JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL 8139:2024

STANDARD FOR SAFETY

Electrical Systems of Electronic Cigarettes and Vaping Devices

Approved American National Standard

ANSI/UL 8139-2024

SCC FOREWORD

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UL Standard for Safety for Electrical Systems of Electronic Cigarettes and Vaping Devices, ANSI/CAN/UL 8139

Second Edition, Dated April 26, 2024

Summary of Topics

This Second Edition of ANSI/CAN/UL 8139 dated April 26, 2024 incorporates editorial changes including renumbering and reformatting to align with current style.

The requirements are substantially in accordance with Proposal(s) on this subject dated September 29, 2023.

No Text on This Page

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ANSI/CAN/UL 8139:2024

Standard for Electrical Systems of Electronic Cigarettes and Vaping Devices

First Edition – April, 2018

Second Edition

April 26, 2024

This ANSI/CAN/UL Safety Standard consists of the Second Edition.

The most recent designation of ANSI/UL 8139 as an American National Standard (ANSI) occurred on April 26, 2024. 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 April 26, 2024.

No Text on This Page

CONTENTS

Preface

This is the Second Edition of the ANSI/CAN/UL 8139 Standard for Safety for Electrical Systems of Electronic Cigarettes and Vaping Devices.

ULSE 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 8139 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.

Annex A, identified as Informative, is for information purposes only.

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 at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

This Edition of the Standard has been formally approved by the Technical Committee (TC) on Electrical Systems of Electronic Cigarettes, TC 8139.

This list represents the TC 8139 membership when the final text in this Standard was balloted. Since that time, changes in the membership may have occurred.

TC 8139 Membership

Name	Representing	Interest Category	Region
Ramon Alarcon	Standards Individuals	General Interest	USA
John Bellinger	Evolv LLC	Producer	USA
Shawn Brueckner	National Research Council of Canada	Government	British Columbia
Douglas Burton	DEVICE SAFETY & RELIABILITY GROUP, LLC	General Interest	USA
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TC 8139 Membership Continued on Next Page

TC 8139 Membership Continued

Name	Representing	Interest Category	Region
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Jonathan Jordan	Engineering Systems INC	General Interest	USA
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Matthew Tyler	ON Semiconductor	Supply Chain	USA
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Jian Yu	Shanghai NEW Tobacco Product Research Institute CO LTD	Producer	China

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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.

INTRODUCTION

1 Scope

1.1 These requirements cover the battery-operated electrical systems that use consumables that may contain varying compositions of flavorings, propylene glycol, glycerin, nicotine, tobacco, cannabis, cannabinoids, or other ingredients, for the generation of directly inhalable aerosols. Examples include but are not limited to vaporizers, vape pens, hookah pens, e-hookah, e-shisha, e-pipes, electronic cigarettes, e-cigarettes and electronic nicotine delivery systems (ENDS), mods, nicotine vapes, heated tobacco products, heat-not-burns, THC vapes, cannabis vapes or carts, dry herb vapes, dabs, concentrates, and other related product types. These systems encompass their charging systems, components, parts and accessories.

1.2 These requirements do not cover the consumables, such as e-liquids and other inhaled aerosol substances, wicks, and other particulate matter inhaled during use, nor do they cover substances in the emissions from the operation of the devices.

NOTE: For example, heavy metal emissions in the aerosol and environmental exposure.

1.3 These requirements do not consider the physiological effects of any consumables used with the devices.

2 Components

2.1 A component that is also intended to perform other functions shall comply additionally with the requirements of the applicable Standard(s) that cover devices that provide those functions.

2.2 A component shall be used in accordance with its rating established for the intended conditions of use.

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

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

b) Is separately investigated when forming part of another component, provided the component is used with its established rating and limitations.

2.4 Components not anticipated by the requirements of this Standard, not specifically covered by a component standard per 2.3, and which pose a potential risk of electric shock, fire or casualty hazard shall be additionally investigated. Reference to other product standards is appropriate where those standards anticipate normal and abnormal use conditions consistent with the application of this Standard.

3 Units of Measurement

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

4 Undated References

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.

5 Referenced Publications

5.1 Any undated reference appearing in the requirements of this standard shall be interpreted as referring to the latest edition of the reference, including all revisions and amendments.

5.2 The following standards are referenced in this standard, and portions of these referenced standards may be essential for compliance.

CSA C22.2 No. 0.17, *Evaluation of Properties of Polymeric Materials*

CSA C22.2 No. 94.2-15, *Enclosures for Electrical Equipment, Environmental Considerations*

CSA C22.2 No. 223, *Power Supplies with Extra-Low-Voltage Class 2 Outputs*

CSA C22.2 No. 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

CSA C22.2 No. 62368-1, *Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements*

CSA E60730-1, *Automatic Electrical Controls, Part 1: General Requirements*

CSA E62133, *Secondary Cells and Batteries Containing Alkaline or Other Non- Acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made From Them, for Use in Portable Applications*

IEC 60529, *Degrees of Protection Provided by Enclosures (IP Code)*

UL 50E, *Enclosures for Electrical Equipment, Environmental Considerations*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 796, *Printed-Wiring Boards*

UL 991, *Tests for Safety-Related Controls Employing Solid-State Devices*

UL 1310, *Class 2 Power Units*

UL 1642, *Lithium Batteries*

UL 2054, *Household and Commercial Batteries*

UL 2089, *Vehicle Battery Adapters*

UL 4200A, *Products Incorporating Button Batteries or Coin Cell Batteries*

UL 60730-1, *Automatic Electrical Controls, Part 1: General Requirements*

UL 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

UL 62133, *Secondary Cells and Batteries Containing Alkaline or Other Non- Acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made From Them, for Use in Portable Applications*

UL 62368-1, *Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements*

6 Glossary

6.1 For the purpose of this Standard the following definitions apply

6.2 AEROSOL – Set of solid or liquid particles in suspension in a gaseous medium. [SOURCE: IEV 395-02-30]

6.3 BATTERY – Assembly of single cell or multiple cells ready for use as a source of electrical energy characterized by its voltage, size, terminal arrangement, capacity and rate capability. A battery may also incorporate protective devices, battery management controls, charging circuits, and monitoring circuitry. A battery may be removable by the user for charging separately from the device or as an integral part of the device. [SOURCE: IEC 62133-2:2017, 3.14, modified]

6.4 BATTERY COMPARTMENT – A cavity or recess intended for battery insertion for electrical contact for charging and/or use.

6.5 BATTERY SYSTEM – A combination of a battery, battery charger, charging interface (if provided), and monitoring and protection circuits.

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

6.7 CHARGING INTERFACE – An assembly used to hold a device or a removable battery for connection to a charging system.

6.8 CONSUMABLE – A solid substrate or receptacle containing a substrate, intended to be used in combination with a device to generate an inhalable aerosol, and which is consumed or depleted through single or multiple use.

6.9 E-LIQUID – Liquid or gel consumable intended for transformation into an aerosol and then inhaled by the user.

6.10 ELECTROLYTE LEAKAGE – A condition where liquid electrolyte escapes through an opening in a designed vent as well as through a rupture or crack or other unintended opening and is visible external to the battery.

6.11 ENCLOSURE – The outer cover of a device that provides protection to its contents.

6.12 END OF DISCHARGE VOLTAGE – The voltage, under load, of the cell or battery at the end of discharge. This value may be specified by the cell manufacturer, as in the case of a voltage terminated discharge, or simply measured in the case of a time-controlled discharge.

6.13 FIRE – The sustained combustion of the battery contents as evidenced by flame, heat and charring or other damage of materials.

6.14 FULLY CHARGED – A battery that has been charged per the cell manufacturer's specifications to its full state of charge.

6.15 FULLY DISCHARGED – A battery that has been discharged according to the cell manufacturer's specifications until the device is no longer operable.

6.16 LOAD – Device intended to absorb power supplied by another device or an electric power system. [SOURCE: IEV 151-15-15]

6.17 NORMAL OPERATING REGION – That region of voltage, current and temperature within which a cell can be appropriately charged and discharged repetitively throughout its anticipated life. See Figure 6.1. These values are then used in the investigation of the device and may vary as the device ages. The normal operating regions will include the following parameters for charging and discharging:

a) CHARGING TEMPERATURE LIMITS – The upper and lower limits of temperature, specified by the cell manufacturer for charging of the cell.

b) DISCHARGE TEMPERATURE LIMITS – The upper and lower limits of temperature, specified by the cell manufacturer for discharging the cell.

c) END OF DISCHARGE VOLTAGE – See 6.12.

d) MAXIMUM CHARGING CURRENT – The maximum charging current in the normal operating region, which is specified by the cell manufacturer. This value may vary with temperature.

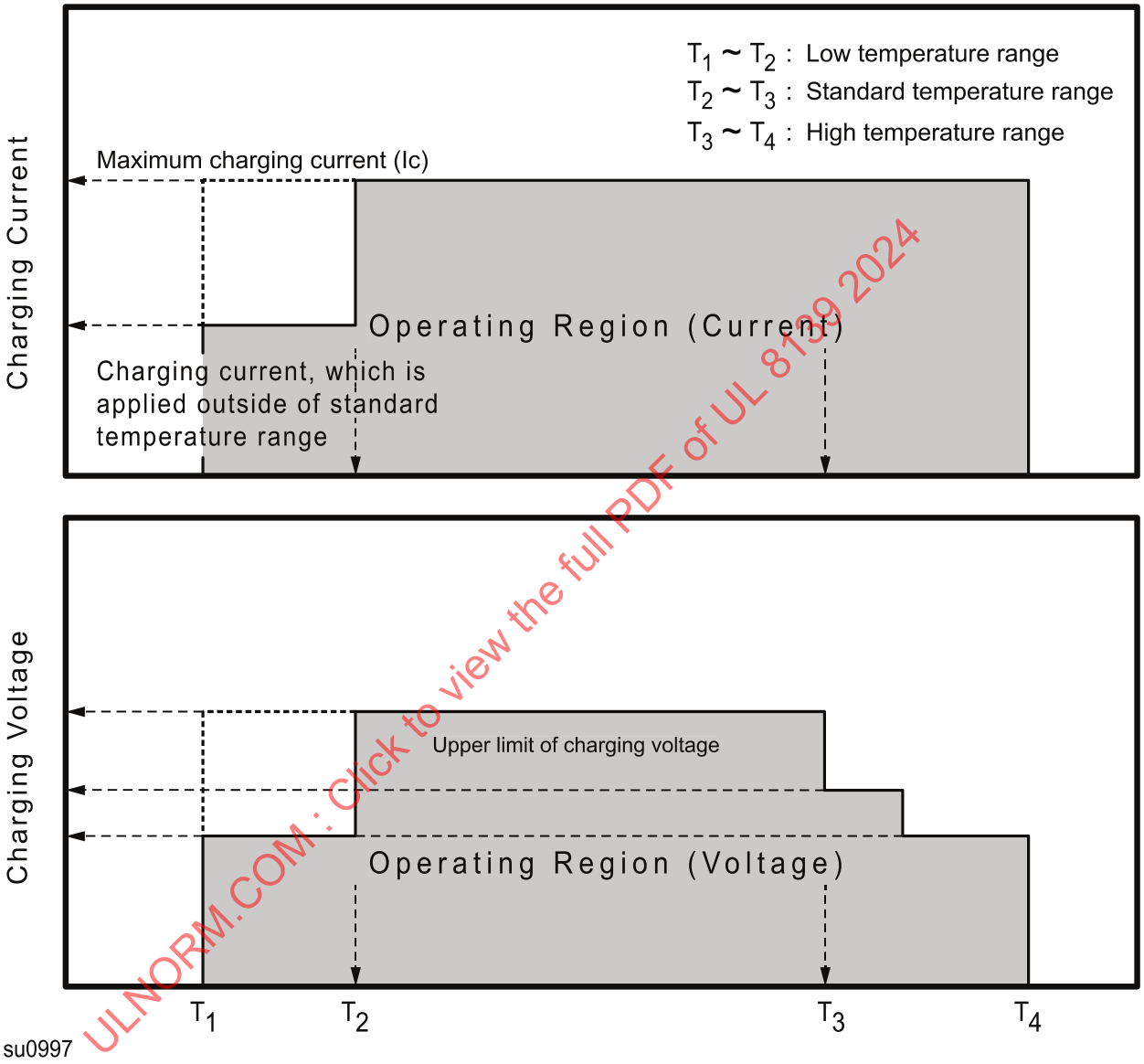
e) MAXIMUM DISCHARGING CURRENT – The maximum discharging current rate, which is specified by the cell manufacturer.

f) UPPER LIMIT CHARGING VOLTAGE – The highest charging voltage limit in the normal operating region specified by the cell manufacturer. This value may vary with temperature.

Figure 6.1

Diagram Representing an Example of a Cell Charging Region

(from the Battery Association of Japan)



6.18 POWER SUPPLY – Electric energy converter which draws electric energy from a source and supplies it in a specified form to a device. [SOURCE: IEV 151-13-76, modified]

NOTE: In the sense of this Standard, power supplies may be referred to as battery chargers, vehicle battery adapters, USB, wireless chargers, etc., that supply the devices and/or their batteries.

6.19 PUFF DURATION – Interval of time, measured in seconds, during which the aerosol intake port of the machine is pneumatically connected to the suction mechanism of the machine.

6.20 PUFF PERIOD – Time between the start of one puff and the start of the subsequent puff measured in seconds.

6.21 PUFF VOLUME – Volume drawn by the machine at the mouth end of the device, as determined at the port of the machine in series with a device pressure drop of 1000 Pa ±50 Pa.

6.22 REFERENCE TEST CURRENT, I_t – charge or discharge current expressed as a multiple of I_t A, where I_t A = C_5 Ah/1 h, as defined in Secondary cells and batteries containing alkaline or other non-acid electrolytes – Guide to designation of current in alkaline secondary cell and battery standards, IEC 61434should this IEC reference be included in the "Referenced Publications section, and based on the rated capacity (C_5 Ah) of the cell or battery. (SOURCE: Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems, IEC 62133-2:2017, 3.18)

6.23 RUPTURE – An unintended mechanical failure of a battery, other than venting, from either internal or external causes, that results in spillage and/or exposure of internal contents including explosion.

6.24 THERMISTOR – Resistor having a large non-linear temperature coefficient of resistance. Thermistors are mainly of two types, NTC (negative temperature coefficient) and PTC (positive temperature coefficient). As temperature rises, NTC thermistor decreases its resistance while PTC thermistor increases its resistance. (SOURCE: IEV 521-04-22, modified)

6.25 VENTING – When the battery or cell electrolyte is emitted as a liquid, droplets, or vapor from a designed vent or through a seal intended to preclude rupture.

CONSTRUCTION

7 Enclosures

7.1 The enclosure of the device or charger interface shall have the strength and rigidity required to resist the possible physical abuses that it will be exposed to during its intended use, in order to reduce the risk of fire, rupture, or injury to persons.

7.2 A non-metallic material serving as an enclosure of the device shall comply with CSA C22.2 No. 0.17, or UL 746C, and shall have:

a) Flammability with a minimum rating of V-2 or comply with the test, Flammability – 20 mm (3/4-inch) Flame, in UL 746C;

b) Mechanical Relative Thermal Index (RTI) suitable for the application;

c) Resistance to Moisture Ingress with a minimum IP rating of IPX4 with the consumable loaded, see the Water Exposure Test, Section 28;

d) Resistance to Impact with the consumable loaded, see the Drop Test, Section 29;

e) Crush Resistance not less than 45.4 kg (100 lbs) with the consumable loaded, see the Crushing Resistance Test, Section 30; and

f) Resistance to Mold Stress Relief Distortion in accordance with the Mold Stress-Relief Distortion Section of CSA C22.2 No. 0.17 and UL 746C.

Exception No. 1: Flammability (a) and mechanical RTI (b) do not apply to non-metallic materials and mouthpieces that are part of, or in contact with, consumables.

Exception No. 2: This does not apply to small combustible parts with a mass less than 4 g (0.14 oz) or with a volume less than 1750 mm^3 (0.11 in^3).

7.3 A metallic material serving as an enclosure of the device shall comply with 7.2 (c), (d) and (e).

7.4 A non-metallic material serving as an enclosure of a charger interface shall comply with 7.2, except for (c).

7.5 When button or coin cell batteries are used, the enclosure shall comply with UL 4200A.

8 Resistance to Corrosion

8.1 Metallic parts shall be corrosion resistant. A suitable plating or coating process fulfills corrosion resistance. Additional guidance on methods to achieve corrosion protection can be found in CSA C22.2 No. 94.2-15 / UL 50E.

8.2 All electrically conductive surfaces in contact at terminals, connectors and connections shall not be subject to corrosion due to electrochemical action.

8.3 Compliance is checked by:

a) The Table of Electrochemical Potentials, Annex J of CSA C22.2 No. 60950-1 / UL 60950-1; or

b) The Electrochemical Potentials (V), Annex N of CSA C22.2 No. 62368-1 / UL 62368-1.

NOTE: Corrosion due to electrochemical action between dissimilar metals that are in contact is minimized if the combined electrochemical potential is below about 0.6 V. Combined electrochemical potentials above the dividing line should be avoided.

9 Current Carrying Parts

9.1 Electrical connections shall be reliable and suitable for the application under normal use and foreseeable misuse specified in this Standard.

9.2 An external terminal of the device, battery, charger, charger interface, or other accessory shall be designed to prevent inadvertent shorting, reverse polarity, and misalignment. In addition to the constructional measure, the inadvertent shorting of external terminals may be addressed by carrying out the Short Circuit Test, Section 25.

9.3 Internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of excessive strain on wire and on terminal connections; loosening of terminal connections; and damage of conductor insulation. For soldered terminations, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering alone to maintain the conductor in position.

9.4 A hole by which insulated wires pass through a metal wall shall be provided with a smoothly rounded bushing or shall have smooth surfaces, free of burrs, fins, sharp edges, and the like, upon which the wires may bear, to prevent abrasion of the insulation.

9.5 During and after the performance tests in Sections 19 – 32, where applicable, no loosening or disconnecting of electrical connections shall occur.

10 Power Supplies

10.1 Power supplies that are intended to charge the battery systems of the devices shall comply with:

a) CSA C22.2 No. 60950-1 / UL 60950-1; or

b) CSA C22.2 No. 62368-1 / UL 62368-1; or

c) UL 1310 or CSA C22.2 No. 223; or

d) UL 2089.

NOTE: Examples include but are not limited to battery chargers, vehicle battery adapters, USB chargers and wireless chargers.

10.2 The outputs of the power supplies shall comply with at least one of the following:

a) A Limited Power Source (LPS) as described in CSA C22.2 No. 60950-1 / UL 60950-1 or CSA C22.2 No. 62368-1 / UL 62368-1; or

b) A Power Source Class 2 (PS2) as described in CSA C22.2 No. 62368-1 / UL 62368-1; or

c) A Class 2 Output as described in UL 1310; and CSA C22.2 No. 223.

10.3 Cable assemblies or wiring with lengths external to the unit not exceeding 3.05 m (10 feet), coiled or uncoiled, shall be constructed of materials rated VW-1 or FT-1 or better.

10.4 A charging interface shall be subjected to the applicable requirements in this Standard when tested as an integral part of the complete electrical system. A charging interface shall comply with the applicable requirements in this Standard or with one of the following:

a) CSA C22.2 No. 60950-1 / UL 60950-1; or

b) CSA C22.2 No. 62368-1 / UL 62368-1.

11 Battery Compartments

11.1 The battery compartment shall be so designed as to only permit insertion of the battery specified by the manufacturer.

Exception: This does not apply to a device for which the batteries are an integral part of the device and therefore are not intended to be replaceable.

11.2 The battery compartment shall be so designed as to prohibit direct replacement of cells.

12 Cells

12.1 Cells shall comply with at least one of the following:

a) UL 1642; or

b) UL 2054; or

c) CSA E62133 / UL 62133.

13 Protection Against Accidental Activation

13.1 A protective means shall be incorporated to reduce the likelihood of accidental activation, unless the device creates no hazards in the sense of this Standard when accidentally activated.

13.2 An acceptable protective means includes, but is not limited to, the following:

a) A manually activated constant pressure switch which cannot be activated by a cylindrical rod with a diameter of 40 mm (1.6 inches) and a hemispherical end, by a force not exceeding 5 N (1.12 lbf); or

b) An activation mechanism which requires the application of a minimum of two independent and simultaneous movements, and resets the device to off-state after each operation; or

c) An activation mechanism which requires a particular action to be repeated for a minimum of two times in succession (for example, press the same button for at least three times) within 2 seconds and resets the device to off-state after each operation; or

d) Any protective means provided that the device complies with Continuous Operation, Section 27; or

e) An activation mechanism that requires a minimum airflow of 5 ml/s.

14 Venting Mechanism

14.1 The device shall incorporate a reliable venting mechanism that channels the pressure wave in the direction where the harm is minimized.

14.2 The device shall comply with the Venting Test, Section 31.

15 Printed Wiring Boards

15.1 Printed wiring boards shall comply with UL 796, for a minimum flame rating of V-1 and maximum operating temperature suitable for the application as determined by the Temperature Test, Section 26.

16 Protective Circuits and Controls

16.1 A cell shall be protected against overcharge and overdischarge (resulting from anticipated normal and abnormal use and conditions including component faults in any control system) and short circuit conditions.

16.2 If the specified operating limits are outside of the normal operating region, the protective circuit shall limit or shut down the charging or discharging of a battery to prevent excursions beyond these operating limits.

16.3 Protective circuits and controls of the device, battery, power supply and any other associated parts shall withstand their respective single fault conditions specified in Section 18 without resulting in any consequences noted in Table 17.1.

PERFORMANCE

17 General

17.1 Each test shall not result in any of the consequences noted in Table 17.1.

NOTE: Examples of temperature measurements include but are not limited to the surface of the cell, touchable surfaces, and components, especially those close to the heating elements.

Table 17.1
Test Summary

Test	Section	Sample size[1]	Ambient[2,6]	Consequence[3,4,5]
Normal Charge	19	5	0, T_{hac}	ABCDEFGM
Normal Charge, Fault[4]	19	–	0, 25	ABCDEFG
Normal Discharge	20	5	-20, T_{had}	ABCDHIJM
Normal Discharge, Fault[4]	20	–	-20, 25	ABCDHIJ
Forced Discharge	21	2	-20, 25	ABCDI
Forced Discharge, Fault[4]	21	–	-20, 25	ABCD
Imbalanced Charging	22	2	0, 25	ABCDF
Imbalanced Charging, Fault	22	–	0, 25	ABCD
Overcharge	23	5	0, 25	ABCDEF
Overcharge, Fault[4]	23	–	0, 25	AB
Abnormal Charging	24	5	0, 25	ABCDEG
Abnormal Charging, Fault[4]	24	–	0, 25	ABCD
Short Circuit	25	5	-20, 25	ABCDI
Short Circuit, Fault[4]	25	–	-20, 25	ABCD
Temperature	26	1	25	See Section 26
Continuous Operation	27	1	25	See Section 27
Water Exposure	28	1	25	ABCD
Drop	29	5	-35	ABCDKL
Crush	30	1	25	ABCDEK
Venting	31	1	25	See Section 31
High Heat	32	1	80	ABCD

[1] The number of separate samples needed for a particular test except for single fault conditions. The sample size for single fault conditions is the number of single fault conditions found to be appropriate.

[2] The test shall be conducted at each ambient indicated, the sample should be kept at the stated temperature for a minimum of 4 hours unless the temperature is monitored and the criteria of thermal equilibrium are met. If the device is not operable under low ambient [for example, minus 20 °C (minus 4 °F)], the test is repeated at the lowest operating ambient temperature specified by the manufacturer. At the manufacturer's discretion, a sample tested for an ambient temperature may be tested again for the other ambient temperature.

minus 35: Not higher than minus 35 °C (minus 31 °F)

minus 20: Not higher than minus 20 °C (minus 4 °F)

0: Not higher than 0 °C (32 °F)

25: 25 ±5 °C (77 ±9 °F)

[3] The test shall not result in any of the consequence identified as follows:

Table 17.1 Continued on Next Page

Table 17.1 Continued

Test	Section	Sample size[1]	Ambient[2,6]	Consequence[3,4,5]
A – Fire				
B – Rupture				
C – Electrolyte leakage				
D – Venting				
E – Charging temperature limit exceeding the normal operating region				
F – Upper limit charging voltage exceeding the normal operating region				
G – Maximum charging current exceeding the normal operating region				
H – Discharge temperature limit exceeding cell manufacturer's specification				
I – End of discharge voltage exceeding the maximum or minimum normal operating region				
J – Maximum discharging current exceeds the normal operating region				
K – Cracks or openings in the enclosure in a way that compromises the integrity of enclosure				
L – The relative change in the open circuit voltage difference between the dropped cell and the reference (undropped) cell exceeding 5 %, see Section 29				
M – The temperatures measured during the test shall not exceed the limits specified in Table 26.1				
[4] Consequences E, F, G, H, I, and J shall be permitted provided that the device becomes inoperable.				
[5] Consequences E, F, G, H, I and J shall be permitted during the operation of the protective devices, circuits and controls.				
[6] T_{hac} denotes the highest ambient temperature for charging specified by the manufacturer while T_{had} denotes the highest ambient temperature for discharging (or operating) specified by the manufacturer.				

17.2 Each test shall be performed on the number of samples specified in Table 17.1.

17.3 Except where noted otherwise, all tests are conducted in a room ambient of 25 ±5 °C (77 ±9 °F).

17.4 Temperature shall be measured using thermocouples consisting of wires not larger than 0.21 mm^2 (24 AWG) and not smaller than 0.006 mm^2 (39 AWG) or an equivalently accurate measuring device. For those tests that require the sample to reach thermal equilibrium (also referred to as steady state conditions), thermal equilibrium is considered to be achieved if, after three consecutive temperature measurements taken at intervals of 10 % of the previously elapsed duration of the test, but not less than 15 minutes, indicate no change in temperature greater than ±2 °C (±3.6 °F). Unless noted otherwise, a cell temperature measurement shall be followed by a 1-hour observation time after reaching room temperature of 25 ±5 °C (77 ±9 °F) prior to concluding the test.

17.5 For multicell batteries, individual cell voltages, temperatures, and charging currents shall be monitored. Each cell shall not experience conditions outside of their normal operating region.

17.6 When measuring voltage, the peak value of any superimposed ripple exceeding 10 % of the average value shall be included. Transient voltages are ignored.

17.7 Measurements of cell voltages shall be made using a single pole resistive-capacitive low pass filter with a cut-off frequency of 5 kHz ±500 Hz. If charging voltages have been exceeded, the peak value of the voltage measured after this network shall be used. The measurement shall have measurement tolerance within ±1 %.

17.8 Currents measured during battery charging shall be the average current with a data collection rate of 1 Hz or greater.

17.9 For a battery design where there is a series arrangement of parallel clusters of cells, the cluster shall be treated as a single cell for those tests that require altering the amount of charge on a single cell prior to conducting the test.

17.10 Risk of fire is determined by performing the test with the device under test covered with cheesecloth consisting of bleached cotton, with a fabric mass of 35.7 g/m^2 to 38.5 g/m^2 (approximately 1.07–1.14 oz/yd^2) and a thread count of 32 ±1 x 28 ±1 Threads/Inch.

NOTE: Grade 60 cheesecloth is known to meet these requirements.

17.11 A USB connection shall comply with Sections 20 – 23 when connected to a constant current supply capable of delivering output current of 8 A or more at its nominal voltage.

NOTE: The nominal voltage of a USB connection may range from 5.25 V dc (USB 3.0) to 20 V dc (USB PD).

17.12 A vehicle battery adapter connection shall comply with Sections 20 – 23 when connected to a constant current supply capable of delivering output current of 8 A or more at 12 V dc or 24 V dc.

17.13 If a test results in the opening of the load, it shall open reliably and consistently as demonstrated by repeating the test twice on a total of three separate samples.

18 Single Fault Conditions

18.1 Where single fault conditions are specified in Table 17.1, the test shall be performed under the conditions of 18.2 – 18.4.

Exception No. 1: This condition is not required to be performed on a protective device or circuit if it does not operate during a test.

Exception No. 2: This condition is not required to be performed if the protective device has been found to comply with CSA E60730-1 / UL 60730-1, or UL 991.

18.2 Each fault condition is to be performed on a single sample. Each fault condition is permitted to be performed on separate samples.

18.3 The single fault condition comprises a single failure (i.e., open, short or other failure modes) of any component and is implemented in conjunction with the test being conducted or may be conducted as part of a verification of a protective circuit. A protective device determined to be reliable based on compliance to applicable component standards and used within its ratings may remain in the circuit without being faulted. See individual tests for when the test is to be repeated under these fault conditions.

18.4 The opening of the load is not considered a protective device, unless it consistently and reliably opens twice on a total of three samples, without resulting in any consequence noted in Table 17.1.

19 Normal Charge Test

19.1 The device and the intended charger, charging interface and accessories specified by the manufacturer shall comply with 17.1 when tested per 19.2 – 19.4.

19.2 Each battery shall be fully discharged. Each fault condition is to be performed on a single sample in accordance with the Single Fault Conditions, Section 18.

19.3 Each battery shall be connected to its intended charging system and operated until it reaches its fully charged state.

19.4 The total sample size of normal charge and charge under single fault conditions shall not be less than five (5).

NOTE: If three (3) single fault conditions are considered necessary, then two (2) out of five samples are subjected to the normal charge test and the other three (3) samples are subjected to a charge test under each single fault condition identified. Likewise, if seven (7) fault conditions are considered necessary, seven samples are subjected to each single fault condition identified and the normal charge test is void.

19.5 The testing of 19.1 – 19.4 shall then be repeated in an ambient not higher than 0 °C (32 °F). If the device is not operable at the low ambient specified in Table 17.1, the test is repeated at the lowest operating ambient temperature specified by the manufacturer.

20 Normal Discharge Test

20.1 The device and the intended charger, charging interface and accessories specified by the manufacturer shall comply with 17.1 when tested per 20.2 – 20.7.

20.2 Each battery shall be installed in the device and fully charged. The device shall be fully loaded with consumables to the quantity specified by the manufacturer. The most unfavorable load condition (including consumables) specified by the manufacturer shall be applied.

20.3 The standard operating regime is referred as a puff session consisting of 15 individual puffs or until the device deactivates automatically, followed by 10 ±0.5 minutes between sessions or until the device indicates it is ready for use, whichever is shorter and then repeated continuously until one of the following events occurs:

a) The battery is fully discharged;

b) The e-liquid is depleted;

c) The device ceases functioning due to low levels of the consumable; or

d) The temperature of the device achieves the criteria for thermal equilibrium.

20.4 With reference to 20.3, an individual puff is defined as:

a) Puff volume: 55 ml (1.86 oz) ±5 %;

b) Puff duration: 3 seconds ±0.1 seconds for devices using e-liquid, 2 seconds ±0.1 seconds for the others; and

c) Puff period: 10 seconds ±0.5 second for devices using e-liquid, 30 seconds ±0.5 seconds for the others.

NOTE: No machine puffing regime can represent all human puffing behavior. The above standard operating regime has been chosen to define a worst-case scenario related to the Temperature Test, Section 26.

20.5 If the standard operating regime in 20.3 is incompatible with the device, it may be adjusted based on the operating limits of the device specified by the manufacturer.

20.6 Each fault condition is to be performed on a single sample in accordance with the Single Fault Conditions, Section 18. The total sample size of normal discharge and discharge under single fault conditions shall not be less than five (5).

20.7 The testing of 20.1 – 20.6 shall then be repeated in an ambient not higher than minus 20 °C (minus 4 °F). If the device is not operable at the low ambient specified in Table 17.1, the test is repeated at the lowest operating ambient temperature specified by the manufacturer.

21 Forced-Discharge Test

21.1 A rechargeable or non-rechargeable battery that is composed of cells that are to be used in series-connected, multicell applications shall comply with 17.1 when tested per 21.2 – 21.5.

21.2 One fully discharged cell shall be connected in series with the remaining fully charged cells and the resultant battery shall be short-circuited.

21.3 The positive and negative terminals of the sample are to be connected with a resistance load of less than or equal to 20 mΩ as measured at 25 ±5 °C (77 ±9 °F). The sample is to discharge until it has reached a completely discharged state of less than 0.2 V and the cell temperature has returned to ±10 °C (18 °F) of ambient temperature or ultimate consequences, whichever occurs first. The voltage at the end of the test may not reach 0.2 V due to operation of protective devices in the circuit.

21.4 Each fault condition is to be performed on a single sample in accordance with the Single Fault Conditions, Section 18, in the discharge protection circuit. The total sample size with or without single fault conditions shall not be less than two (2) where at least one sample shall be subjected to the test without single fault conditions.

NOTE: If two (2) single fault conditions are considered necessary, then two (2) samples are subjected to the test under each single fault condition identified and an additional sample shall be subjected to the test without single fault conditions, resulting in a total sample size of three (3) samples.

21.5 The testing of 21.1 – 21.4 shall then be repeated in an ambient not higher than minus 20 °C (minus 4 °F). If the device is not operable at the low ambient specified in Table 17.1, the test is repeated at the lowest operating ambient temperature specified by the manufacturer.

22 Imbalanced Charging

22.1 A rechargeable or non-rechargeable battery that is composed of cells that are to be used in series-connected, multicell applications shall comply with 17.1 when tested per 22.2 – 22.4.

22.2 One cell at approximately 50 % state of charge shall be connected in series with the remaining fully charged cells. The imbalanced battery shall be connected to its charger until fully charged.

22.3 Each fault condition is to be performed on a single sample in accordance with the Single Fault Conditions, Section 18, in the charging protection circuit. The total sample size with or without single fault conditions shall not be less than two (2) where at least one sample shall be subjected to the test without single fault conditions.

NOTE: If two (2) single fault conditions are considered necessary, then two (2) samples are subjected to the test under each single fault condition identified and an additional sample shall be subjected to the test without single fault conditions, resulting in a total sample size of three (3) samples.

22.4 The testing of 22.1 – 22.3 shall then be repeated in an ambient not higher than 0 °C (32 °F). If the device is not operable at the low ambient specified in Table 17.1, the test is repeated at the lowest operating ambient temperature specified by the manufacturer.

23 Overcharge Test

23.1 A rechargeable battery, its battery system, and the intended charging interface shall comply with 17.1 when tested per 23.2 – 23.8.

23.2 Each fully discharged battery shall be subjected to constant-current continuous charging at the maximum charging current, applying the following:

a) For lithium batteries, 150 % of the rated output voltage of the power supplies; or

b) For nickel-metal hydride batteries, a high-rate charge of 2.5 times the recommended charging current for a time that produces a 250 % charge input of its rated capacity.

23.3 If an overcurrent protective device operates during the test, the test is repeated at the maximum charging current without tripping the protective devices.

23.4 A re-settable protective device such as a PTC thermistor that actuates during the test shall be allowed to reset and the test shall be resumed, cycling as often as necessary, but no less than 10 times, to complete the test. Automatic reset devices are allowed to cycle during the test.

23.5 The test is to be continued until:

a) The condition specified in 23.2 is reached; or

b) The maximum obtainable steady-state charging condition if the condition specified in 23.2 cannot be reached due to protection.

The cell temperature is monitored for an additional 7 hours unless the test is terminated by consequences noted in Table 17.1.

23.6 If the battery is operational after the test, it shall be subjected to one additional discharge/charge operation sequence in an ambient of 25 ±5 °C (77 ±9 °F).

23.7 Each fault condition is to be performed on a single sample in accordance with the Single Fault Conditions, Section 18, in the charge protection circuit. The total sample size with or without single fault conditions shall not be less than five (5) where at least one sample shall be subjected to the test without single fault conditions.

23.8 The testing of 23.1 – 23.7 shall then be repeated in an ambient not higher than 0 °C (32 °F). If the device is not operable at the low ambient specified in Table 17.1, the test is repeated at the lowest operating ambient temperature specified by the manufacturer.

24 Abnormal Charging Test

24.1 A rechargeable battery, its battery system, and the intended charging interface shall comply with 17.1 when tested per 24.1 – 24.8.

24.2 Each battery shall be fully discharged in accordance with the Normal Discharge Test, Section 20.

24.3 Each fully discharged battery shall be subjected to constant-current continuous charging at the highest current among the following:

a) 2 times I_t; or

b) 5 A; or

c) The maximum current without tripping the protective devices.

24.4 The test is to be continued until the voltage attains the rated output voltage of the power supplies or otherwise the maximum obtainable steady-state charging condition if the rated output voltage cannot be reached due to protection. The cell temperature is monitored for an additional 2 hours unless the test is terminated by consequences noted in Table 17.1.

24.5 If the battery is operational after the test, it shall be subjected to one additional discharge/charge operation sequence in an ambient of 25 ±5 °C (77 ±9 °F).

24.6 A re-settable protective device such as a PTC thermistor that actuates during the test shall be allowed to reset and the test shall be resumed, cycling as often as necessary, but no less than 10 times, to complete the test. Automatic reset devices are allowed to cycle during the test.

24.7 Each fault condition is to be performed on a single sample in accordance with the Single Fault Conditions, Section 18, in the charge protection circuit. The total sample size with or without single fault conditions shall not be less than five (5) where at least one sample shall be subjected to the test without single fault conditions.

24.8 The testing of 24.1 – 24.7 shall then be repeated in an ambient not higher than 0 °C (32 °F). If the device is not operable at the low ambient specified in Table 17.1, the test is repeated at the lowest operating ambient temperature specified by the manufacturer.

25 Short Circuit Test

25.1 A device and its intended rechargeable or non-rechargeable battery shall comply with 17.1 when tested per 25.2 – 25.7.

25.2 A device with a fully charged battery shall be short-circuited by connecting the positive and negative terminals of the sample with a circuit load having a total resistance of less than or equal to 20 mΩ.

25.3 Another device with a fully charged battery shall be overloaded to the maximum obtainable, steady-state discharge current without tripping the protective device. In this case, single fault conditions do not apply.

25.4 The sample shall be discharged until:

a) The battery is fully discharged; or

b) Ultimate consequences occur and the battery returns to ambient temperature conditions.

25.5 If the battery is operational after the test, it shall be subjected to one additional charge/discharge operation sequence in an ambient of 25 ±5 °C (77 ±9 °F).

25.6 Each fault condition is to be performed on a single sample in accordance with the Single Fault Conditions, Section 18, in the discharge protection circuit. The total sample size with or without single fault conditions shall not be less than five (5) where at least one sample shall be subjected to the test of 25.2 and 25.3, respectively, without single fault conditions.

25.7 The testing of 25.1 – 25.6 shall then be repeated in an ambient not higher than minus 20 °C (minus 4 °F). If the device is not operable at the low ambient specified in Table 17.1, the test is repeated at the lowest operating ambient temperature specified by the manufacturer.