NFSA TechNotes

NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

Editor - Roland Asp, CET | #466 | 06/22/2021

This issue of TechNotes was written by Jeff Dunkel, PE, Fire Protection Engineer at the NFSA.

NFSA's Voting Guide for NFPA Technical Meeting

Calling all NFPA members!

The NFSA voting guide for the 2021 June NFPA Technical Meeting is now available. The debate is happening now until June 25th. Voting will be from June 28-July 2. Cast your vote for the 2022 editions of NFPA 13, NFPA 72, and more during the week of June 28 - July 2. See the voting positions and current information as the hearings progress here.

NFSA's Guide is Here

Understanding the Hazard

Lithium-Ion (Li-ion) battery technology is not new but the ability to store electricity in a small package lends itself to many new applications. This ability to store energy in a small package is also known as energy density and is measured in Kilo-watthours (kWh) in a given area. Traditionally Li-ion batteries have been used for portable electronics. As the technology has improved and the energy densities have increased, new applications come to play. One of the fastest growing markets for Li-ion is large and small scale Energy Storage Systems (ESS). ESS can be used for many applications from small scale residential back-up power, commercial level Uninterrupted Power Supplies (UPS), to large scale grid level Peak Shaving facilities. NFPA has created a new standard, NFPA 855 *Standard for the Installation of Stationary Energy Storage Systems*.

While useful, Li-ion batteries present a unique hazard called thermal runaway. NFPA 855 defines Thermal Runaway as the condition when an electro chemical cell increases its temperature through self-heating in an uncontrollable fashion and progresses when the cell's heat generation is at a higher rate than it can dissipate. This potentially leads to off-gassing, fire, or explosion. Once thermal runaway begins it can be difficult if not impossible to stop and cannot be stopped within the battery cell where it originated. The key to mitigating this hazard is to prevent the continuation to adjacent cells or battery racks.

Available Resources

To date there are only two large scale fire tests available. One test was on an 83-kWh system made up of Lithium-iron-phosphate batteries and the other was a 125-kWh system made up of nickel-manganese-cobalt-oxide batteries. While these tests provided guidance for these specific arrangements, the main take-away was that chemistries and arrangements matter and guidance to be used globally for any application has not yet been determined. For this reason, once an ESS system exceeds a specific threshold, large scale testing must be provided to determine adequate protection criteria.

NFPA 855 Section 4.11.2.1 requires an ESS of a maximum stored energy of 50 kWh in each unit (groups) shall be designed using a minimum density of 0.3 gpm/ft2 over the area of the room or 2,500 sqft2. Each group must be separated by 3 feet. A lower density can be used if proven by large-scale fire testing. Any systems with groups greater than 50 kWh requires large scale fire testing to be conducted with the specific technology and arrangement to be used.

Large Scale Testing

The requirement to separate ESS systems in these limited groups makes building based ESS facilities impractical. For this reason, until more data is collected, and global criteria can be provided it is likely that large scale fire testing along with a Hazard Mitigation Analysis (HMA) will be needed in many cases.

The hazard mitigation analysis in conjunction with large-scale testing needs to determine the following:

1. Ceiling sprinkler protection can prevent or delay a fire from spreading beyond the ESS rack of origin. However, obstructions caused by the design of the ESS system (e.g., solid-metal cabinet encompassing tightly packed battery modules) limits the ability to suppress or extinguish fires within the rack of origin.
2. Minimum space separation has been provided from the ESS to surrounding combustibles to limit the potential for additional fire spread, including nearby ESS racks.
3. Minimum space separation has been provided from the ESS to surrounding noncombustible objects to limit the potential for damage.
4. If fire does spread to an adjacent ESS rack (i.e., installed side-by-side), it does not impact the design and electricity capacity of battery components as well as the design of the ESS cabinet that houses that battery

components (ES., battery components (e.g., battery modules).

5. Adequate cooling of the batteries is provided to prevent re-ignition, which can occur after a fire appears to be extinguished. A fire watch should be present until all potentially damaged ESS equipment containing Li-ion batteries is removed from the area following a fire event.
6. Adequate building component rating is provided to withstand the expected intensity and duration of an ESS fire event.

One of the primary avenues for this large-scale testing is the UL 9540a test method. The UL 9540a test method consists of four different tests which separately test ESS systems at various levels. A typical ESS system is made up of multiple battery racks, each rack consists of multiple modules, and each module consists of individual battery cells. The summary of each test is as follows:

- Cell Level Test: Testing a single battery cell to determine the ability of the cell to experience thermal runaway and gather data such as heat release rate and off-gas composition.
- Module Level Test: Test of a group of battery cells to determine the likelihood of thermal runaway propagation within the module from cell to cell. This test also gathers data on the heat and gas release rates of that module.
- Unit level Test: Test of multiple battery racks. Like the previous test, this test measures the likelihood of thermal runaway to propagate from one battery rack to an adjacent battery rack. Heat and gas release rates are collected, re-ignition, and deflagration hazards are also evaluated.
- Installation Level Test: The goal of this test is to evaluate the intended installation arrangement. This test should be done with the exact rack arrangement, detection system installation, and suppression system installation intended. Like all the other tests heat and gas release rates are evaluated. This test also includes the effectiveness of the fire suppression and detection systems.

Contractor Involvement

It is possible if not probable that this testing and hazard mitigation analysis will be done early in the planning process and before the fire sprinkler contractor is involved. So why is this important for a fire sprinkler professional to be familiar with this process? When bidding or designing an ESS project it is important to understand how that criteria was developed and be able to identify any constructability issues as early as possible. Often battery manufacturers prefer to keep the UL 954a testing confidential. However, it is important for the sprinkler professional to have access to the installation arrangement used during the installation level testing. While the heat and gas release data may not be pertinent, direct knowledge of the exact design and installation during the testing is vital. Any deviation from the testing arrangement could result in costly changes or retesting.

The arrangements used to mitigate thermal runaway propagation and to increase the energy density vary greatly. Some manufactures are using passive barriers others are using active suppression systems. In some cases, integrated water spray nozzles are installed in the battery racks themselves, with the intent to have the water supplied from the building fire sprinkler system. When these integrated water spray systems are provided it is important to ensure the fire sprinkler design density along with the flow and pressure required for the integral water spray systems are provided in the Hazard Mitigation Analysis. Along with the design criteria for the integrated systems, acceptance, inspection, testing, and maintenance criteria should also be provided in the HMA.

While the fire sprinkler contractor may not be involved in the initial stages of testing or the HMA, they could be a helpful team member if included. Fire sprinkler contractors can identify installation issues that may not be apparent during testing in a lab. Early involvement from the sprinkler contractor will promote continuity throughout the design process. This will mitigate costly changes that may occur during installation.

Layout Technician Training

TECH TRAINING
LAYOUT TECHNICIAN TRAINING CLASS

Not ready for Top Tech yet? Check out NFSA's Layout Technician Training class. This class will get you started on the path to a productive, successful layout technician. The training class covers sprinkler selection, sprinkler spacing and location, obstructions to sprinklers, water supplies (public mains, tanks and pumps), hydraulic calculation of sprinkler systems, and standpipe system layout and calculation. Don't miss out on the opportunity to bring this highly requested training class into your office!

Layout Technician Training - Virtual Training Class

August 10 - Sept 2, 2021

November 2 - December 2, 2021

More Information

Blended Learning Layout Technician Virtual Practicum

August 25 - Sept 2, 2021

November 17 - December 2, 2021

More Information

New EOD Process

Starting on July 15, 2020, the NFSA has a new EOD process where members can submit questions, track the progress, and view their EOD cases. The step by step process is detailed in **TechNotes #442**.

National Fire Sprinkler Association
514 Progress Dr, Ste A,
Linthicum Heights, MD 21090
1-800-683-NFSA (6372)

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