



FEATURE STORY

UL 9540A Battery Energy Storage System (ESS) Test Method

Battery explosions and fires are a serious concern. Fire safety requirements have been updated in the latest model code requirements for ESS installations. Learn about our new full-scale test methods for ESS in UL 9540A.



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In 2015 work began on developing fire safety requirements in U.S. fire codes to address modern energy storage systems (ESS). This effort focused on mitigating the potential hazards of large indoor and outdoor lithium-ion battery ESS installations.

The greatest concern for ESS installations was thermal runaway in a battery module that could propagate to a significant fire or explosion, especially since there were no proven methods for controlling or suppressing a fire or mitigating a potential explosion. At the time there was a lack of research and fire performance data to use as a basis for developing protection solutions.

Size (electrical capacity in a unit), separation and maximum allowable quantity (total electrical capacity in one space) requirements were introduced in the 2018 International Fire Code and the NFPA 1 Fire Code to address uncertainty with thermal runaway and fire propagation of battery ESS. The size and electrical energy density of ESS installations were limited by these requirements. However, the codes allowed ESS installations with larger capacities or smaller separation distances when approved by the code authority using large-scale fire and fault condition testing results from an approved testing laboratory. This testing needed to demonstrate that a fire involving one ESS unit would not propagate to an adjacent unit and would be contained within a battery room.

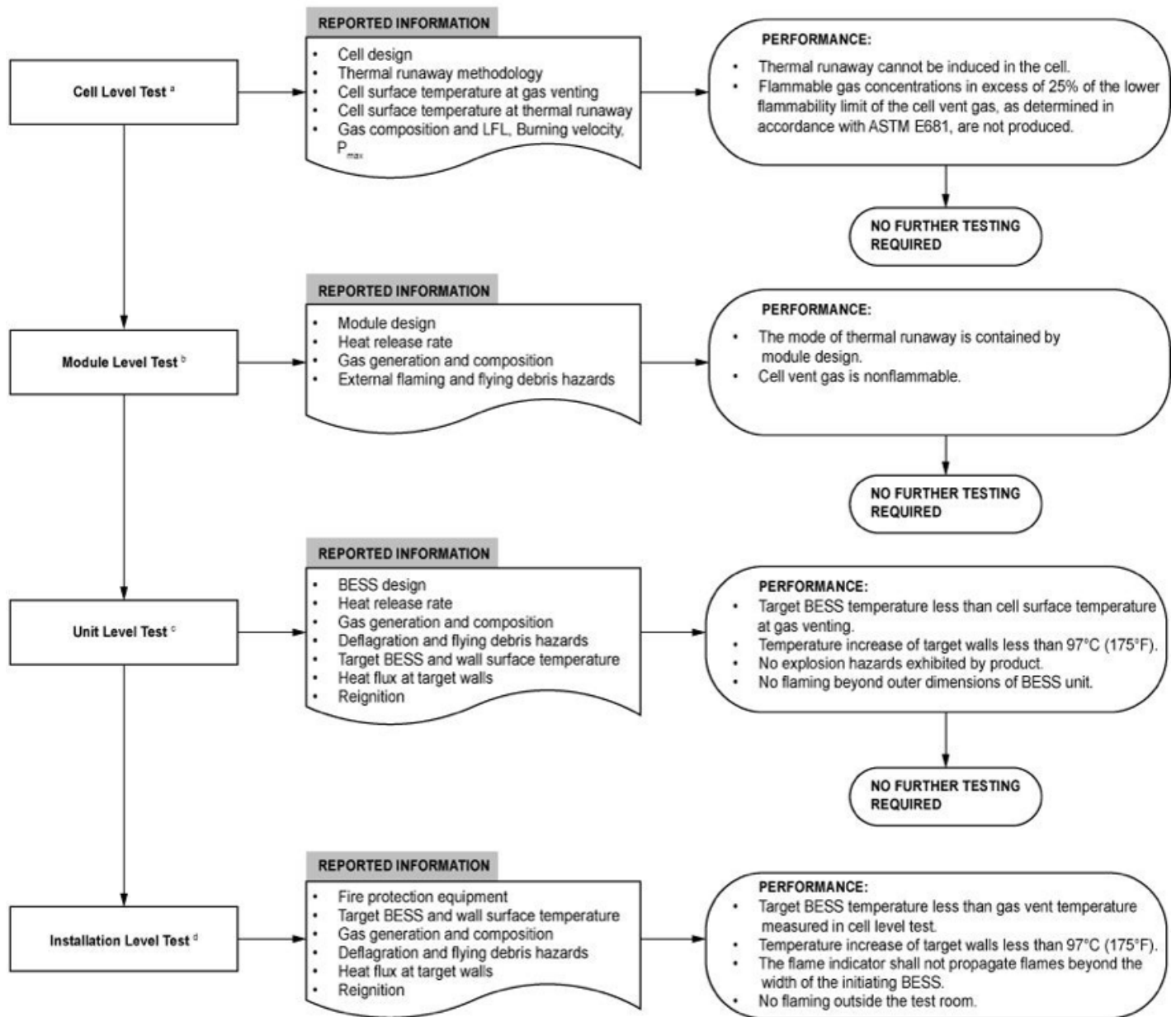
UL stepped up to meet the needs of the ESS industry and code authorities by developing a methodology for conducting battery ESS fire tests by publishing UL 9540A¹, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems in November 2017. The requirements were designed to evaluate the fire characteristics of a battery ESS that undergoes thermal runaway. The data generated was intended to be used to determine the fire and explosion protection required for an installation of a battery energy storage system. It also meets the objectives of the International Fire Code (IFC) and NFPA 1 relative to fire propagation hazards and fire mitigation methods from a single battery energy storage system unit.

UL 9540A included a series of progressively larger fire tests, beginning at the cell level and progressing to the module level, unit level, and finally the installation level. Each test generated specific data used to evaluate thermal runaway characteristics and fire propagation without specific pass/fail test criteria. Instead, the complete data package was provided to code authorities so they could evaluate the suitability of a battery ESS installation.

As fire codes evolved, and UL gained additional experience with battery ESS fire propagation testing, thermal runaway characteristic, and the data needed by code authorities, UL 9540A was updated in rapid succession with a second edition published in January 2018 and a third edition published in June 2018. With the technical foundation for battery ESS large-scale fire testing firmly in place, UL engaged Standard Technical Panel 9540 in 2019 to develop a binational edition of the test method. The fourth edition of ANSI/CAN/UL 9540A was published November 12, 2019 and is an ANSI and SCC (Standards Council of Canada) accredited standard.

A few of the significant changes introduced into the fourth edition of UL 9540A include:

- Criteria introduced to the cell level, module level, and unit level tests that identify when progressively larger tests are unnecessary, essentially establishing acceptance criteria for the tests. The flow chart accompanying this article provides details on the test sequence UL 9540A¹.



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1. Adapted from UL 9540A copyright © 2019 Underwriters Laboratories Inc.

- Enhancements to the unit level test to include specific test criteria for testing indoor floor mounted battery energy storage systems (BESS), outdoor ground mounted BESS, indoor wall mounted BESS and outdoor wall mounted BESS. All of

these types of systems are covered by specific installation requirements in the latest editions of the IFC, NFPA 1 and NFPA 855.

UL 9540A will continue to evolve to reflect changes in ESS installation requirements, advancements in fire science, and the needs of the ESS industry and code authorities. For additional information on UL 9540A, visit [www.UL.com/batteries](https://www.ul.com/batteries).