is no fire spread through the cable systems connecting the BESS.

The need for large scale fire testing assumes that something could go wrong even with protection controls in place due to the quantities of energy stored within large BESS systems. This step-by-step testing procedure is intended to establish that BESSs installed within buildings do not pose an unacceptable fire risk to property and occupants.

UL 1974, Evaluation for Repurposing Batteries

Another area of standardization that UL is attempting is in the area of re-purposed batteries. Batteries for electric vehicles, which are primarily lithium ion battery systems, tend to be rather complex and expensive parts of the vehicle, and with any battery, energy storage capability is lost over time due to use and other factors. A vehicle traction battery is not useful if it loses more than about 20 percent of its useful energy storage capability, which means that it has to be replaced at that point. However, the used battery may still have about 80 percent useful energy storage capability left in it. If the used battery is still determined to be safe for use in another application, this provides a possible second market for these batteries.

The entities that obtain these used batteries with plans to use them for other applications need to have a process in place for establishing the health of the battery and some processes for sorting and grading cells and modules if disassembled from the battery for reconfiguring for another application. This entity essentially becomes a type of repurposing manufacturer of these systems using the used cells, modules or even complete batteries for another use, which is often stationary energy storage. Since this repurposing manufacturer is typically not the original battery manufacturer, it is important to safety that they have the appropriate processes in place to determine if these batteries are suitable for repurposing. The UL 1974 approach is to identify critical steps needed for repurposing.

Unlike the other standards described in this paper, UL 1974 is not a product safety standard, but rather a process standard. It identifies key items to be considered for repurposing of used batteries, provides recommended testing and evaluation procedures that should be in place, and then finally references end-product standards that the used batteries would need to comply with in order to be considered for repurposing. UL 1974 is currently under development, with the preliminary review stage completed, and with a bulletin for review and balloting coming out the first or second quarter of 2018.

US Codes Impacting Energy Storage

Impact of NFPA 70, National Electric Code (NEC)

The 2017 edition of NFPA 70, National Electric Code (NEC), contained new articles impacting energy storage systems. The most critical one was the new article 706 for energy storage systems. Article 706 was intended to put requirements for energy storage systems in one location of the NEC. Requirements in Article 706 borrowed from several different areas of the NEC such as Article 480 for storage batteries, Article 690 for photovoltaic, and others, along with added criteria to better address various battery technologies being used for energy storage. In the 2017 edition of the NEC, Article 706 identified three different scenarios that were used for current energy storage system installations: self-contained, which are defined as a complete energy storage system within one container or unit; pre-engineered of matched components, which is defined as systems that are made up of multiple parts that are field assembled by a single entity; and finally an “other” category, which is any system that is not self-contained or pre-engineered of matched components.

Article 706 requires that the major components of the energy storage system be listed, which is defined as being maintained on a published list by a third party indicating compliance to a suitable and accepted set of criteria, such as a safety standard and that is subjected to periodic production inspections. It also indicates that self-contained systems can be listed as a system. In addition, UL 9540 is referenced in Article 706 as an informative reference that can be used to evaluate energy storage systems. UL 1973 is also referenced in the NEC as a standard that can be used to evaluated stationary batteries. Article 706 provides specific criteria for battery energy storage systems and does include requirements for flow batteries.

The next edition of NFPA 70 is under development at this time. At the time of the development of Article 706 for the 2017 edition of the NEC, it was thought that Article 706 would, in time, replace Article 480 for storage batteries. However, it was later decided that the battery specific criteria in Article 706, with the exception of flow battery requirements, would be moved back into Article 480 so that all storage battery-specific criteria be located in that article. There are a number of revisions being proposed based upon use of Article 706, and a revision to the definitions for the different types of energy storage system to clarify when the device is an energy storage system, as opposed to a system intended as a UPS; as well as a requirement that both self-contained and pre-engineered types be listed as systems.

Impact of ICC International Fire Code (IFC)

The 2018 edition of the ICC International Fire Code (IFC), was updated to better address energy storage system technologies, with section 1206 provided for energy storage system requirements. As noted in Section 1206, Table 1206.2, there are threshold quantities based upon energy limits, which indicate when permitting of systems are required and which systems must meet the requirements outlined in 1206. For example, the threshold quantity for lithium systems is 20 kWh. In addition, energy storage system arrays, which are essentially individual units, are limited to 50 kWh if installed in buildings, unless they are listed, which then allows them to be 250 kWh. Separation distances are also rather strict, with separation distances between individual BESSs and between BESSs and structure walls that need to be at least 3 ft. In addition, there are maximum allowable quantity (MAQ) limits of battery energy storage systems that, if exceeded, will require special group H occupancy requirements. The IFC also designates that the energy storage systems be listed to 9540 if self-contained or pre-engineered and that batteries be listed to UL 1973.

There are exceptions for the limitations outlined in the IFC, such as exceptions to the threshold quantities of Table 1206.2, or ability to install technologies not identified in the table through a hazard mitigation analysis. Sizes of energy storage system units can be increased beyond the energy limitations through listing and through large scale fire testing. In addition, separation distances can be reduced and maximum quantities increased through large scale fire testing approved by the AHJ. If an installer wishes to use energy storage systems that are larger than 250 kWh and space them closer to each other or walls than three feet, the large-scale fire testing must be conducted and approved by the AHJ. The UL 9540A test method was developed specifically to provide a method to meet the large-scale fire testing required for these exceptions to the fire codes. Figure 4 below provides a brief overview of the limitations on energy storage systems in the 2018 IFC.

There has been work underway to further update Section 1206 of the IFC to more finely tune the installation requirements based upon how and where energy storage systems are being installed. These include separating them into the following: outdoor remote installations and outdoor near exposures (e.g. occupied buildings); indoors in dedicated use building and indoors in non-dedicated use buildings; and two special installations: on rooftops and in parking garages. In addition, more battery technologies with technology-specific limits have been added. The next revisions of the IFC are under development at this time, but are evolving to better fit the needs of the various stakeholders of energy storage systems and stationary battery systems. In addition to referencing UL 9540 for energy storage systems and UL 1973 for battery systems, the proposed revisions reference UL 9540A for large-scale fire testing.

Figure 4 – Some Limitations imposed on Energy Storage Systems in the 2018 ICC IFC		
Parameter	**Limitation Imposed**	**Exceptions**
Threshold Quantities that must comply with IFC requirements of Section 1206: • lead acid or nickel • lithium, sodium and flow • other technologies	70 kWh 20 kWh 10 kWh	Hazard mitigation analysis per 1206.2.3
Size of Individual Array (BESS unit)	50 kWh	• Lead acid and nickel cadmium technologies, • 250 kWh for other technologies pre-engineered and pre-packaged if Listed • > 250 kWh for other technologies if Listed and if LSF testing &AHJ approval
Separation distances between BESS arrays or between arrays and structure	≥ 3 ft	• Lead acid and nickel cadmium technologies • Smaller separation distances for other technologies if Listed and if LSF testing & AHJ approval
Outdoor installation separation from exposures	≥ 5 ft	Smaller separation distances if LSF testing & AHJ approval
Maximum Allowable Quantities: • lithium, flow or sodium • other	600 kWh 200 kWh	• Lead acid and nickel cadmium technologies • Group H-2 Occupancy • Hazard mitigation analysis is conducted, LSF testing & AHJ approval
Installation floor level limits: • above lowest level of fire vehicle access • below lowest level of exit discharge	≤ 75 ft ≥ 30 ft	• Lead acid and nickel cadmium technologies • > 75 ft above fire vehicle access if installed on noncombustible rooftop, does not restrict FF rooftop operations and if AHJ approval
AHJ – authority having jurisdiction LSF – large scale fire testing, which can be addressed by the 9540A test method FF – fire fighter		

Overview of NFPA 855, Standard for Installation of Energy Storage Systems

The purpose of the NFPA 855 installation standard for energy storage systems is to ease installation of energy storage systems by having all installation criteria located in one document. The effort to develop this installation standard was started in 2016 and at the writing of this paper is currently at the second draft level of development.

A lot of what is proposed for NFPA 855 matches what is in or proposed for the ICC IFC. At some point after NFPA 855 is published, the IFC can refer to NPFA 855 for most of the installation criteria for energy storage system criteria rather than including this information in the IFC. This would also be true for NFPA 1, Fire Code.

Similar to the NEC and the IFC, NFPA 855 refers to the UL 9540 standard and requires listing of energy storage systems. The draft NFPA 855 also mirrors what is in the IFC for sizes and limits on installations based upon energy limits and provides exceptions to these limits based upon large scale fire testing as noted below in Figure 5. UL 9540A is also referenced in the second draft of NFPA 855 as a method to comply with the large-scale fire testing. Many of the changes being proposed for the IFC, such as implementing different criteria based upon different types of outdoor and indoor installations and special installations, are included in the second draft of NFPA 855. As with the IFC, it was agreed that installation requirements need to consider differences between the needs of remote installations versus those near occupied buildings, and that requirements for dedicated buildings should be different than those for non-dedicated use buildings. The NFPA 855 second draft also addresses requirements for special installations for energy storage systems, such as rooftops and parking garages.

NFPA 855 addresses the life cycle of the energy storage system, as it is anticipated that these systems will be installed for a length of time, where there will be repairs and replacements of parts and upgrades or changes to systems during that time. In addition, NFPA 855 addresses the commissioning and the decommissioning of the system, as these are part of the overall installation process, and planning for the safe installation of the system over its life.

There are also exceptions throughout NFPA 855 for Lead Acid and Ni-Cad technologies rated less than 50 Vac or 60 Vdc to provide allowances for traditional technologies that have been used for many years in telecom applications. NFPA 855 includes criteria for mobile applications, which are essentially movable energy storage systems that are brought on site and operated as a stationary energy supply and then removed when no longer needed. NFPA 855, similar to the ICC IFC, has requirements specific to the various battery technologies that are currently commercially available. In addition, it includes options for others should new technologies be made available for use in the market.

The development of NFPA 855 continues with the next step of the second draft stage, which will occur over the 2018 year. It is planned to be published in 2019 as a NFPA 855: 2020 edition.

Figure 5 – Some Limitations imposed on Energy Storage Systems in NFPA 855 second draft

Parameter	Limitation Imposed	Exceptions
Maximum rated ESS energy: • Lead acid • Ni-Cad • Flow • Sodium • Lithium ion • Other	 600 kWh 600 kWh 600 kWh 600 kWh 600 kWh 200 kWh	• Lead acid and Ni-Cad technologies for telecom applications meeting NFPA 76 • Hazard mitigation analysis and LSF testing and approved by AHJ
Separation Distances	≥ 3 ft	• Lead Acid and Ni-Cad if < 50 Vac or 60 Vdc in Telecom meeting NFPA 76, or • LSF testing and AHJ approval
BESS size limitations (Must be UL 9540 Listed)	250 kWh (50 kWh supported by fire service)	• Lead Acid and Ni-Cad if < 50 Vac or 60 Vdc in Telecom meeting NFPA 76, or • ≤ 250 kWh and Listed, or • LSF testing and AHJ approval
Fire Suppression System:	≥ 0.3 gpm/ft2	• Sprinkler with lower density with LSF testing and

Sprinkler density		AHJ approval • Alternate systems with LSF testing and AHJ approval
LSF – large scale fire testing per UL 9540A AHJ – authority having jurisdiction		

Summary

A lot of effort has been underway over the past several years to address the safety of energy storage systems and stationary batteries including the safety of their installation. Although this work primarily impacts energy storage systems, there is impact to UPS systems that employ batteries as well. UL 1973 is referenced in the codes and is a battery product safety standard that can be used to evaluate batteries and battery systems for stationary applications in both the USA and Canada. UL 9540, which references UL 1973 in the codes and compliance to UL 9540, is critical to getting energy storage systems installed. UL 9540A provides a testing method to provide some flexibility for installation criteria, and UL 1974 will provide requirements to safely process used batteries for repurposing for energy storage and other second-use applications. Revisions have been ongoing in the model codes to better address energy storage systems and non-traditional battery technologies, as well as the type of installations where these systems can be found. All of these efforts should help to ensure acceptable levels of safety for the energy storage system design and for the infrastructure where the energy storage systems are installed.

References

The following are documents referenced in the report.

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