



UL 9540A

STANDARD FOR SAFETY

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

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

Third Edition, Dated June 15, 2018

Summary of Topics

A third edition has been issued for the Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, UL 9540A. This Test Method evaluates the fire characteristics of a battery energy storage system that undergoes thermal runaway. The data generated will be used to determine the fire and explosion protection required for an installation of a battery energy storage system.

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JUNE 15, 2018

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UL 9540A

Test Method for Evaluating Thermal Runaway Fire Propagation in Battery

Energy Storage Systems

First Edition – November, 2017

Second Edition – January, 2018

Third Edition

June 15, 2018

This Test Method is definitive procedure that produces a test result.

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APPENDIX A

Test Concepts And Application Of Test Results To Installations

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INTRODUCTION

1 Scope

1.1 The test methodology in this document evaluates the fire characteristics of a battery energy storage system that undergoes thermal runaway.

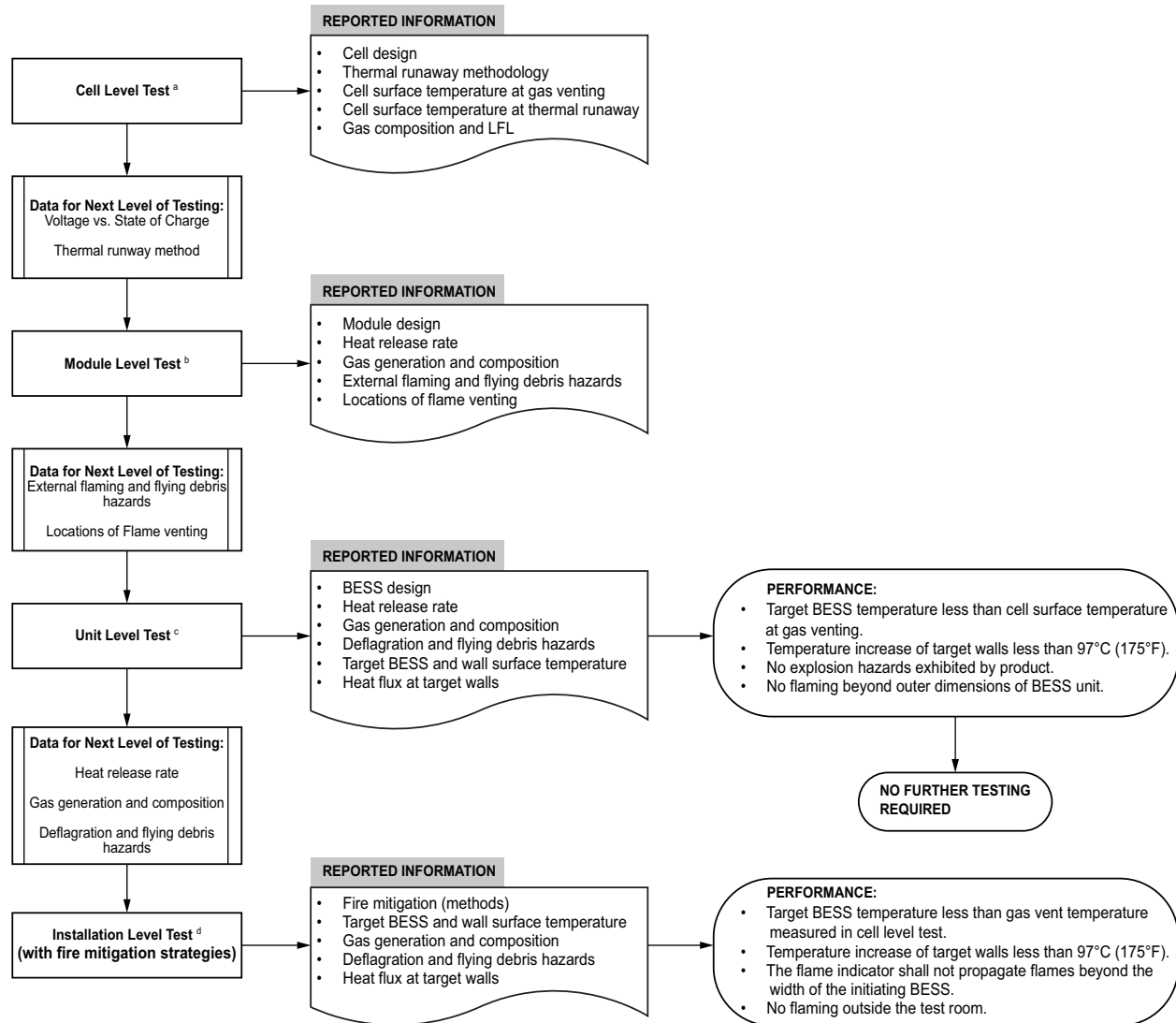
1.2 The data generated will be used to determine the fire and explosion protection required for an installation of a battery energy storage system intended for installation, operation and maintenance in accordance with the International Fire Code (IFC), the Fire Code, NFPA 1, the National Electrical Code, NFPA 70, the National Electrical Safety Code (NESC), IEEE C2, other energy storage system codes, and the manufacturer's installation instructions.

1.3 Fire protection requirements not related to battery energy storage system equipment are covered by appropriate installation codes.

1.4 See Figure 1.1 for a schematic of the test sequence in this document. See Appendix A which explains:

- a) The purpose of the tests included in this Test Method;
- b) Explanation of individual tests; and
- c) Interpretation and application of the results.

Figure 1.1
Schematic of Test Sequence



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^a See Section 6.^b See Section 7.^c See Section 8.^d See Section 9.

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2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values in parentheses are a soft conversion.

3 References

3.1 Any undated reference to a code or standard appearing in the requirements of this Test Method shall be interpreted as referring to the latest edition of that code or standard.

3.2 The following model codes or standards are referenced in this Test Method.

American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)

ASHRAE 34

Designation and Safety Classification of Refrigerants

ASTM International

ASTM E681

Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)

European Standards

EN 15967

Determination of Maximum Explosion Pressure and the Maximum Rate of Pressure Rise of Gases and Vapours

Institute of Electrical and Electronics Engineers (IEEE)

IEEE C2

National Electrical Safety Code (NESC)

International Code Council (ICC)

International Fire Code (IFC)

National Fire Protection Association (NFPA) Codes and Standards

NFPA 1

Fire Code

NFPA 68

Standard on Explosion Protection by Deflagration Venting

NFPA 70

National Electrical Code

NFPA 220

Standard on Types of Building Construction

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UL Standards

UL 1685

Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

UL 1973

Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications

UL 9540

Energy Storage Systems and Equipment

4 Glossary

4.1 For the purpose of these requirements, the following definitions apply.

4.2 BATTERY ENERGY STORAGE SYSTEM (BESS) – Stationary equipment that receives electrical energy and then utilizes batteries to store that energy for later use in order to supply electrical energy when needed. The BESS consists of one or more modules, a power conditioning system (PCS) and balance of plant components.

a) INITIATING BATTERY ENERGY STORAGE SYSTEM UNIT (INITIATING BESS) – A BESS unit which has been equipped with resistance heaters in order to create the internal fire condition necessary for the installation level test (Section 8).

b) TARGET BATTERY ENERGY STORAGE SYSTEM UNIT (TARGET BESS) – The enclosure and/or rack hardware that physically supports and/or contains the components that comprise a BESS. The target BESS unit does not contain energy storage components, but serves to enable instrumentation to measure the thermal exposure from the initiating BESS.

4.3 CELL – The basic functional electrochemical unit containing an assembly of electrodes, electrolyte, separators, container, and terminals. It is a source of electrical energy by direct conversion of chemical energy.

4.4 DUT – Device under test.

4.5 ELECTRICAL RESISTANCE HEATERS – Devices that convert electrical energy supplied from a laboratory source into thermal energy.

4.6 FLEXIBLE FILM HEATERS – Electrical resistance heaters of a film, tape or otherwise thin sheet like construction that easily conform to the surface of cells.

4.7 MODULE – A subassembly that is a component of a BESS that consists of a group of cells or electrochemical capacitors connected together either in a series and/or parallel configuration (sometimes referred to as a block) with or without protective devices and monitoring circuitry.

4.8 STATE OF CHARGE (SOC) – The available capacity in a BESS, pack, module or cell expressed as a percentage of rated capacity.

4.9 THERMAL RUNAWAY – The incident when an electrochemical cell increases its temperature through self-heating in an uncontrollable fashion. The thermal runaway progresses when the cell's generation of heat is at a higher rate than the heat it can dissipate. This may lead to fire, explosion and gas evolution.

4.10 UNIT – A frame, rack or enclosure that consists of a functional BESS which includes components and subassemblies such as cells, modules, battery management systems, ventilation devices and other ancillary equipment.

CONSTRUCTION

5 General

5.1 Cell

5.1.1 The design of the cells associated with the BESS that were tested shall be documented in the test report, including general cell chemistry, the physical format of the cell (i.e. prismatic, cylindrical, pouch), cell electrical rating in capacity and nominal voltage, the overall dimensions of the cell, and weight.

5.1.2 The cell documentation included in the test report shall indicate if the cells associated with the BESS comply with UL 1973.

5.2 Module

5.2.1 The design of the modules associated with an BESS that were tested shall be documented in the test report, including the generic (e.g., metallic or nonmetallic) enclosure material, the general layout of the module contents and the electrical configuration of the cells in the modules and the modules in the BESS.

5.2.2 The module documentation included in the test report shall indicate if the modules associated with the BESS comply with UL 1973.

5.3 Battery energy storage system unit

5.3.1 The BESS unit documentation included in the test report shall include the manufacturer, model and electrical ratings, including energy capacity of BESS units that comply with UL 9540, including certification information.

5.3.2 For BESS units for which UL 9540 compliance cannot be determined, the documentation included in the test report shall include number of modules, electrical configuration of the module, and physical layout of the modules, battery management system (BMS) and other major components of the BESS. The BESS enclosure overall dimensions and generic (e.g., metallic or nonmetallic) material used for the enclosure shall be documented.

5.3.3 The details of any fire detection and suppression systems associated with the BESS shall be noted in the test report.