



Application of NFPA 855 Lessons Learned for National Labs

August 8, 2023

Matthew Paiss

Technical Advisor, PNNL

Nicholas Bartlett

Fire Marshal, NREL



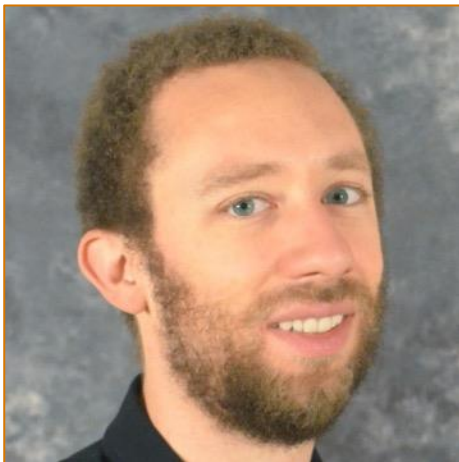
PNNL is operated by Battelle for the U.S. Department of Energy





- **Matt Paiss**

- PNNL ESS Safety Lead
- Retired Captain from San Jose Fire Dept – 23 years service
- Representative to NFPA 855, UL 9540, 1974, and IEC TC120



- **Nick Bartlett**

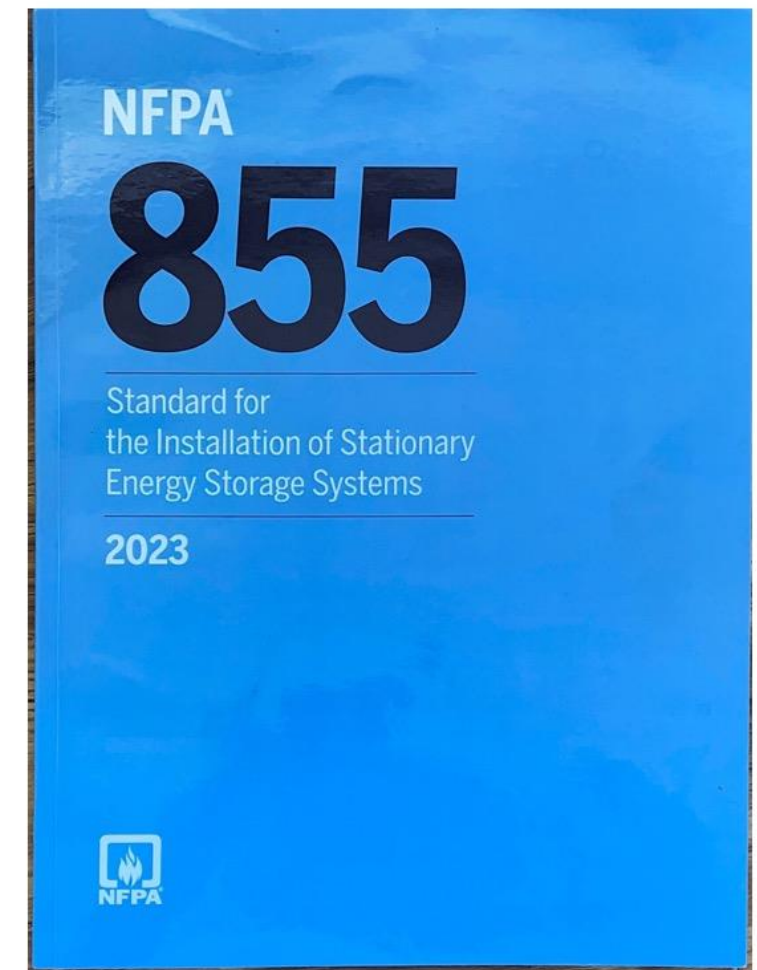
- NREL Fire Marshal
- Previously Senior FPE – LBNL; Consultant – Hughes Associates; Engineer- UL
- Alternate NFPA 855; UL 1487 representative

1.1* Scope.

This standard applies to the design, construction, installation, commissioning, operation, maintenance, and decommissioning of stationary energy storage systems (ESS), including mobile and portable ESS installed in a stationary situation and the storage of lithium metal or lithium-ion batteries.

1.2 Purpose.

This standard provides the minimum requirements for mitigating the hazards associated with ESS and the storage of lithium metal or lithium-ion batteries.



Is NFPA 855 Required?



- DOE 420.1C, Chg., 3, Chapter II – Fire Protection:
- Codes and Standards. The codes and standards determined to be applicable, including DOE technical standards, the building code, National Fire Protection Association (NFPA) codes and standards, and other industry codes and standards, must be identified in the fire protection and emergency response programs. The fire protection and emergency response programs may specify provisions for relief (exemptions and equivalencies) from identified, applicable fire protection codes and standards; otherwise, see Attachment 1, Section 2 for relief provision.

Is NFPA 855 Required?

- 2015-2021 IFC

[A] 102.8 **Where applicable standards or requirements are not set forth in this code**, or are contained within other laws, codes, regulations, ordinances, or bylaws adopted by the jurisdiction, **compliance with applicable standards of the National Fire Protection Association or other nationally recognized fire safety standards**, as approved, shall be deemed as prima facie evidence of compliance with the intent of this code.



Is NFPA 855 Required?

- 2024 IFC!

1201.1 Scope. The provisions of this chapter shall apply to the installation, operation, maintenance, repair, retrofitting, testing, commissioning, and decommissioning of energy used for generating or storing energy

including but not limited to energy storage systems under the exclusive control of an electric utility or lawfully designated agency. It shall not apply to equipment associated with generation, control, transformation, transmission, or distribution of energy installations that is under the exclusive control of an electric utility or lawfully designated agency. **Energy storage systems regulated by Section 1207 shall comply with this chapter as appropriate and NFPA 855.**



NFPA 855 Application Research v. Infrastructure

- 2023 NFPA 855, §1.3.1: ESS shall comply with the requirements of this standard as applicable
- 2023 NFPA 855, §A1.3.1: **Where approved by the AHJ, alternate safety requirements can be applied for the purpose of research, development, and testing.**



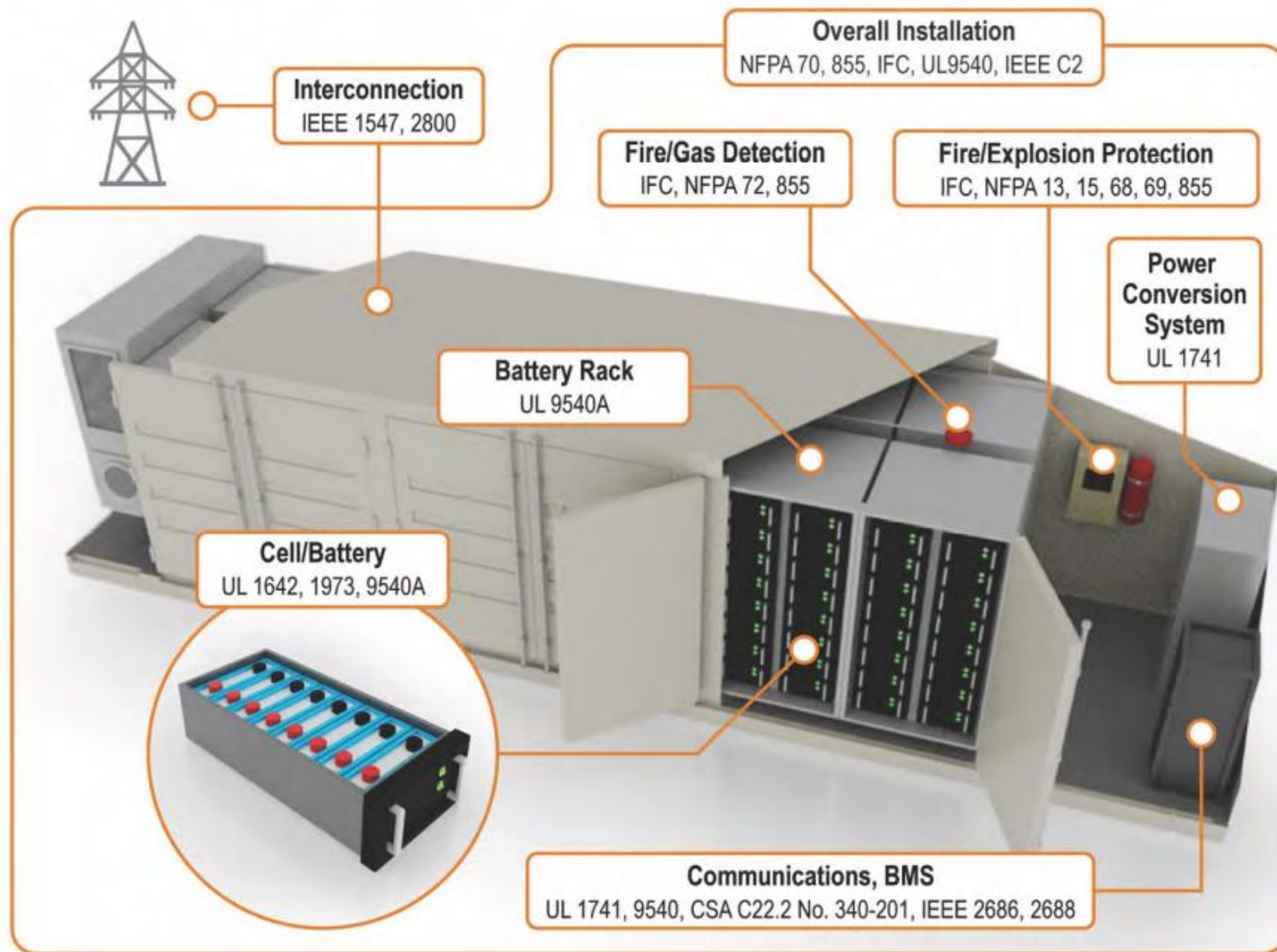
For permanent installation: Apply NFPA 855
For R&D: Some AHJ interpretation is allowed!

NFPA 855 Application Research v. Infrastructure

PROPOSED FUTURE LANGUAGE

- NFPA 855, §1.3.5: This standard shall not apply to product research, development, and testing conducted at laboratory occupancies and pilot plants.
- NFPA 855, §A1.3.5: In some instances, such as for testing and research laboratories, Department of Energy National Laboratories, research universities and manufacturers engaged in product development, it is not possible to meet all prescriptive requirements of NFPA 855.

ESS Codes & Standards



UL 9540 Listing

- This is a SYSTEM listing (or certification).
- Includes a UL1973 listed battery & UL1741 listed inverter
- Construction & Performance
- Mechanical & Environmental Tests
- Communications Systems
- Functional Safety
- HVAC
- Includes requirements for UL9540a fire testing



**ANSI/CAN/UL
9540:2023**

JOINT CANADA-UNITED STATES
NATIONAL STANDARD

STANDARD FOR SAFETY

Energy Storage Systems and
Equipment



scc  ccn

This document is only permissible for use by CSDS for CSDS use. 6/29/2023 7:40:06 AM

UL 9540a Test Method

- Test method, NOT a listing or certification
- 4th edition has clarifications on module test
- Used to characterize gas characterizations for chemistries that go into TR.
- Used to design fire protection and explosion studies.
- Required for any ESS unit >50kWh, where spaced <3' apart, or residential wall mounted units.



**ANSI/CAN/UL
9540A:2019**

JOINT CANADA-UNITED STATES
NATIONAL STANDARD

STANDARD FOR SAFETY

Test Method for Evaluating Thermal
Runaway Fire Propagation in Battery
Energy Storage Systems



EV Charger Integrated ESS

- Utilized for DC fast charging where supply can't provide power demands.
- Work with your Transportation or Electrical Group
- Must include UL 9540 for batteries >20KWh



Examples

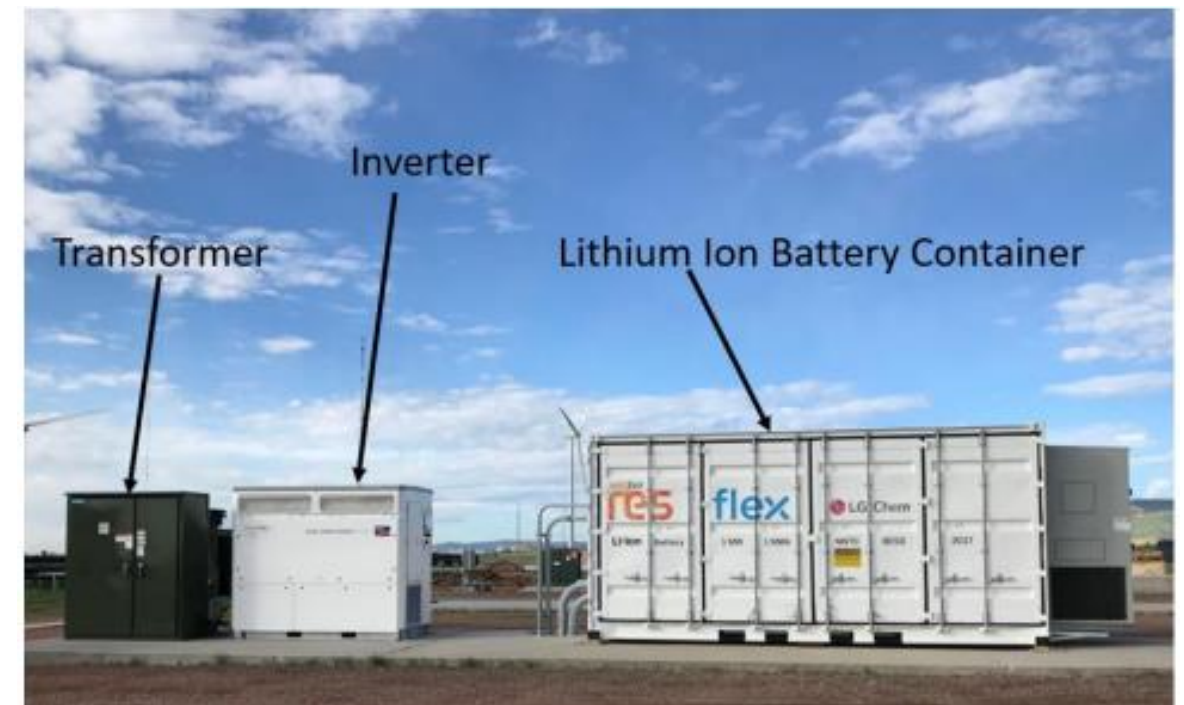
- Commercial Product
 - 43 kWh Battery
 - Batteries NOT UL 1973
 - Not UL 9540
- Initially Rejected; Later accepted with reduced battery capacity < 20 kWh



- Research Asset
 - 80 kWh
 - Not UL 9540
 - No explosion control
 - No suppression
 - Located in area of high traffic
 - Battery UL 1973; Inverter UL 1741



- Permanent Research Infrastructure
 - Installed 2016
 - No UL 9540/UL 1973
 - Undertaking HMA
 - Separation distances
 - Vegetation (wildland fire)



- Smaller Wall Packs
 - 5 kWh each
 - Greater 20 kWh *fire area*
 - UL 9540 and UL 9540A
 - Size and separation

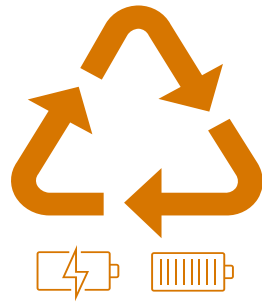


Small Rooftop Batteries

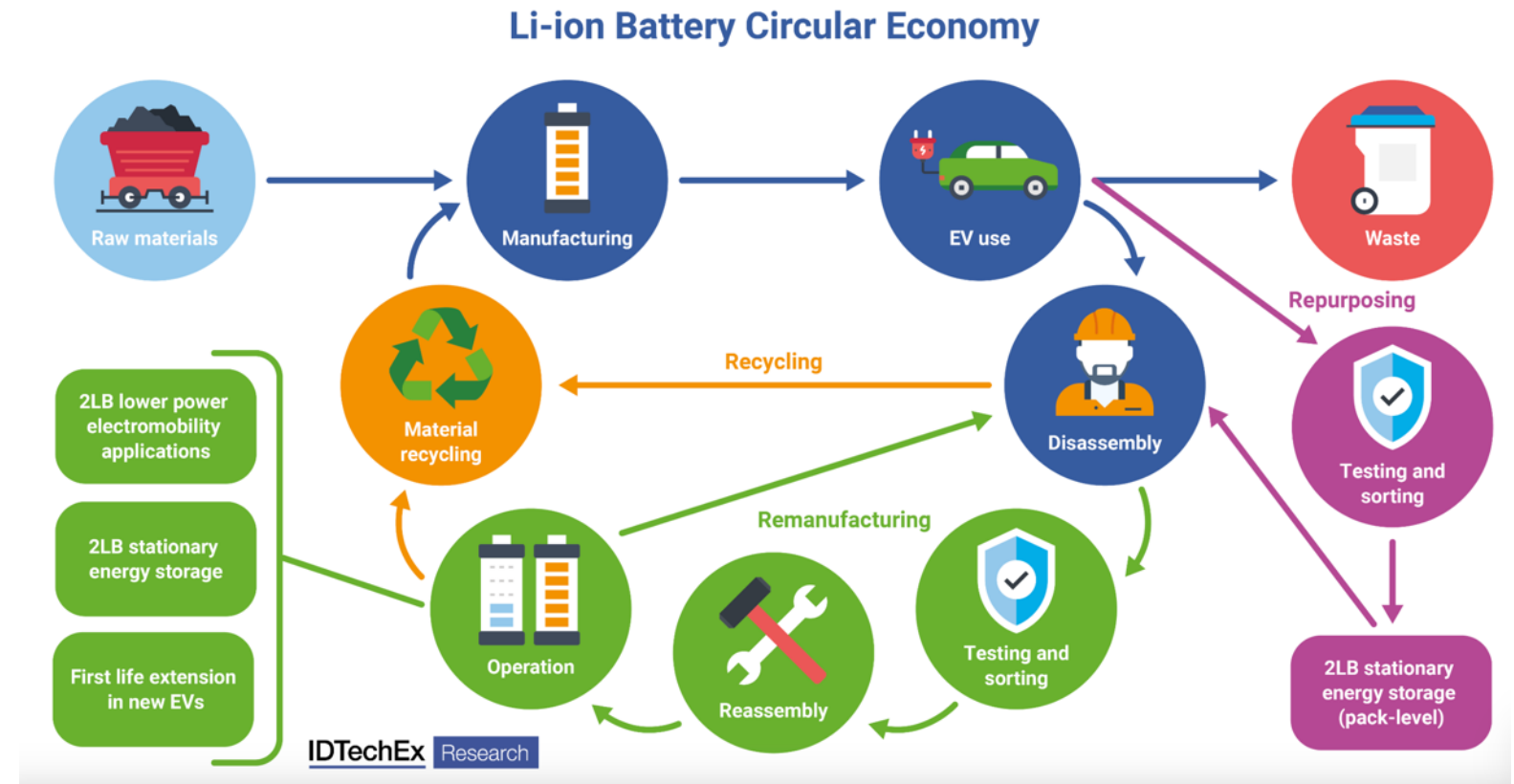


- Batteries less than 20 kWh each
- Can include ESS in PV array
- Must meet indoor residential fire test (cheesecloth).

Second Life Batteries/Repurposed Batteries



- Forecast market to be \$7.3B by 2033*
- NFPA 855 requires:
 - UL1973 on battery
 - UL 9540 on ESS
 - UL 1974 Repurposing facility certificate only (not a product UL Listing!)
 - Area of significant interest and unclear path for acceptance.
 - Potential R&D application of NFPA 855

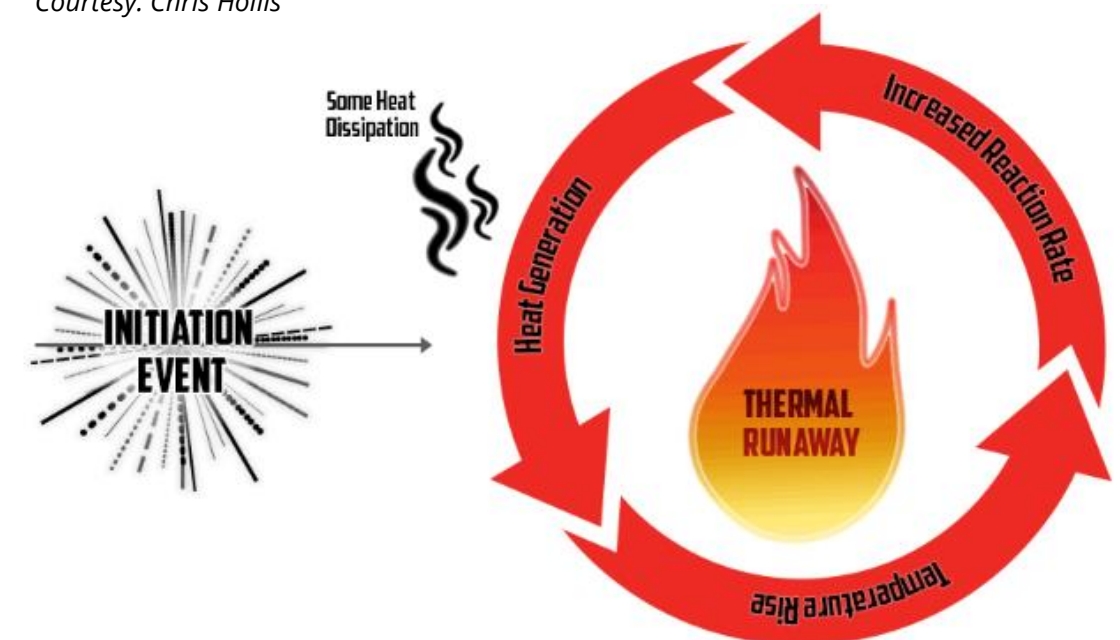


Fire Suppression of LiB's

- Suppression does not stop thermal runaway unless demonstrated in UL 9540A reports.
 - In some cases, even though required, it can lead to an explosive environment. Good for fires that are not related to thermal runaway.
- Common theme: Manufacturer will rely on aerosols and NOVEC and not focus on explosion control.

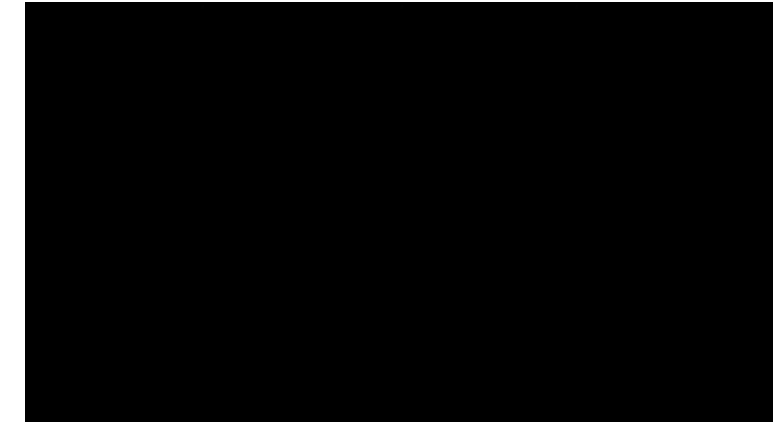


Courtesy: Chris Hollis



Explosion Risks

- Chemistry affects ignition but not flammable gas production.
- NMC/NCA will often produce sparking and flame igniting gases quicker than LFP.
- LFP generates more H₂ than NMC/NCA
- Lower SOC in any chemistry will decrease TR and explosion risks.



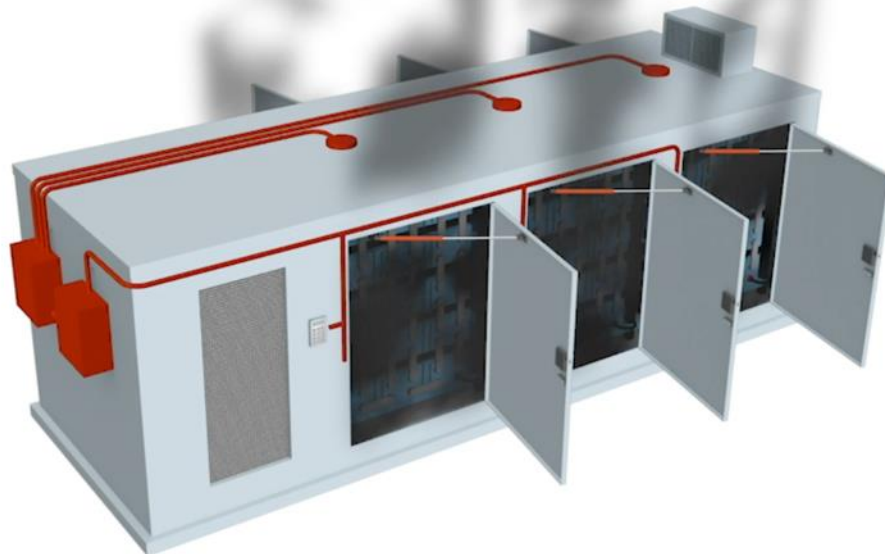
Explosion Control Options

Three options for meeting requirement:

1. NFPA 68 – Deflagration Venting.
 - Blow-out panels to protect structure from explosion based on max gas production in module tests.
2. NFPA 69 – Deflagration Prevention.
 - Exhaust system designed to keep below 25% of LEL in area.
3. Engineered Cabinet – Based on Large Scale Fire Test has shown that no pressure waves will occur, and no projectiles can be ejected.



Courtesy: Fike Corp.



PNNL-SA-186396



Courtesy: EVLO

- **Always** request UL 9540A report
- Explosion Control to follow NFPA 68 or NFPA 69
- For NFPA 69:
 - Gas detection to trigger fan
 - Fan size based on UL 9540A report (gas constituents, volumes and extent of fire propagation).
 - NFPA 855 and NFPA 69 have specifics about gas detection. For example:
 - ✓ Battery Backup for both detection and exhaust fan
 - ✓ Monitoring requirements
 - ✓ Triggering requirements at 10% LFL to maintain <25% LFL
 - ✓ SIL-2 reliability
- For containers, CFD model and formal design report is recommended

Field Evaluations vs. Listing

- Field eval does not include factory quality control inspections
- Depth of evaluation more open to interpretation by NRTL
- Field evaluation may be acceptable for some aspects of the ESS, but not for others.
- Requiring all ESS to be listed limits one-off designs, may not be a true benefit in long run.



HMA is required :

- >600 KWh
- Multiple technologies in same fire area
- New technologies not listed, or other hazards present

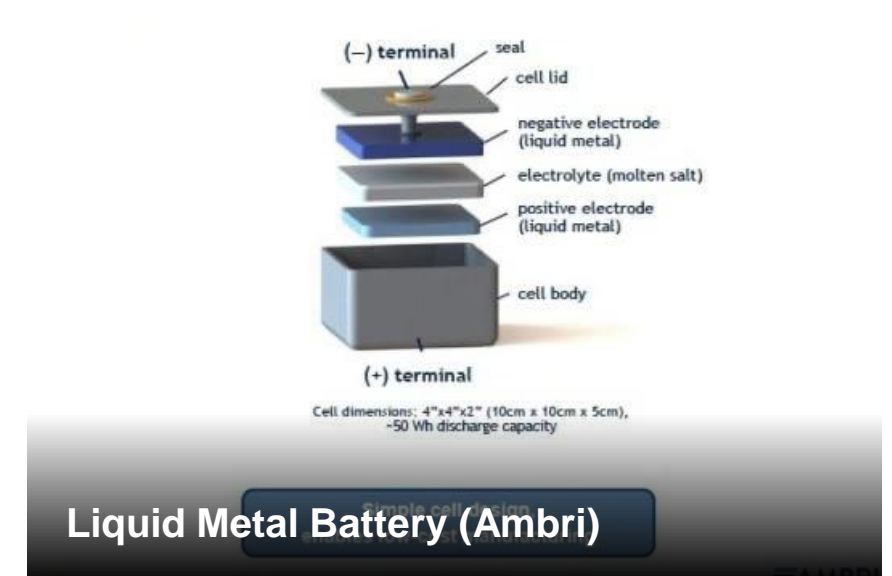
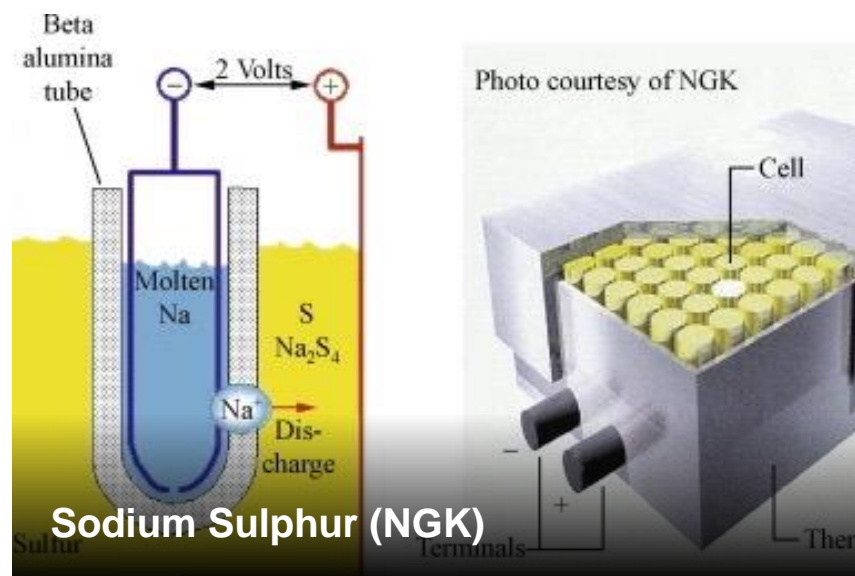
HMA shall include:

- Thermal runaway in a single battery array
- Failure of the energy management system
- Failure of ventilation system
- Voltage surges on the primary side
- Short circuits on the load side of the batteries
- Failure of the smoke or gas detection, fire suppression



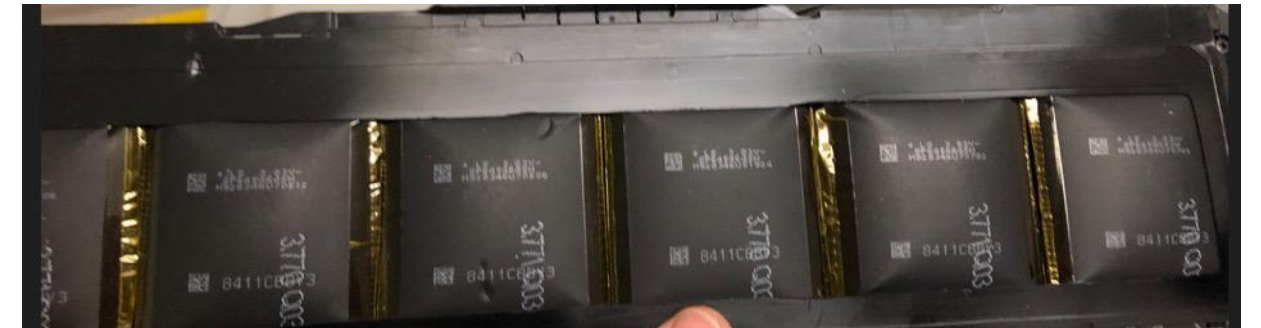
AHJ should take advantage of IFC sec 104.8.2 Technical Assistance to require SME support.

Other Electrochemical Chemistries/Technologies



Chapter 14 | Storage of Lithium-ion Batteries

- Old and improperly stored LiB's present risks to lab facilities and research¹.
- Fire resistant overpacking for damaged cells
- UL 1487 in development
- IT personnel regularly handle puffy/vented batteries
- IFC and 855 address this requirement



Labs: Response/Collection/Disposal policies needed.

1. <https://www.nature.com/articles/s41557-023-01254-6>



Resources

- DOE Tech Specs
- NREL LLP



[International Association of Fire Chiefs Li-ion and ES Toolkit](#)



[IREC Clean Energy Training](#)



[EPRI Failure Database](#)



Thank you

