An inside look at the updates to UL 9540A: 2025

Key changes to the Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

LET'S GO

UL 9540A, Fifth Edition: Enhancements in Testing Methodology for Battery Energy Storage

UL 9540A, the Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems (BESS), is a binational standard for both the U.S. and Canada that assesses a battery technology's susceptibility to thermal runaway and evaluates the associated fire and explosion hazards.

The fifth edition of this standard, released in March 2025, builds on its ongoing evolution and incorporates insights gained from years of testing experience and real-world incidents. These updates address the growing use of energy storage technology across various sectors. The revisions aim to clarify and refine the testing methodology, streamline testing efficiency, and improve consistency.

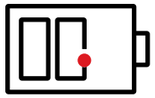
UL 9540A is officially cited in:

- National Fire Protection Association (NFPA) 855
- International Code Council (ICC)
- International Fire Code (IFC)
- ICC International Residential Code (IRC)
- UL 9540, the Standard for Energy Storage Systems and Equipment

Updates to UL 9540A consist of new definitions and updates to the following:

- Measurement requirements
- Test methods for specific battery chemistry types
- Cell-level testing requirements
- Module-level testing requirements
- Unit-level testing requirements
- Installation-level testing requirements
- UL 9540A test report
- Standard references

Terms newly defined in UL 9540A: 2025



Cell, initiating:
The cell that is faulted through thermal, electrical or mechanical means to establish a thermal runaway condition

Thermal runaway propagation:
The transfer of energy released from one or more cells undergoing thermal runaway that induces thermal runaway of other cell(s) without additional initiating mechanism(s)

Non-residential use:
Equipment intended for use on or in structures other than those defined for residential use

Residential use:
Equipment suitable for use on or in detached one- and two-family dwellings and townhouses

Open parking garage:
A parking structure with openings on two or more sides that is used for the parking or storage of motor vehicles, designed to provide natural ventilation per local building code requirements

Updates to measurement requirements

Temperature locations and heat flux:
Except for the cell temperature, the temperature of the test wall and other locations, and the heat flux value are measured by taking the average over every 60 seconds throughout the test.

Cell sample state-of-charge (SoC) status:

- Rest for at least 1 hour before testing.
- Measure and record the sample's open circuit voltage (OCV) prior to conducting the test; if the sample is not fully charged, a recharge is required.

Total hydrocarbons:

- **Must** be measured using a flame ionization detector (FID).
- The hydrocarbon components may additionally be measured using an FTIR.

Hydrogen:

- **Must** be measured using an appropriate sensor for the anticipated range and for exposure to anticipated contaminants.

Heat flux:

- Allow water-cooled Gardon-type heat flux gauge to measure heat flux.

Updates to test methods for specific battery chemistries

Lead-acid and nickel-cadmium batteries:

- The cell-level test method has been added.

Flow batteries

- The cell-level test method has been updated, and the unit-level test method has been added.

High-temperature sodium batteries:

- The cell-, module-, unit- and installation-level test methods have been added.

1

Updates to cell-level testing requirements

Prismatic cell:

- **Must** be constrained during the test to simulate the constraint in BESS

Clarify the location of thermocouples during cell testing using a film heater:

- The cell center under the heater to measure the heating rate
- The cell surface near the heater, but not covered by the heater, to measure the cell temperature
- The cell case near the vent indicates the cell case vents

If the cell separator's melting temperature is unknown or a temperature holding phase is not required at the manufacturer's request, the thermal ramp-up process can be continuous until the cell's thermal runaway occurs.

If a film heater does not induce thermal runaway, the following methods are employed as needed:

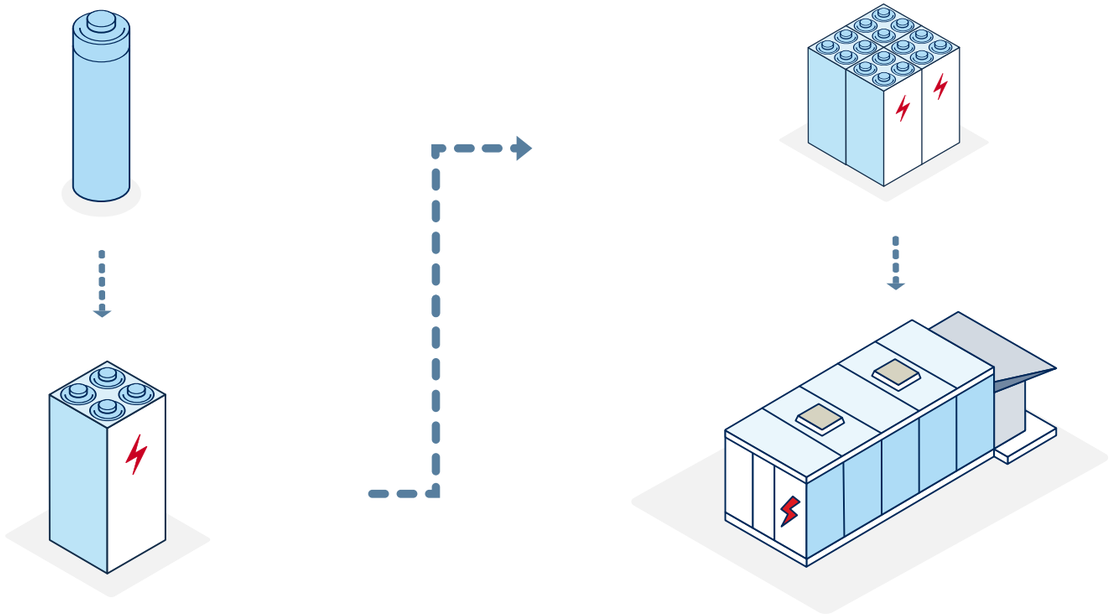
- Electrical stress method
- Alternate heating method
- Mechanical abuse

1

Cell-level test
Cell-level testing evaluates the thermal runaway characteristics of the cell as well as the composition and flammability of the gases.

3

Unit-level test
Unit-level testing evaluates the likelihood of fire spread between modules, the unit's heat and gas release rates, and the potential for deflagration or re-ignition.



2

Module-level test
Module-level testing evaluates the tendency of cell thermal runaway propagation, the heat and gas release rate of the module, and the potential danger of ignition or deflagration.

4

Installation-level test
Installation-level mainly evaluates the effectiveness of the fire protection system, as well as the heat and gas release rate of the system and the danger of deflagration or re-ignition.

2

Updates to module-level testing requirements

Cell-to-cell thermal runaway propagation:

- When at least one additional non-initiating cell goes into thermal runaway during the test

Number of cells to be failed:

- A number sufficient to cause cell-to-cell thermal runaway is needed. For example, this may be may be three cells when cell capacity is greater than 10 ampere-hours (Ah) or, for cell capacities less than 10 Ah, the equivalent of 30 Ah of cells.

Performance criteria:

- Cell vent gas is nonflammable.
- There is no spread of flame outside of the module.
- The module exterior surface temperature does not exceed the cell venting temperature.

1

Cell-level test
Cell-level testing evaluates the thermal runaway characteristics of the cell as well as the composition and flammability of the gases.

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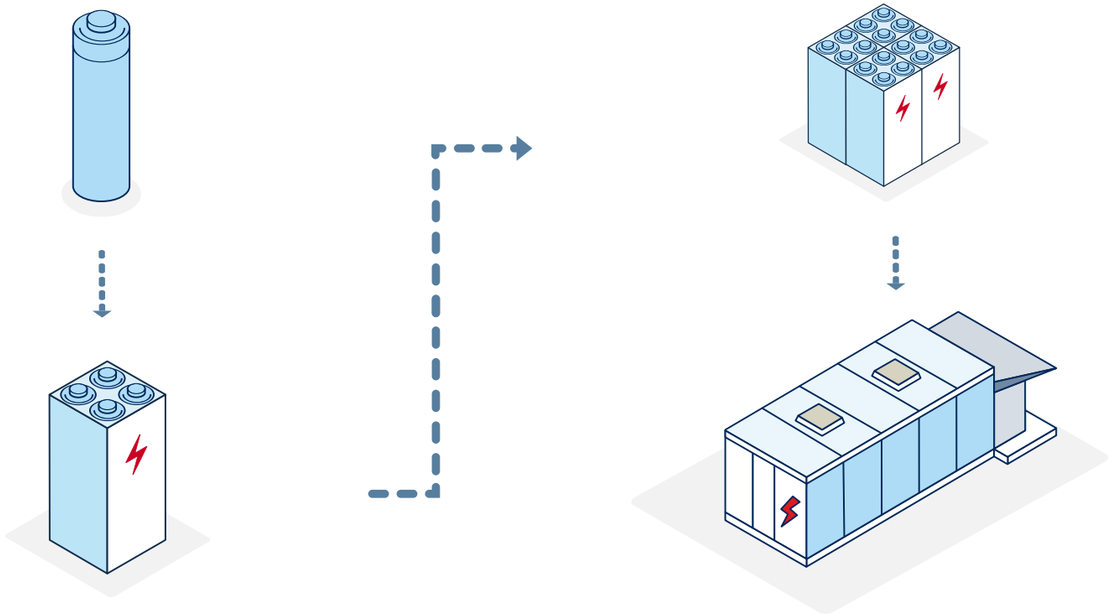
Unit-level test
Unit-level testing evaluates the likelihood of fire spread between modules, the unit's heat and gas release rates, and the potential for deflagration or re-ignition.



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Updates to unit-level testing requirements

Target BESS unit:

- May include one live populated module

Incremental visual reference:

- Is now provided on the instrumented wall sections for scale so that flame extension can be accurately measured if applicable

Gypsum wall thickness:

- Changed from 16 mm (5/8 in) to minimum 13 mm (1/2 in)

Added additional test termination conditions; one of the following must be met:

- Three consecutive temperature readings that decrease over 15-minute intervals for 10% of the test duration **or**
- Module temperature decreases below 60°C

Revised performance criteria:

- The criteria “accumulation of battery vent gases are not observed,” has been deleted.
- The heat flux limit at the egress only applies to outdoor installations.
- Residential outdoor ground mounted — no flames shall be observed outside the BESS unit.
- Non-residential outdoor installation — criteria related to “Flaming outside the initiating BESS unit” has been deleted.

Indoor floor mounted:

- The wall height changed to not less than 2.13 m (7 ft).
- Heat flux measurement for the egress has been removed.

Indoor wall mounted:

- The NFPA 286 test room was replaced with an instrumented wall not less than 2.44 m (8 ft) in height and width and with a horizontal ceiling 0.3 m (1 ft) wide. The thermocouple array on the walls shall extend to the ceiling surface.

Outdoor wall mounted:

- An optional substrate of 13 mm (1/2 in) or 16 mm (5/8 in) gypsum board is permitted to be added to the plywood test wall.
- Heat flux for the accessible means of egress or in front of the BESS shall be measured.

Outdoor/open parking garage installation:

- Heat flux for egress shall be measured at the minimum horizontal distance from the BESS specified by the manufacturer, but not in the center of the accessible means of egress.

Combustible rooftop installation:

- The BESS shall be mounted on gypsum board, and the roof’s temperature shall be measured under the center of the BESS in locations anticipated to receive the most significant thermal exposure.

Installation beneath photovoltaic (PV) panels or other obstructions:

- The BESS unit is to be tested with it mounted underneath the obstructions as specified by the manufacturer.

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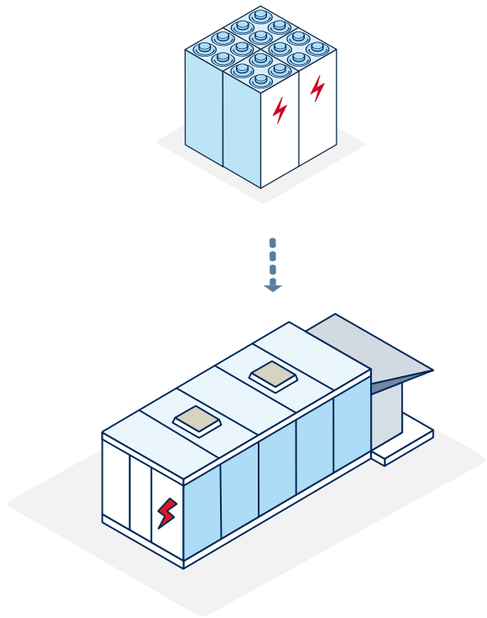

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4

Updates to installation-level testing requirements

Residential BESS:

- Units intended to be installed in residential occupancies other than detached one- or two-family dwellings and townhouses **may additionally** perform the installation level test to determine sprinkler effectiveness.

Performance criteria:

- Observation of reignition within the initiating unit **shall be recorded after the test has concluded and the sprinkler operation has been discontinued.**

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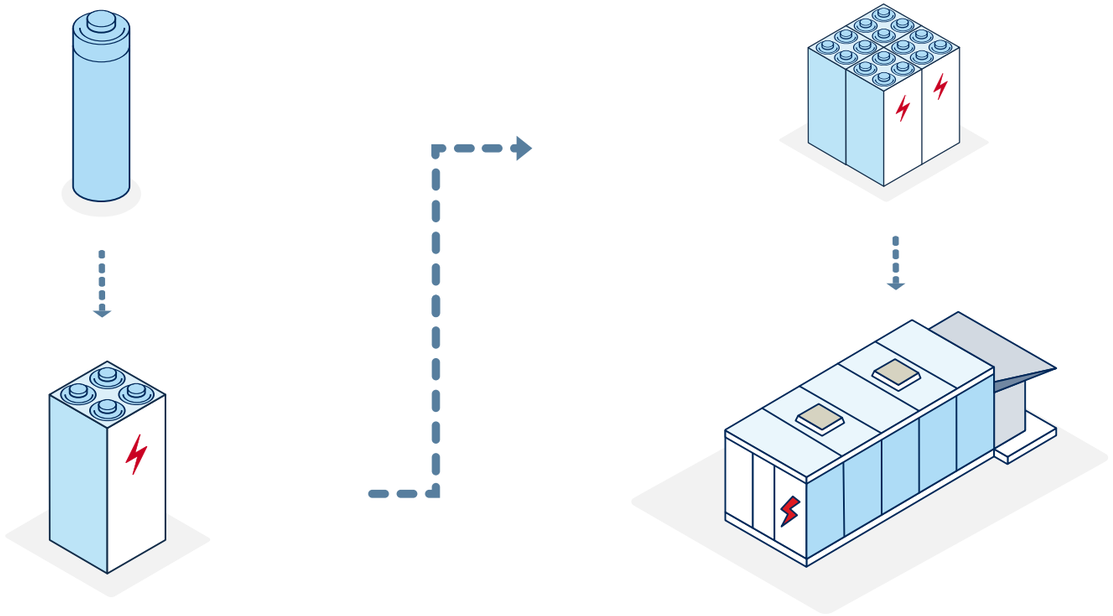

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Updates to the UL 9540A test report

Cell-level test report:

- Removed requirement to include "whether the energy storage system has achieved UL 9540 certification."

Module-, unit-, installation-level test reports:

- **Shall** include a test report summary for previous test levels.

Unit- and installation-level test report:

- **Shall** include the circumstances of test termination.

UL Solutions

CELL LEVEL TEST REPORT
UL 9540A
Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems (ANCI)

Project number	123456789
File number	MH12345
Date of issue	2025-XX-XX
Total number of pages	xx
UL Report Office	UL Solutions
Applicant name	Company A
Applicant address	123 Main St. Anywhere, XX 12345 US
Standard	UL 9540A 2025, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, 5th Edition, March 12, 2025
Test procedure	Section 7
Non-standard test method	N/A

General disclaimer

The test results presented in this report relate only to the sample tested in the test configuration noted.

UL LLC did not select the sample(s), determine whether the sample(s) were representative of production samples, witness the production of the test sample(s), nor were we provided with information relative to the formulation used in the test sample(s).

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Updates to code and standard references within UL 9540A

Codes/standards referencing UL 9540A:

- NFPA 855, IRC and UL 9540 were added

Unit-level test:

- The reference to "the Standard for Fire Suppression Control" has been updated as "UL 864, Control Units and Accessories for Fire Alarm Systems."

Installation level test:

- For flame indicator cables, the reference to "UL 1685" has been replaced with "UL 2556, Wire and Cable Test Methods."

UL 9540A set to advance fire testing standards for energy storage systems with new large-scale test method

In the coming months, UL 9540A is expected to evolve to address large-scale fire testing criteria in NFPA 855. A dedicated task group within the UL 9540A Technical Committee has developed a test method to address the increased demand for robust fire and explosion testing scenarios. The technical committee convened on April 29, 2025, to present and discuss the proposed large-scale fire test method. This preliminary review proposal period was accompanied by weekly open forum discussions among task group members to gain critical insights from key stakeholders including BESS manufacturers, fire service, and code authorities, to refine the proposed test method before it is submitted as a formal ballot in June to be voted on by the entire 150+ member technical committee.

We remain committed to helping battery innovators enhance energy storage design alongside of increased capacity with services to support greater safety, performance and reliability.

“Our committee consists of diverse stakeholders vested in ESS safety, including leading global OEMs, ESS integrators, code authorities, insurance leaders, specialized consultants and testing organizations. We are actively collaborating with the NFPA 855 to align on final requirements. I am confident this task group is producing a quality proposal to revise UL 9540A to address increased requests for large-scale fire testing of energy storage systems that go beyond a single module test.”

Paul Hayes
Chair of **the UL 9540 task group** for large-scale fire testing and vice president energy infrastructure at The Hiller Companies, **a fire protection engineering consultancy**

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