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UL 9540A – Evolving to Meet the Safety Challenges of BESSs

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Origins of UL 9540A



MOTORIZED FIRE TRUCK AND MEN, CHATTANOOGA, TENN

Origins of UL 9540A



The fire codes established strict limits for Battery energy storage (BESS) to control fire hazards:

Some examples of these current limits:

- Limits on individual BESS size – 50 kWh
- Large separation distances – 3 ft
- Limits to total amount of BESS energy in an area – 600 kWh
- Large clearances to exposures – 10 ft
- More stringent sprinkler requirements – 0.3 gpm/ft²

These limits could be increased/reduced based upon what was originally referred to as: “Large Scale Fault and Fire Test” and is now referred to **“Large Scale Fire Test”**

- The concern was with a fire originating within a BESS
- There were no test methods for this testing at the time

Origins of UL 9540A

The UL Fire Research Group at UL LLC Northbrook began work on development of UL 9540A in 2016

To develop UL 9540A internal and external resources were used:

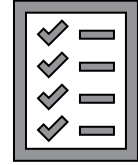
- UL has extensive experience with large scale fire testing (UL Fire Research and Operations staff)
- UL has extensive experience with battery research and safety testing (Battery Research and Operations staff)
- UL has a depth of building and fire code knowledge from the UL Regulatory group
- UL had many discussions with the fire service community on the goals of this test
- UL had many discussions with the building regulatory community on the goals of this test
- UL consulted with various experts in the field
- UL conducted research testing on the various test levels



UL 9540A Addresses Key Fire Safety Concerns

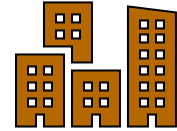
1. BESS Installation Parameters

- Enables determination of separation distances between units to minimize unit-to-unit fire propagation
- Enables determination of separation distances between units and enclosure walls
- Enables determination of potential of fire spread to overhead cabling



2. Installation Ventilation Requirements

- Quantifies deflagration potential
- Quantifies heat generation



3. Fire Protection (Integral or External)

- Evaluates fire protection strategies



4. Fire Service Strategy and Tactics

- Characterizes magnitude of potential fire event
- Documents re-ignitions within a BESS unit under test
- Measures and documents gases generated



UL 9540A Test Levels



From its start, UL 9540A has been a multi-level test:



Cell Level

- Whether cell can exhibit thermal runaway
- Thermal runaway characteristics
- Gas composition and properties



Module Level

- Propensity for propagation of thermal runaway
- Heat and gas release rates (severity/duration)
- Flaming/deflagration hazards



Unit Level

- Evaluation of fire spread
- Heat and gas release rates (severity/duration)
- Deflagration hazards
- Re-ignition hazards

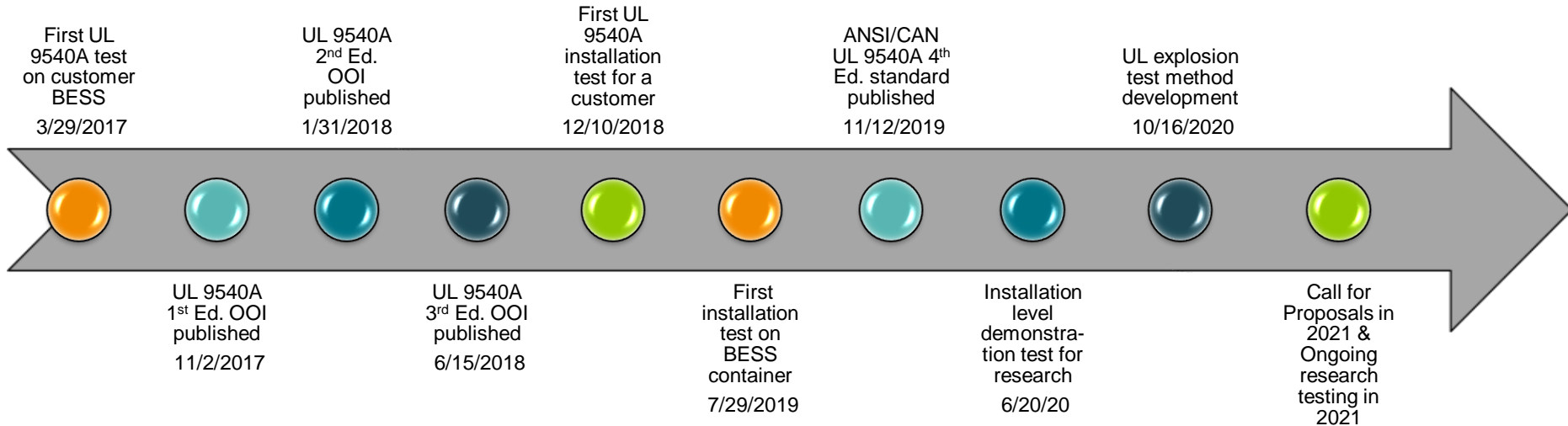


Installation Level

- Effectiveness of fire protection system(s)
- Heat and gas release rates (severity/duration)
- Deflagration hazards
- Re-ignition hazards



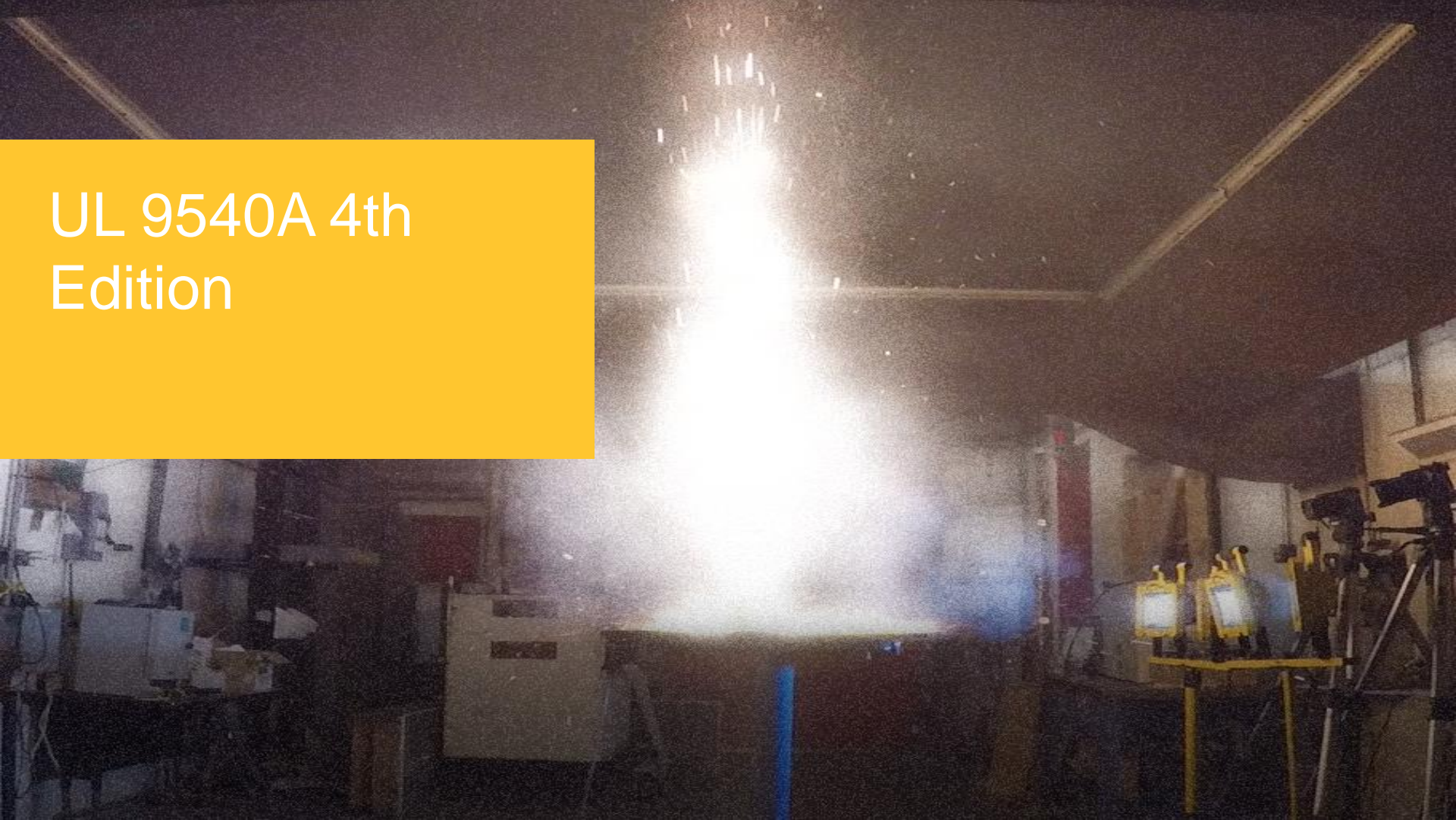
A timeline of critical milestones for UL 9540A



UL fire research testing to inform UL 9540A test methods and customer testing to UL 9540A has been ongoing



UL 9540A 4th Edition



UL 9540A 4th Edition



ANSI/CAN UL 9540A, 4th Ed.: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

Scope – Test method that determines the capability of a battery technology to undergo thermal runaway and then evaluates the fire and explosion hazard characteristics of those battery energy storage systems that have demonstrated a capability to undergo thermal runaway.

- USA and Canada Safety Standard
- Published: 11/12/2019



UL 9540A 4th Edition

Details were added in the 4th edition to clarify the test method based upon testing experience

Cell Level: Clarification of external heater method, details for report, Clarify the methods to establish vent gas properties (LFL, S_u , P_{max})

Module Level: Clarification that propagation is goal, smoke release rate details, heat release rate (chemical) details. details for report

Unit Level: Clarification for various test set ups: Indoor floor mounted, Outdoor ground mounted, Wall mounted, Open garage and Roof top, Residential, Non-residential, additional heat flux measurements including egress path, additional details of heat release rate (chemical and convective); details for report

Installation Level: Clarification for Method 1 (sprinkler) and Method 2 (other suppression methods) test set ups, details for report



UL 9540A 4th Edition

Examples of some unit level test set ups have been added for clarification

Figure 9.4
Example of Outdoor Wall Mounted BESS Test Arrangement

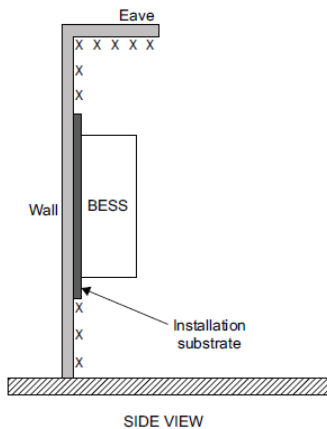


Figure 9.2
Example of Outdoor Ground Mounted Residential Use BESS Test Arrangement

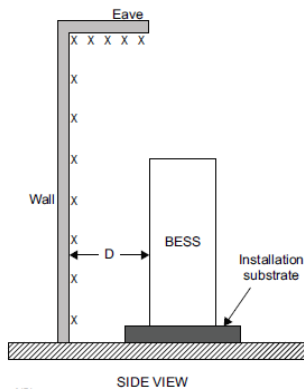


Figure 9.1
Examples of Indoor Floor Mounted BESS Test Arrangements

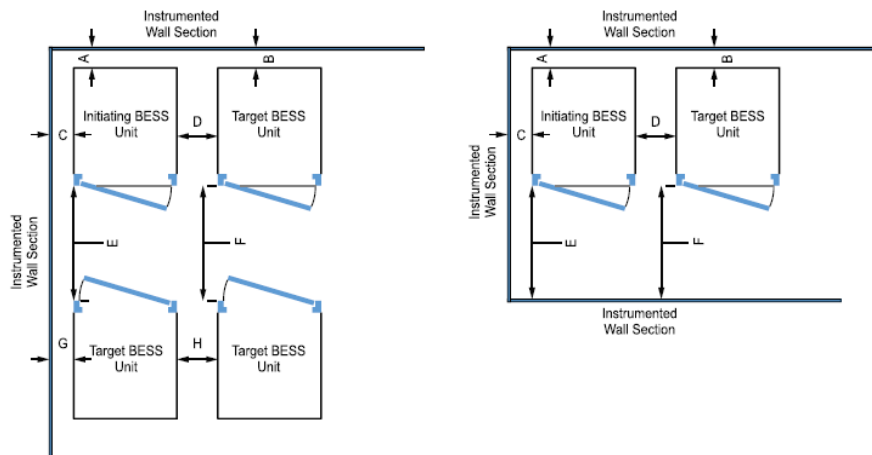
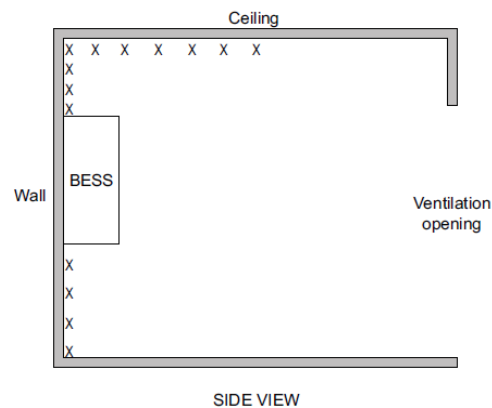


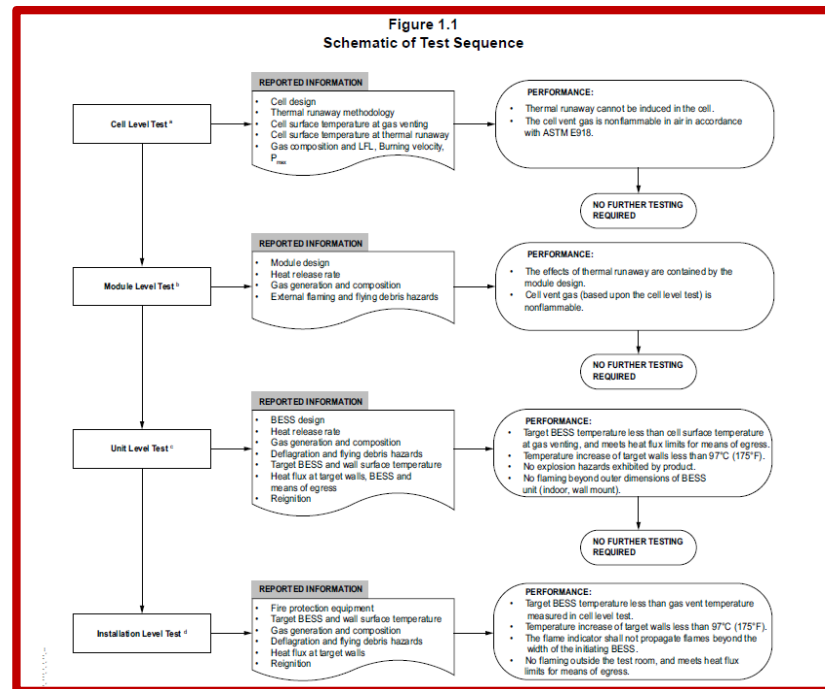
Figure 9.3
Example of Indoor Wall Mounted BESS Test Arrangement



UL 9540A 4th Edition

Addition of Performance Criteria for each level

- If the device under test (DUT) meets the performance Criteria for that level, testing can stop at that level
 - Examples:
 - Cell level – Thermal runaway cannot be induced **and** cell vent gas is not flammable
 - Module – Thermal runaway is contained within the module **and** cell vent gas is not flammable
- Addition of flow charts/diagrams to aid in understanding of the test method, and use of gas data for deflagration protection determination
 - **Figure 1.1** Schematic of Test Sequence
 - **Figure A.1** BESS Fire Assessment Propagation Flow Chart (cell, module and unit)
 - **Figure A.2** BESS Fire Assessment Propagation Flow Chart (installation)
 - **Figure A.3** BESS Deflagration Protection Assessment



UL 9540A 4th Edition

Addition of criteria for evaluating flow battery systems

- Evaluation of charged electrolyte for flammability
 - Determination flash point temperature
- Determine if flow battery electrolyte reaches flash point temperature under abnormal conditions




UL 9540A 4th Edition

UL Test Reports:

- Using a TRF format similar to the IEC report method
- Ongoing revisions to the format to improve clarity

Online database of clients that completed UL 9540A testing through UL:

- Voluntary resource for UL 9540A client
- Publicly available online
- AACD is the CCN that can be used as search
- Level of details provided decided by the client

	UNIT TEST REPORT UL 9540A Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems (AACD)
Project Number	: 12345678
Issue Date	: July 1, 2020
Pages	: 43
Client Name	: UL LLC, Northbrook, IL 60062 USA
Product Name	: ACME Energy Storage
Product Location	: Anywhere USA
Revision	: 4 th Edition, Section 7, November 12, 2019
Test Method	: UL 9540A, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
Version	: 9.1 – 9.8
Test Method	: N/A
© UL LLC All Rights Reserved.	
The information presented in this report relate only to the sample tested.	
To select the sample(s), determine whether the sample(s) was representative of production or the production of the test sample(s), nor were we provided with information relative to the identification of component materials used in the test sample(s).	
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<i>This is a sample report to demonstrate the content provided in a UL 9540A unit level test report. This sample report contains real measurements taken from UL 9540A testing of a non-proprietary example product fabricated by UL for the purposes of creating demonstration data. This report has been created for the purposes of demonstrating a minimum level of information and data that should be provided for a UL 9540A unit level test report.</i>	



Future Considerations for UL 9540A



Future Considerations for UL 9540A



Addition of more test details for consistency of testing for users of the standard

- Developed from test experience and feedback from staff and clients
- Updates for residential system testing
- Some details on the propagation consideration of 8.2.4 to improve clarity and consistency between users
- Revisions to some of the gas collection methods for ease of testing/clarity

Future Considerations for UL 9540A

Clearer delineation between different unit level tests:

- Outdoor vs Indoor
- Residential vs Non-residential
- Wall mount vs ground or floor mount
- Additional details for roofs or parking garages



Future Considerations for UL 9540A



Test method for technologies:

- Lead acid and Nickel Cadmium
- Revisions to some flow battery testing for clarity
- Other technologies



Future Considerations for UL 9540A

UL 9540A method for lead acid and ni-cd batteries

- From UL 1973 CRD and proposed Appendix H “*Overcharge Thermal Runway Test*”
- *Overcharge for 168 hours while gathering temperature data*
- Includes off gassing method per 7.4 or use of calculations based upon IEEE 1635/ASHRAE Guide 21 for various technologies of LA and Ni-CD batteries

UL 1973 CRD and Appendix H Proposal

- Certification Requirement Decision (CRD)
- Provides a complete program for evaluation of lead acid and ni-cd cells and batteries



Future Considerations for UL 9540A



Installation Level Test Method for Container Systems

- Define difference between a container system and an enclosed BESS
- Test container systems as a type of installation:
 - Test with installed integral fire suppression
 - Test with their installed deflagration/explosion protection
 - Treat the internal rack as a BESS unit with other racks as targets
 - Determine how many populated units besides initiating.



Future Considerations for UL 9540A

Research work had been underway in 2019-2020 on large container systems:

- Without fire suppression
- With clean agent fire suppression
- With sprinkler fire suppression
- In coordination with various stakeholders including UL's FSRI (Firefighter Safety Research Institute)

Research work into explosion test methods for residential systems underway in 2020-2021

- Maybe ready for proposal for UL 9540A in 2021





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Questions?

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