JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL 5800:2021

STANDARD FOR SAFETY

Battery Fire Containment Products

ANSI/UL 5800-2021

SCC FOREWORD

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UL Standard for Safety for Battery Fire Containment Products, ANSI/CAN/UL 5800

First Edition, Dated December 8, 2020

Summary of Topics

This revision of ANSI/CAN/UL 5800 dated June 16, 2021 has been issued to reflect the latest ANSI and SCC approval dates, and to incorporate the proposals dated April 9, 2021 which include editorial revisions to Clauses 4.2, 8.2.3, 8.2.5, 8.2.6, 8.2.10, Figure 8.1, and Figure 8.2.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated April 9, 2021.

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ANSI/UL 5800-2021

DECEMBER 8, 2020
(Title Page Reprinted: June 16, 2021)

ANSI/CAN/UL 5800:2021

Standard for Battery Fire Containment Products

First Edition

December 8, 2020

This ANSI/CAN/UL Safety Standard consists of the First Edition including revisions through June 16, 2021.

The most recent designation of ANSI/UL 5800 as an American National Standard (ANSI) occurred on June 16, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This standard has been designated as a National Standard of Canada (NSC) on June 16, 2021.

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Preface

This is the First Edition of ANSI/CAN/UL 5800, Standard for Battery Fire Containment Products.

UL is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

This ANSI/CAN/UL 5800 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

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This Edition of the Standard has been formally approved by the UL Standards Technical Panel (STP) on Battery Fire Containment Products, STP 5800.

This list represents the STP 5800 membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

STP 5800 Membership

Name	Representing	Interest Category	Region
Ackerman, Eva	Rectorseal	Supply Chain	USA
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Colton, Bradford	Extinguish Ltd	Producer	USA

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STP 5800 Membership Continued

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Underwriters Laboratories Inc.
171 Nepean Street, Suite 400
Ottawa, Ontario K2P 0B4
Phone: 1-613.755.2729
E-mail: ULCStandards@ul.com
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This Standard is intended to be used for conformity assessment.

The intended primary application of this standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

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INTRODUCTION

1 Scope

1.1 These requirements provide fire test and performance criteria to evaluate fire containment products intended for a battery-powered portable electronic device (PED).

1.2 The containment product may include active fire suppression features without manual intervention beyond arming the suppression agent.

1.3 These requirements cover fire containment products that are intended to be used by a qualified/trained person.

1.4 This standard covers installed and uninstalled lithium ion batteries and cells.

1.5 The fire condition represented by the testing in this standard simulates the ignition of a battery-powered portable electronic device (PED), combustible components, and assemblies associated with the device.

1.6 These requirements cover containment products intended to be used for inhabited aircraft compartments.

1.7 The fire condition represented by this test is limited to devices with electrical energy with a maximum of 300 Wh.

1.8 This standard evaluates the containment product performance from the time that the battery-powered portable electronic device (PED) is inside the containment product which is closed in accordance with the containment product manufacturer's instructions.

1.9 This standard covers containment products to be used for only one thermal runaway event.

1.10 These requirements do not cover fires caused by non-battery operated devices.

1.11 These requirements cover visible smoke, but do not cover the mitigation of gas (toxic, flammable).

1.12 These requirements do not cover containment products intended to be used for cargo protection.

1.13 These requirements do not cover fire containment products with active fire suppression means requiring manual operation beyond arming the suppression agent, such as utilizing separate handheld fire extinguishers.

2 Components

2.1 A component of a product covered by this Standard shall:

a) Comply with the requirements for that component as specified in this Standard;

b) Be used in accordance with its rating(s) established for the intended conditions of use; and

c) Be used within its established use limitations or conditions of acceptability.

2.2 A component of a product covered by this Standard is not required to comply with a specific component requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product;

b) Is superseded by a requirement in this Standard; or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations

2.3 A component not anticipated by the requirements of this end product Standard, not specifically covered by the component standards noted in this Standard, and that involves a risk of fire, electric shock, or injury to persons, shall be additionally investigated in accordance with the applicable UL Standard, and shall comply with 2.4.

2.4 With regard to a component being additionally evaluated, reference to construction and performance requirements in another UL end product Standard is suitable where that Standard anticipates normal and abnormal use conditions consistent with the application of this end product Standard.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Referenced Publications

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

4.2 The following publications are referenced in this Standard:

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 969, *Marking and Labeling Systems*

UL 1439, *Test for Sharpness of Edges on Equipment*

UL 1479, *Fire Tests of Penetration Firestops*

C22.2 No. 0.15, *Adhesive Labels*

EN 12477, *Protective gloves for welders*

NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*

5 Glossary

5.1 For the purpose of this standard, the following definitions apply.

5.2 CLASS RATING – As defined below.

Class	Representative Capacity Lithium Ion (Wh)
1	0 ≤ 60
2	61 ≤ 100
3	101 ≤ 160
4	161 ≤ 300

5.3 COMPONENT – Refers to subassemblies or a single element used in the construction or in the operation of the containment product.

5.4 CONTAINMENT PRODUCT – Refers to the assembly or product, into which the PED is encapsulated to mitigate the effects of a smoke/fire event.

5.5 DEDICATED VENT – Refers to a portion of the outer product enclosure designed for the sole purpose of venting gas. This feature cannot serve dual-purpose as a handle, closure mechanism, or part of the suppression agent delivery system.

5.6 FLAME – A body or stream of gaseous material involved in the combustion process and emitting radiant energy at specific wavelength bands determined by the combustion chemistry of the fuel. In most cases, some portion of the emitted radiant energy is visible to the human eye.

5.7 FREE SPACE – The remainder of stackable space in the plastic enclosure of the fuel load/package after the cells have been inserted.

5.8 FUEL LOAD/PACKAGE – In accordance with the specifications detailed in 8.2.2 – 8.2.8.

5.9 INTUMESCENT MATERIAL – A substance that expands as a result of heat exposure, thus increasing in volume and decreasing in density.

5.10 PORTABLE ELECTRONIC DEVICE (PED) – Any piece of lightweight battery-powered equipment. These devices are typically consumer electronic devices capable of communications, data processing and/or utility. Examples range from handheld, electronic devices such as tablets, e-readers, laptops, and smartphones to small devices such as MP3 players and electronic toys.

5.11 STACKABLE SPACE – Internal volume of an enclosure in which 18650 cells may be stacked together in intimate contact. This space excludes screw bosses, standoffs, and other void spaces that are not large enough to fit one 18650 cell.

5.12 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.

5.13 VISIBLE SMOKE – The airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis, combustion or other thermal or electrochemical process, which can be detected by light obscuration measurements.

CONSTRUCTION

6 General

6.1 The design of a containment product and detail of included operating instructions shall be such that the method of operation is obvious after reading the operating instructions.

6.2 The design of a containment product shall be such that after initial preparation steps are completed, the operator of the containment product is not required to take further manual actions to maintain the performance of the containment product. The containment product shall be entirely operable by one user, without assistance from a second individual.

6.3 The edges and surfaces of all containment products shall not be sufficiently sharp to constitute a risk of injury to persons during intended handling, maintenance, and use.

6.4 Whenever reference measurements are necessary to determine that a part as described in 6.3 is not sufficiently sharp to constitute a risk of injury to persons, the method described in UL 1439 is to be employed.

FIRE PERFORMANCE

7 General

7.1 The manufacturer shall provide a fire containment product with a minimum of the following components present:

a) Containment product representative of the finished product,

b) All peripheral materials or subassemblies required for the end use deployment, and

c) Instructions and safety information.

7.2 The closure mechanism, including but not limited to zippers, flaps, mechanical latches, etc. shall be installed as intended for proper use of the finished product.

7.3 The containment product assembly shall be documented in the test report in accordance with 9.2.

8 Containment Test

8.1 Test equipment and instrumentation

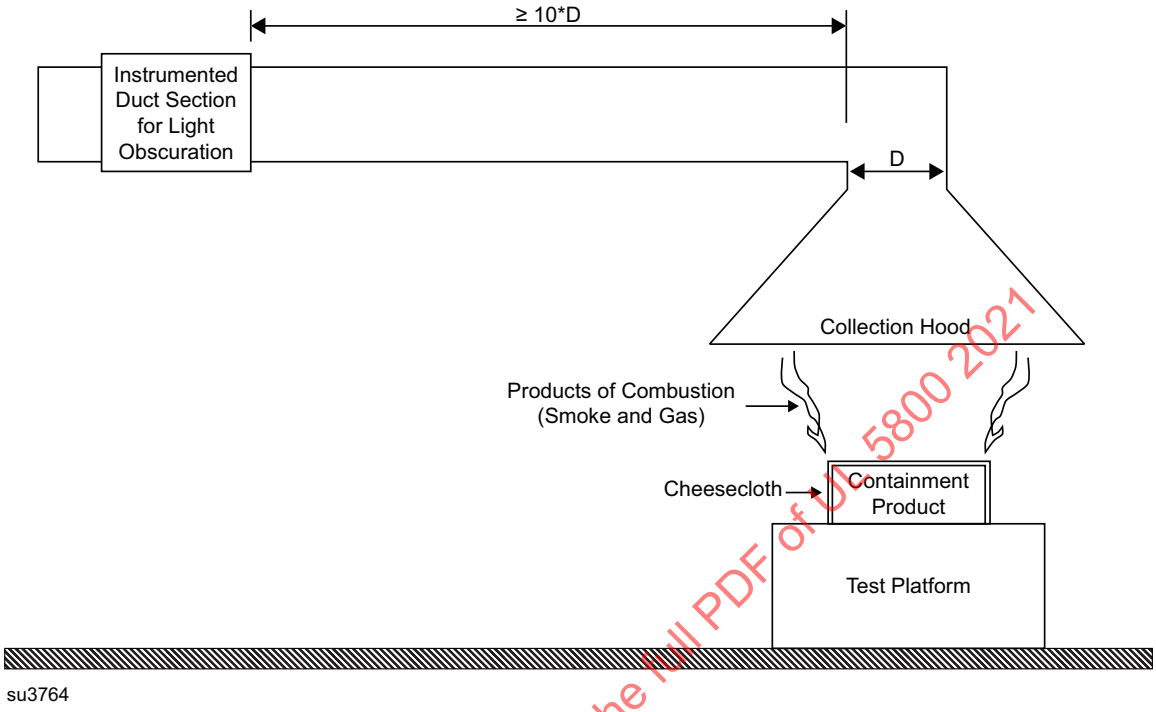
8.1.1 The requirements of 8.1.2 and 8.1.12 shall be met for containment products evaluated to Performance Level 1 (as described in 8.5.3) and Performance Level 2 (as described in 8.5.4). The requirements of 8.1.3 through 8.1.11 shall be met only for containment products evaluated to Performance Level 2 (as described in 8.5.4).

8.1.2 A laboratory suitable to conduct fire tests, shall be free of direct drafts with a ventilation hood for combustion products.

8.1.3 The collection hood for products of combustion is to be installed centrally above the test specimen. The lower edge of the collection hood is to be positioned so that the hood collects all products of combustion, as illustrated in Figure 8.1.

Figure 8.1

Test Setup



Key

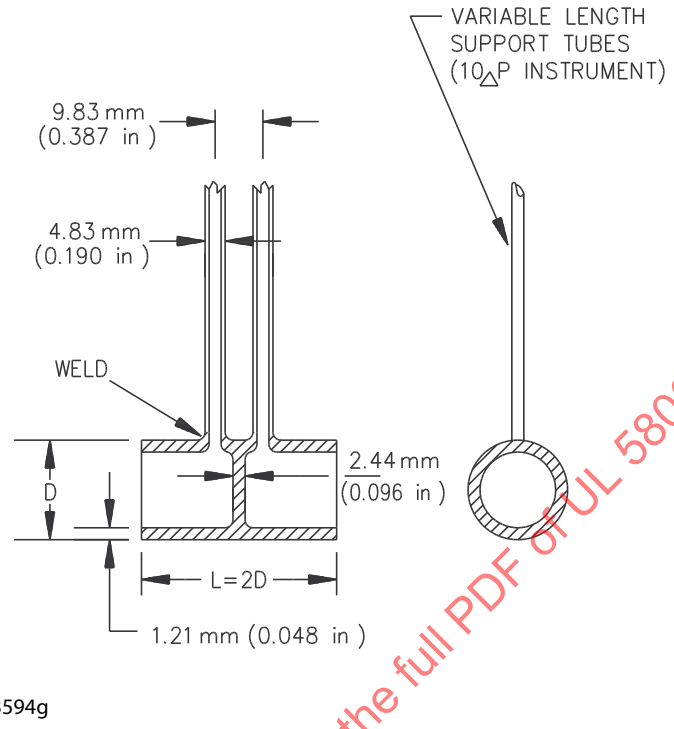
D = diameter of the duct

8.1.4 The duct of the collection hood is to run horizontally at least 10 times the duct diameter downstream from the last turn in the duct prior to location of instrumentation, in order to provide for a fully developed turbulent gas flow. Mixing vanes are to be installed in the duct if concentration gradients are found to exist.

8.1.5 The velocity in the exhaust duct is to be determined by measuring the differential pressure in the flow path with the use of a bidirectional probe as shown in Figure 8.2, connected to an electronic pressure gauge or an equivalent measuring system. The probe is to consist of a stainless steel cylinder with a solid diaphragm in the center that divides the probe into two chambers. The probe is to have a cylinder length nominally two times its outside diameter, with a minimum length of 25 mm (1.0 in) and a maximum length of 50 mm (2.0 in). The pressure taps on either side of the diaphragm are to support the probe.

Figure 8.2

Example of Bidirectional Probe



Key

D = probe outside diameter

L = probe length

8.1.6 The axis of the probe is to be located at the approximate centerline of the duct a minimum of 10 times the duct diameter downstream from the last turn in the duct. The probe shall not be positioned at other locations except where the alternative position has been shown to provide equivalent results. The pressure taps are to be connected to a pressure transducer with a minimum resolution of 0.25 Pa (0.001 inch water).

8.1.7 The temperature of the exhaust gas is to be measured at the approximate same location as the probe at the centerline of the duct with a 0.08 mm^2 (28 AWG) Type K thermocouple with an inconel sheath.

8.1.8 The light transmission in the exhaust duct shall be measured using a white light source and photo detector for the duration of the test, and the smoke release rate and total smoke release shall be calculated. See 8.1.9 and 8.1.10.

8.1.9 Smoke release rate shall be calculated as follows:

$$SRR = 2.303\left(\frac{V}{D}\right)Log_{10}\left(\frac{I_0}{I}\right)$$

Where

SRR = Smoke release rate (m^2/s)

V = Volumetric exhaust duct flow rate (m^3/s)

D = Duct diameter (m)

I_0 = Light transmission signal of clear (pre-test) beam (V)

I = Light transmission signal during test (V)

8.1.10 Total smoke release shall be calculated as follows:

$$TSR = \int_{t_0}^{t_{end}} SRR dt$$

Where

TSR = Total smoke released during test duration (m^2)

SRR = smoke release rate (m^2/s)

t_0 = Time of first thermal runaway event (s)

t_{end} = Time of test termination (s)

A measurement of the light transmission across the duct may be taken at the conclusion of the test once the laboratory air has been ventilated of smoke. This value may be taken into account for the totalization of smoke release rate.

8.1.11 Linearity of the photometer system is to be verified by interrupting the light beam with multiple calibrated neutral density filters to cover the range of the recording instrument. Transmittance values measured by the photometer, using neutral density filters, are to be within ±3% of the calibrated value for each filter.

8.1.12 A data acquisition system is used to collect pressure, temperature, and smoke measurements. The speed and capacity of the data system shall be sufficient to collect the data every 1 s or less.

8.2 Sample preparation

8.2.1 The containment product shall be pre-conditioned for at least 24 h at 20 ±5°C and less than or equal to 55% relative humidity. The fire test shall be conducted within 1 h after removing the test article from the conditioning environment.

8.2.2 A fuel load/package representative of the product's intended containment capacity and classification shall be prepared in accordance with Table 8.1 and details provided in 8.2.3 – 8.2.8.

Table 8.1
Fuel Load/Package Details

Class	Representative capacity (Wh)	Number of cells	Cell	Cell configuration (see Figure 8.3)	Maximum free space (see 5.7)
1	0 ≤ 60	5	18650 format 3300 mAh	2 rows	1 cell
2	61 ≤ 100	9	18650 format	2 rows	2 cell

Table 8.1 Continued on Next Page

Table 8.1 Continued

Class	Representative capacity (Wh)	Number of cells	Cell	Cell configuration (see Figure 8.3)	Maximum free space (see 5.7)
			3300 mAh		
3	101 ≤ 160	14	18650 format 3300 mAh	2 rows	2 cell
4	161 ≤ 300	25	18650 format 3300 mAh	3 rows	4 cell

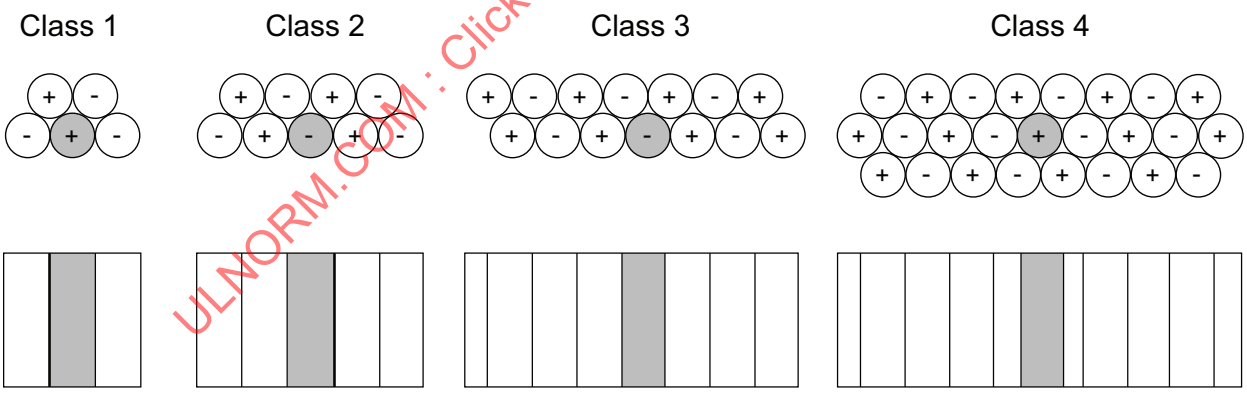
8.2.3 Cells utilized in the fuel load/package shall be lithium ion 18650 format (nominal 18 mm diameter, 65 mm length) with capacity of 3400 ±100 mAh. All cells shall be charged to 100% state of charge (SOC). Cells shall not be electrically connected. The rated capacity of each cell shall be verified prior to testing. See Annex B, Cell Capacity Check Procedure.

8.2.4 Cell layout shall be evenly divided into two or three rows (see Table 8.1 and Figure 8.3). Cells shall be held in direct thermal contact with each other to enable for cell-to-cell propagation of thermal runaway. Cells shall be bundled together with a single layer of adhesive polyimide or glass cloth tape to maintain direct thermal contact during heating. Cells shall not be constrained in a way that prohibits ejection of cells from the fuel load/package during and after thermal runaway.

8.2.5 One flexible film heater having a rating of 10 W/in^2 and covering a majority of the cell surface shall be wrapped around one cell located centrally in the middle or bottom row, as highlighted in Figure 8.3. One Type K thermocouple, 0.21 mm^2 (24 AWG) or 0.05 mm^2 (30 AWG), shall be attached to the cell surface using polyimide tape, or equivalent, to monitor temperature on the initiating cell.

Figure 8.3

Cell Stacking and Fuel Load/Package Configuration



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8.2.6 One Type K thermocouple, 0.21 mm^2 (24 AWG) or 0.05 mm^2 (30 AWG), shall be attached to the cell surface using polyimide tape, or equivalent, on at least one cell at each end of the fuel load/package to monitor for cell-to-cell propagation.

8.2.7 The cells shall be contained within a UL 94 HB rated ABS plastic enclosure with a nominal thickness of 3 ±1 mm (0.12 ±0.04 in). Commercially available enclosures may be used and features such as external flanges, screw boss, standoffs, elastomeric seals, metal fastening screws, and discreet areas that may exceed 4 mm (0.16 in) in thickness shall be acceptable. Sealant material capable of withstanding

conditions anticipated inside the fuel load/package shall be applied around the opening where thermocouple and heater wires exit the fuel package such that the enclosure shall be watertight prior to thermal runaway initiation.

8.2.8 The enclosure shall be appropriately sized to accommodate the stackable space for the Class and quantity of cells. The maximum free space shall not exceed the limitations for each Class as described in Table 8.1. Filler material shall not be used to meet the requirement.

8.2.9 The fuel load/package shall be placed inside the containment product and secured in accordance with the containment product manufacturer's instructions. Any procedural steps or features considered optional in the provided instructions shall not be included or applied during the containment test procedure. If a modification to the containment product is needed to accommodate instrumentation wire passthroughs, the opening shall be sealed such that gases do not escape from the opening during testing.

8.2.10 The 0.21 mm^2 (24 AWG) or 0.05 mm^2 (30 AWG) Type-K exposed junction thermocouples shall be adhered with polyimide tape, epoxy, room-temperature vulcanizing silicone, or equivalent, to the containment product's surface in locations evenly spaced, with a density not less than 1 thermocouple per 232.3 cm^2 (36 in^2) of surface area. At least one thermocouple shall be placed on both the containment product's exterior surface directly above and below the location of the fuel load/package within the containment product. Additional thermocouples shall be placed in other locations as determined appropriate, such as dedicated vents, openings, handles, latches, or other non-uniform areas.

8.2.11 The containment product shall be oriented so that the largest area of flat surface is in contact with the test surface described in 8.2.12, unless the manufacturer's instructions specify another orientation.

8.2.12 The containment product shall be placed on a softwood surface that has been covered with white tissue paper and then a single layer of cheesecloth in accordance with 8.2.13 is to be loosely draped over the containment product.

8.2.13 The cheesecloth is to be bleached cheesecloth having a density of approximately 26 – 28 m^2/kg mass (14 – 15 yd^2/lbm) and having what is known in the trade as a "count of 32 by 28", that is, for any square centimeter, 13 threads in one direction and 11 in the other direction (for any square inch, 32 threads in one direction and 28 threads in the other direction).

8.3 Test method

8.3.1 Ambient laboratory conditions shall be 20 ±5°C and less than 75% RH.

8.3.2 Temperature and smoke release rate measurements shall be recorded at a minimum rate of 1 sample per second.

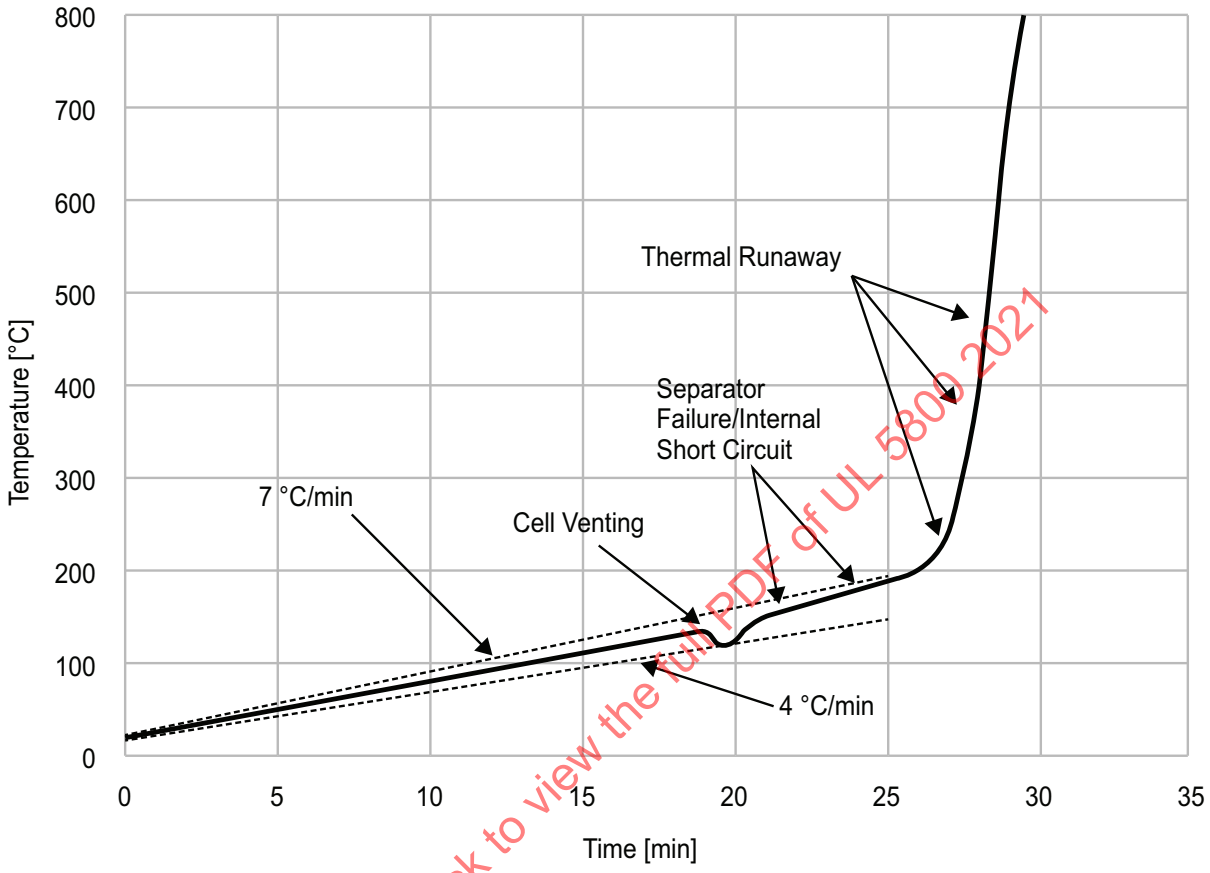
8.3.3 The test shall begin when the surrogate fuel load/package is driven to thermal runaway by heating the flexible film heater at a rate of 4 – 7°C/min. Once thermal runaway is initiated the heating device shall be disconnected.

8.3.4 Onset of thermal runaway shall be determined by the point at which the rate of change of the surface temperature of the cell exceeds that of the externally applied heat input. Cell venting may occur first, but it is necessary to continue heating when using the heater method until thermal runaway occurs. See Figure 8.4 for an illustrative example of a temperature curve of a cell that has undergone thermal runaway. If there is a transitory temperature dip during the cell venting, the heat input may need to be increased to bring it back to the heating rate range.

NOTE: As defined in 5.12, thermal runaway is a condition where there is heating of the cell in an uncontrolled manner and should not be confused with overheating leading to venting only.

Figure 8.4

Illustrative Example of a Thermal Runaway Temperature Curve



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8.3.5 The data collection shall continue for 6 h from the first thermal runaway event, unless all cells in the fuel load/package have undergone thermal runaway and temperatures measured on the cells return to 40°C (104°F).

8.3.6 Three tests shall be conducted. Each test shall be conducted with a new containment product. If any of the three consecutive tests do not meet the acceptance criteria outlined in 8.5, the test program shall be terminated.

8.4 Aging Test

8.4.1 If the containment product includes intumescent material or other materials that change chemical composition as a result of environmental aging, the Environmental Exposure Testing included in UL 1479 shall be applied.

8.5 Acceptance criteria

8.5.1 All three tests shall meet the performance criteria outlined in 8.5.3 or 8.5.4 to achieve that performance level. If a test does not meet 8.5.3(f) or 8.5.4(f), the test shall be repeated and not counted towards the three test requirement.

8.5.2 A containment product is in compliance, if it meets 8.5.3 (Performance Level 1) or 8.5.4 (Performance Level 2) criteria.

8.5.3 A containment product complies with Performance Level 1 if all of the following conditions are met:

a) Flames do not breach the containment product as determined by glowing or igniting of the cheesecloth or tissue paper specified in 8.2.12 and 8.2.13.

b) All visible smoke is confined within the containment product.

c) Shrapnel, sparks or other harmful debris of the test do not escape the containment product.

d) Surface temperatures of the containment product at any location do not exceed those values found in Table 8.2.

e) Compliance with 8.4, as applicable.

f) All cells in the fuel load shall undergo thermal runaway, unless the containment product limits thermal runaway propagation by the design feature of the containment product.

8.5.4 A containment product complies with Performance Level 2 if all of the following conditions are met:

a) Flames do not breach the containment product as determined by glowing or igniting of the cheesecloth or tissue paper specified in 8.2.12 and 8.2.13.

b) No more than 5 m^2 of total smoke is released from the containment product.

c) Shrapnel, sparks or other harmful debris of the test do not escape the containment product.

d) Surface temperatures of the containment product at any location do not exceed those values found in Table 8.2.

e) Compliance with 8.4, as applicable.

f) All cells in the fuel load shall undergo thermal runaway, unless the containment product limits thermal runaway propagation by the design feature of the containment product.

Table 8.2
Maximum Surface Temperatures

Location	Composition of surface[a]			
	Metallic		Nonmetallic	
	°C	(°F)	°C	(°F)
A handle, knob, or surface that is grasped for lifting, carrying or holding.	50	(122)	60	(140)
A surface that may be contacted but does not involve lifting, carrying, or holding.	60	(140)	85	(185)
A dedicated vent.[b]	100	(212)	100	(212)

[a] A handle, knob, or similar part made of a material other than metal, that is plated or clad with metal that is less than or equal to 0.13 mm (0.005 in) thick is determined to be a nonmetallic part.

[b] Dedicated vents shall be marked in accordance with 10.2.1.

9 Report

9.1 The report on testing shall include the following:

a) Product manufacturer name and model designation.

b) General description of the containment product, including dimensions, openings, securement methods and any other features unique to the product's performance and operation.

c) The Class rating and Performance Level.

d) Manufacturer and model designation for the 18650 cell used in the fuel load/package.

e) Measured capacity of each cell used in the fuel/load package.

f) Visual observation and notation of:

1) Flames outside the containment product.

2) Smoke outside the containment product.

3) Breach of the containment product by shrapnel or object (fuel load/package).

4) Observations of the damage to the containment product.

5) Observations of propagation throughout the fuel load/package.

g) Plots of surface thermocouple measurements for the duration of the test.

h) The maximum surface thermocouple measurements.

i) Plots of smoke release rate for Performance Level 2.

j) Total smoke released for Performance Level 2.

k) The time of initiation and termination of the test.

l) Video of the test.

m) Photos of the containment product pre- and post-test.

9.2 As noted in 7.3, the containment product assembly design shall be documented in the test report, which shall include the general construction, size, enclosure material(s), latching / closure system,