



# TechNotes

Editor - Roland Asp, CET

#486

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## NFSA TechNotes #486 - Fire Sprinkler Design Criteria for Bulk Storage of Lithium-Ion Batteries

NFSA has covered protection of Lithium-Ion (Li-ion) batteries in detail in recent publications. The May-June 2021 edition of the National Fire Sprinkler Magazine discussed Energy Storage Systems with Li-ion batteries. TechNotes #466 covered the same topic more specifically to the design and application of sprinkler systems in these occupancies, and the upcoming edition of the National Fire Sprinkler Magazine will contain an article on the emerging trend of waste management facility fires caused by in-properly discarded Li-ion batteries. While much has been covered, not all issues have been addressed.

### Current Guidelines

There currently are many uses and applications for Li-ion batteries, and these applications are growing every day. With such widespread use, there is inevitably a need to store large quantities of these cells, or devices powered by them. Typically, the first step to determine design criteria for storage is to establish the commodity classification, herein lies the problem. NFPA 13, 2022 edition in Annex Table A.20.4 (a) lists Li-ion batteries as a commodity not addressed by NFPA 13. This section makes it clear that prescriptive criteria through NFPA 13 is not available for Li-ion batteries. The next avenue could be a performance-based design; however, without large scale testing to back up any proposed criteria it may be difficult for an AHJ to sign off.



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### The Research

Fortunately, while NFPA 13 does not provide guidance on commodity classification or design criteria for Li-ion batteries, The NFPA Research Foundation in conjunction with FM Global commissioned research to assist in the development of protection criteria to protect rack storage of cartoned Li-ion batteries. This project was completed in three phases, the first of which is a hazard analysis titled “Lithium-Ion Batteries Hazard and Use Assessment.” This assessment is a literature review of battery technology, failure modes and events, usage, codes, and standards, and hazard assessment during the life cycle of storage and distribution. The second phase, titled “Lithium-Ion Batteries Hazard and Use Assessment” is a comparison of the flammability characterization of common lithium-ion batteries to standard commodities in storage. Testing in phase III was conducted by FM Global who issued a report titled “Flammability Characterization of Lithium-ion Batteries in Bulk Storage,” subsequently NFPA released a report based on the findings referenced by FM Global.

Each phase building on the next, the findings in Phase III were the most consequential in regard to actual, usable fire sprinkler design criteria. While criteria was recommended, the FM Global report made it clear that the information provided by the testing does not provide the same level of information regarding protection system performance gained through Commodity Classification, meaning the report did not establish a commodity classification. This is an important distinction, since the commodity classification was not established, the only criteria that can be used without additional testing is the criteria recommended for the arrangement specifically. The storage conditions referenced in the report are:

- Rack Storage up to 15 feet
- Ceiling Heights up to 30 feet
- Bulk-packaged small-format li-ion batteries in corrugated board cartons (i.e., 18650-format cylindrical cells, power tool packs (comprised of 18650 format cells), and Polymer cells) at 50% state of charge.

Due to the cost and availability of large quantities of Li-ion batteries, Phase II established that Cartoned Unexpanded Plastics (CUP) were a suitable surrogate for Li-ion batteries, provided the protection system design suppresses the fire within 5 minutes. Essentially, if the suppression system can suppress the fire within 5 minutes this would be sufficient to prevent the battery cells, inside a plastic casing and cartoned from being damaged which could creating a thermal run-away event.

## Testing

Ultimately, two tests were conducted in phase III using a three-tier-high 15-foot rack-storage array that was centered among four sprinklers, both tests utilized sprinklers rated for 165° F. The first test conducted utilized K-25.2 sprinklers under a 30-foot ceiling, the second utilized K-14.0 sprinklers under a 25-foot ceiling. In both tests the CUP commodity cartons breached before the initial sprinkler operation, and the CUP commodity itself continued to burn beyond the predicted time of battery enrollment of 5 minutes, therefore the effectiveness of the ceiling level sprinklers could not be assessed.

While not an entirely successful outcome, this research did provide valuable input and assistance for future testing regarding bulk storage of cartoned Li-ion batteries. The equivalency established in phase II will allow cartoned unexpanded plastics to be used as a surrogate commodity for future testing, which will greatly reduce the cost for much needed future testing. Also, the data gathered in phase III was sufficient for FM Global to release protection criteria.

## FM Criteria

FM Data Sheet 8-1 currently is the only prescriptive criteria available for storage of Li-ion batteries and dictates no more than 3 tiers of rack or palletized storage limited to 15 ft and a maximum ceiling height of 40 ft. Sprinklers must be either K-22.4 or K-25.2 and the calculations are based on 12 sprinklers flowing at a minimum 35 psi. Other limitations to allow this criteria are, maximum battery state of charge of 60%, a maximum electrolyte weight of 20%, and a maximum battery capacity of 41 Ah. Packaging must be a carton, with cellulosic and/or unexpanded plastic internal packaging only. If the maximum battery and packaging properties are exceeded, Scheme A from FM Data Sheet 7-29 must be followed.



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## Future NFPA Criteria

While it is likely additional testing is needed before NFPA 13 provides criteria specific to Li-ion batteries, this research project will allow the industry to take a step forward. The need for approved prescriptive criteria is needed and may not be too far off.

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