SAND2022-1361C

CLOSING THE BESS INSTALLATION CODE GAP

What Is The Intersection of Product Listing & Installation Standards/Codes and What is Really Required?

NRECA America's Electric Cooperatives

TECHADVANTAGE® 2022 EXPERIENCE

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Presenter Bio – Waylon Clark

- Sandia National Laboratories | R&D Electrical Engineer | Energy Storage Technology & Systems
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Purpose

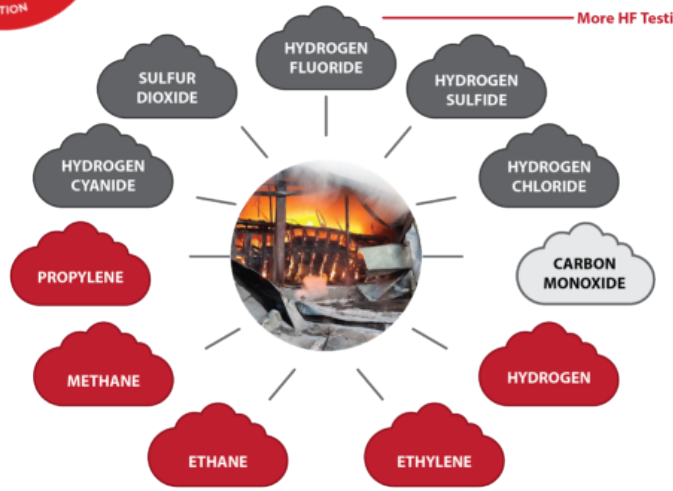
- Knowledge gaps currently exist concerning the difference between Product Listing & Installation Codes by:
  - Battery/Container Manufacturer
  - BESS Installer/Integrator
  - **Owner**
  - AHJ's
- In particular – there is a knowledge gap surrounding the Explosion Control (4.12) requirements of NFPA 855 (and referenced in the IFC)
  - In relation to Explosion Control are the Outdoor Installations (4.4.3), Size and Separation (4.6), & Maximum Stored Energy (4.8) sections

Li-Ion Battery Hazard Refresher

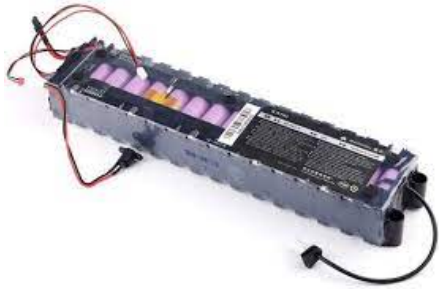
“The process where self heating occurs faster than can be dissipated resulting in vaporized electrolyte, fire, and/or explosions”

- Initial exothermic reactions leading to thermal runaway can begin at 175° - 245°F
- Venting of electrolyte gasses
- Ignition of gasses (fire or explosive)
- Propagation within module
- External flame initiates preheating of additional cells/modules

Thermal Runaway



Thermal Runaway



- Typical battery pack found in an electric scooter ~30 18650 cylindrical form factor Li-ion cells

Best Practice - Safety Standard/Code Compliant BESS Installation

UL 9540
Energy Storage Systems and Equipment

4.2.1 Listings

Intro

4.1.5 Large-Scale Fire Test

NFPA 855
Standard for the Installation of Stationary Energy Storage Systems

Explosion Mitigation 4.12

Federal

Chapter 12

IFC
International Fire Code

State*

*Code year adoption varies by State and many times by Municipalities within States

UL 9540A
Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

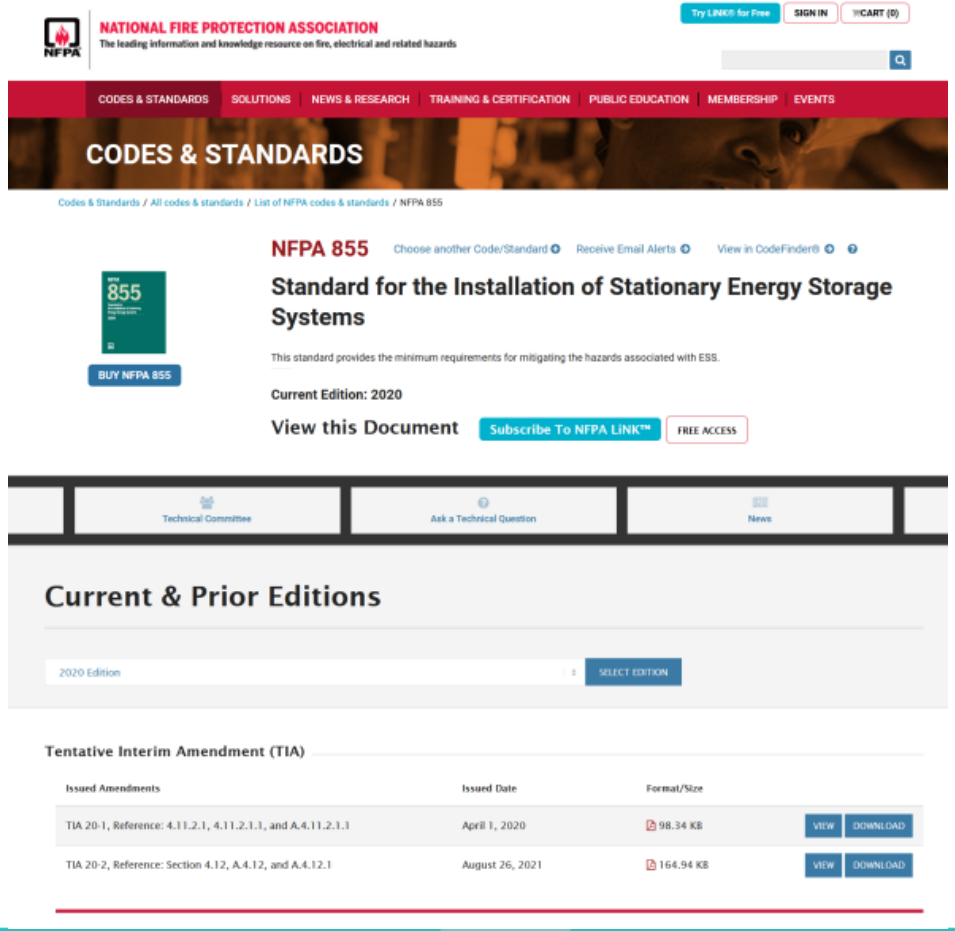
NFPA 68
Standard on Explosion Protection by Deflagration Venting

NFPA 69
Standard on Explosion Prevention Systems
(Exhaust systems)

Other Method
I.E. Automatic Door Opening Systems (PNNL Intellivent)
TIA_855_20_2

Product Listing Standard

Installation Codes



Tentative Interim Amendment

NFPA® 855

Standard for the Installation of Stationary Energy Storage Systems

2020 Edition

Reference: Section 4.12, A.4.12 and A.4.12.1
TIA 20-2
(SC 21-8-37 / TIA Log #1585)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*, 2020 edition. The TIA was processed by the Technical Committee on Energy Storage Systems, and was issued by the Standards Council on August 26, 2021, with an effective date of September 15, 2021.

1. *Revise Section 4.12 to read as follows:*

4.12* Explosion Control. Where required elsewhere in this standard, explosion prevention or deflagration venting shall be provided in accordance with this section.

4.12.1* ESS installed within a room, building, ESS cabinet, or ESS walk-in unit shall be provided with one of the following:

(1) Explosion prevention systems designed, installed, operated, maintained, and tested in accordance with NFPA 69.

(2) Deflagration venting installed and maintained in accordance with NFPA 68.

4.12~~.2~~.1.1 Explosion prevention and deflagration venting shall not be required where approved by the AHJ based on large-scale ~~fire~~ testing in accordance with 4.1.5 and a deflagration hazard study that demonstrates that flammable gas concentrations in the room, building, ESS cabinet, or ESS walk-in unit cannot exceed 25 percent of the LFL ~~in locations where the gas is likely to accumulate~~.

4.12.1.2 Where approved, ESS cabinets that have been designed to ensure no hazardous pressure waves, debris, shrapnel, or enclosure pieces are ejected, as validated by installation level large-scale testing and engineering evaluation complying with 4.1.5 that includes the cabinet, shall be permitted in lieu of providing explosion control complying with NFPA 68 or NFPA 69.

NFPA TIA 855_20_2 Substantiation

"…The exclusion of "cabinets" in chapter 4.12 has had unintended consequences. It has led to the perception of some in the industry that ESS cabinets do not require explosion control. Some in the industry have assumed that since ESS cabinets were not included in the description they must be excluded. Use of this "loophole" can lead to what the TC would consider an unsafe installation."

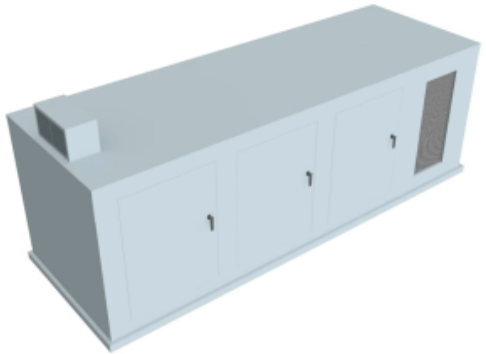
Photos: Arizona Public Service From: https://spectrum.ieee.org/dispute-erupts-over-what-sparked-an-explosive-liion-energy-storage-accident

Difficulties With NFPA 68 & 69 Compliance

- NFPA 68 – Deflagration Venting
  - It is not prevention – you are acknowledging the fact that a deflagration will occur
  - Current battery container design offerings are usually of the ‘cabinet’ type
    - There may not be enough surface area for properly sized deflagration panels on a cabinet type BESS
- NFPA 69 – Explosion Prevention Systems
  - Current battery container design offerings are usually of the ‘cabinet’ type
  - System must be installed to Safety Integrity Level (SIL) 2 at minimum
  - Expense associated with making a battery container SIL 2

Alternative Method Added by TIA

4.12.1.2 Where approved, ESS cabinets that have been designed to ensure no hazardous pressure waves, debris, shrapnel, or enclosure pieces are ejected, as validated by installation level large-scale testing and engineering evaluation complying with 4.1.5 that includes the cabinet, shall be permitted in lieu of providing explosion control complying with NFPA 68 or NFPA 69.



Automatic Door Opening Technology

Ex. PNNL Intellivent

Key Take-Aways

- Specify best-practice, most up-to-date Code/Standard requirements in your Request for Proposal (RFP)
  - NFPA 855 2020, Including TIA's/IFC 2021
  - UL9540 2020
- Understand and ask appropriate questions of all bidders about how they plan on meeting installation requirements
  - Specifically ask about explosion control
- Consider re-examining the locations of existing BESS already installed and consider retrofits

Thank You!

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Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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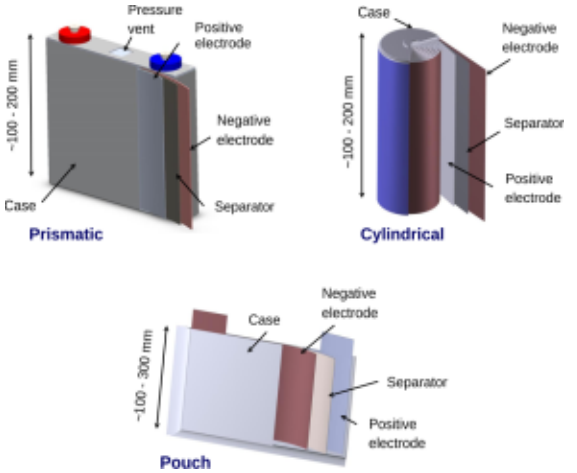
Additional Slides

UL9540A

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

- Tests are conducted at different ‘assembly’ levels:
  - Cell
  - Module
  - Unit (Rack)
  - Installation

Cell Level Testing



https://dieselnet.com/tech/energy_powertrains_batteries.php

Battery Cell Form Factors

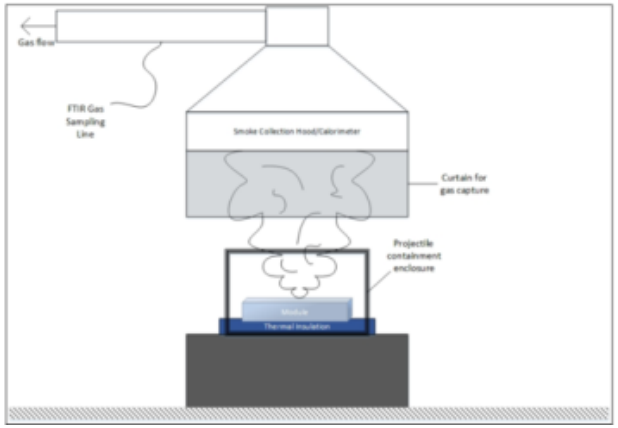
Battery Test Chamber

Data Documentation

- Test method
- Cell temps monitored
  - What temp does the cell vent?
  - What temp does the cell go into thermal runaway?
- Collect vent gas composition

Module Level Testing

Battery Modules



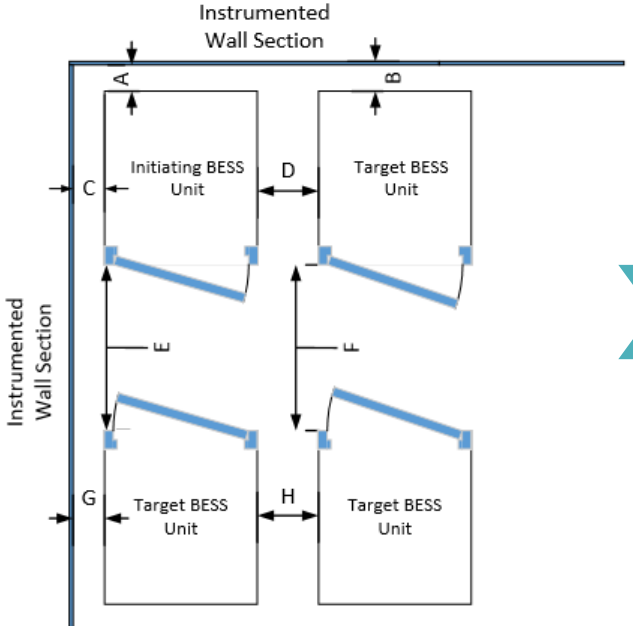
Module Test Chamber

Data Documentation

- Propagation from cell to cell within the module
- Measure chemical heat release rate, smoke release rate
- Collect vent gas composition
- Module enclosure integrity after the test

Unit (Rack) Level Testing

Battery Unit (Rack)



Unit Test Layout

Data Documentation

- Monitor fire behavior of unit under test
- Measure heat release rates, smoke release rate, heat flux on other units & walls
- Collect vent gas composition
- Explosion, deflagration and flying debris

Installation Level Testing

Battery Energy Storage System (BESS)

Data Documentation

- Test method
- Cell temps monitored
  - What temp does the cell vent?
  - What temp does the cell go into thermal runaway?
- Collect vent gas composition