



ANSI/CAN/UL 2272:2024

JOINT CANADA-UNITED STATES
NATIONAL STANDARD

STANDARD FOR SAFETY

Electrical Systems for Personal E-Mobility Devices



SCC FOREWORD

National Standard of Canada

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UL Standard for Safety for Electrical Systems for Personal E-Mobility Devices, ANSI/CAN/UL 2272

Second Edition, Dated April 19, 2024

Summary of Topics

This new Second Edition ANSI/CAN/UL 2272 dated April 19, 2024 includes the following new and/or revised requirements:

- ***Updated battery pack compartment requirements; [9.2.3](#)***
- ***Added more specific evaluation requirements of gaskets and seals; [5.2](#), [7.7](#),***
- ***Clarified flammability requirements for nonmetallic materials; [7.8](#) – [7.13](#)***
- ***Updated charger requirements; [11.2](#), Section [36](#)***
- ***Added external output terminal marking requirement; [5.2](#), Markings, [47.5](#), Annex [B](#)***
- ***Updated temperature requirements; [6.23](#), [6.24](#), [27.3](#), [27.5](#)***
- ***Added reference to UL 2054, UL 62133-1 / CSA C22.2 No. 62133-1, UL 62133-2 and UL 62133-2 / CSA C22.2 No. 62133-2 for rechargeable batteries providing power other than drivetrain unit; [5.2](#), [17.9](#), [17.10](#)***
- ***Revised post-test cycle for non-operational condition; [22.1](#)***
- ***Revised the Vibration Test; [5.2](#), [34.1](#) – [34.3](#)***
- ***Revised the Partial Immersion test to allow the DUT to drain after the test; [44.2.2](#)***
- ***Clarified the definition in [6.25](#) to exclude motorized wheelchairs including mobility scooters for medical purposes.***
- ***Updated the Component Section and Annex [A](#); Section [2](#)***
- ***Updated the component cell requirements; [5.2](#), [17.1](#), [17.2](#), [17.4](#), [17.7](#), [17.8](#)***
- ***Added UL 62368-1 as the alternative electrical spacing requirement; [14.2](#), [31.4](#)***
- ***Aligned the dielectric strength test condition; [30.2](#)***

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated November 3, 2023 and February 23, 2024.

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ANSI/CAN/UL 2272:2024

Standard for Electrical Systems for Personal E-Mobility Devices

First Edition – November, 2016

Second Edition

April 19, 2024

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

The most recent designation of ANSI/UL 2272 as an American National Standard (ANSI) occurred on April 19, 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 19, 2024.

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CONTENTS

Preface (UL).....5

INTRODUCTION

1 Scope 7

2 Components 7

3 Units of Measurement 7

4 Undated References 7

5 Normative References.....8

6 Glossary.....10

CONSTRUCTION

7 Non-Metallic Materials 13

8 Metallic Parts Resistance to Corrosion 15

9 Enclosures 15

 9.1 General 15

 9.2 Battery compartments.....16

10 Wiring and Terminals 16

11 Chargers.....17

12 Fuses 18

13 Lighting 18

14 Electrical Spacings and Separation of Circuits 18

15 Insulation Levels and Protective Grounding 19

16 Protective Circuits and Safety Analysis 20

17 Cells and Batteries 21

18 Motors 22

19 Manufacturing and Production Line Testing 22

PERFORMANCE

20 General 23

21 Tolerances 25

22 Post Test Cycle 25

23 Results Criteria 26

ELECTRICAL TESTS

24 Overcharge Test.....26

25 Short Circuit Test.....27

26 Overdischarge Test 28

27 Temperature Test 28

28 Post-Discharge Charging Determination Test 31

29 Imbalanced Charging Test 31

30 Dielectric Voltage Withstand Test.....32

31 Isolation Resistance Test 34

32 Leakage Current Test 34

33 Grounding Continuity Test.....35

MECHANICAL TESTS

34 Vibration Test.....35

35 Shock Test.....36

36 Input Test.....37

37 Crush Test 37

38 Drop Test.....38

39 Mold Stress Relief Test 38

40 Handle Loading Test.....39

41 Motor Overload Test 39

42 Motor Locked Rotor 40

43 Strain Relief Tests (Cord Anchorages) 41

 43.1 General.....41

 43.2 Strain relief pull test 41

 43.3 Push-back test 41

ENVIRONMENTAL TESTS

44 Water Exposure Tests.....42

 44.1 IPX4 Code rating 42

 44.2 Partial immersion.....42

45 Thermal Cycling Test 43

46 Label Permanence Test 44

MARKINGS

47 General 44

INSTRUCTIONS

48 General 46

ANNEX A (Informative) – STANDARDS FOR COMPONENTS

A1 Component Standards 47

ANNEX B – SAFETY MARKING TRANSLATIONS (Normative for Canada and Informative for the US)

Preface (UL)

This is the Second Edition of the ANSI/CAN/UL 2272, Standard for Electrical Systems for Personal E-Mobility 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 2272 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.

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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.

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INTRODUCTION

1 Scope

1.1 These requirements cover the electrical drive train system including the battery system, other circuitry and electrical components for electric powered scooters and other devices to be referred to as personal e-mobility devices as defined in this Standard.

1.2 This standard is intended for evaluation of the safety of the electrical drive train system and battery and charger combination for energy and electrical shock hazards and does not evaluate the performance or reliability of these devices. In addition, it does not evaluate the physical hazards that may be associated with the use of personal e-mobility devices.

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.

NOTE: See Annex [A](#) for a list of Standards covering components generally used in the products covered by this Standard.

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 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.4 A component that is also intended to perform other functions such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable standard(s) that cover devices that provide those functions.

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 Normative References

5.1 Products covered by this Standard shall comply with the reference standards noted in this section as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product shall comply with the standards for all countries where it is intended to be used.

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

CSA C22.2 No. 0.15, *Adhesive Labels*

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

CSA C22.2 No. 0.2, *Insulation Coordination*

CSA C22.2 No. 0.8, *Safety Functions Incorporating Electronic Technology*

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

CSA C22.2 No. 100, *Motors and Generators*

CSA C22.2 No. 107.1, *Power Conversion Equipment*

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

CSA C22.2 No. 282, *Plugs, Receptacles, and Couplers for Electric Vehicles*

CSA C22.2 No. 60529, *Degrees of Protection Provided by Enclosures (IP Code)*

CSA E60730-1, *Automatic Electrical Controls for Household and Similar Use – Part 1: General Requirements*

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

CSA C22.2 No. 62133-1, *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 1: Nickel Systems*

CSA C22.2 No. 62133-2, *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*

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

IEC 60068-2-64, *Environmental Testing – Part 2-64: Tests – Test Fh: Vibration, Broadband Random and Guidance*

IEC 60417, *Graphical Symbols for Use on Equipment*

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

IEC 60812, *Analysis Techniques for System Reliability – Procedure for Failure Mode and Effects Analysis (FMEA)*

IEC 61025, *Fault Tree Analysis (FTA)*

IEC 61508-1, *Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems – Part 1: General Requirements*

ISO 6469-1, *Electrically Propelled Road Vehicles – Safety Specifications – Part 1: Rechargeable Energy Storage System (RESS)*

ISO 7010, *Graphical Symbols – Safety Colours and Safety Signs – Registered Safety Signs*

MIL-STD-1629A, *Procedures for Performing a Failure Mode, Effects, and Criticality Analysis*

SAE J1739, *Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)*

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

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

UL 157, *Gasket and Seals*

UL 746B, *Polymeric Materials – Long Term Property Evaluations*

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

UL 810A, *Electrochemical Capacitors*

UL 840, *Insulation Coordination Including Clearances and Creepage Distances For Electrical Equipment*

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

UL 969, *Marking and Labeling Systems*

UL 1004-1, *Rotating Electrical Machines – General Requirements*

UL 1004-2, *Impedance Protected Motors*

UL 1004-3, *Thermally Protected Motors*

UL 1004-7, *Electronically Protected Motors*

UL 1012, *Power Units other than Class 2*

UL 1310, *Class 2 Power Units*

UL 1642, *Lithium Batteries*

UL 1989, *Valve Regulated or Vented Batteries with Aqueous Electrolytes*

UL 1998, *Software in Programmable Components*

UL 2054, *Household and Commercial Batteries*

UL 2251, *Plugs, Receptacles, and Couplers for Electric Vehicles*

UL/ULC 2271, *Batteries for Use In Light Electric Vehicle (LEV) Applications*

UL/ULC 2580, *Batteries for Use in Electric Vehicles*

UL 2849, *Electrical Systems for eBikes*

UL 60730-1, *Automatic Electrical Controls for Household and Similar Use – Part 1: General Requirements*

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

UL 62133-1, *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 1: Nickel Systems*

UL 62133-2, *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*

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 BATTERY – A generic term for one or more cells electrically connected in series and/or parallel with or without monitoring and protection circuitry for charging and discharging.

6.3 BATTERY PACK – Batteries that are ready for use in a personal e-mobility device, contained in a protective enclosure, with protective devices, with a battery management system, and monitoring circuitry and that may be removable by the user for charging separately from the device.

6.4 BATTERY SYSTEM – Battery system includes the battery, charger and monitoring and protection circuit for charging and discharging of the battery.

6.5 CAPACITY, RATED – The total number of ampere-hours that can be withdrawn from a fully charged battery at a specific discharge rate to a specific end-of-discharge voltage (EODV) at a specified temperature as declared by the manufacturer.

6.6 CASING – The container that directly encloses and confines the electrolyte, and electrodes of a cell.

6.7 CELL – The basic functional electrochemical unit (sometimes referred to as a battery) containing an electrode assembly, electrolyte, separators, casing, and terminals. It is a source of electrical energy by direct conversion of chemical energy.

6.8 CHARGING – The application of electric current to battery terminals, which results in a Faradic reaction that takes place within the battery that leads to stored electro-chemical energy. For personal e-mobility devices, charging of the battery can occur through one or more of the following methods:

- a) Regenerative charging which utilizes energy from regeneration through braking or acceleration (i.e. when going down a hill).
- b) Off board charging which utilizes an ac to dc charger, a dc charger, or an inductive charger external to the device.
- c) On board charging which utilizes a charger on the personal e-mobility device to convert the ac mains supply to dc for charging.

6.9 CHARGING, CONSTANT CURRENT (CC) – Charging mode where current is held constant while charging voltage is allowed to vary.

6.10 DUT – Device under test.

6.11 ELECTRIC SHOCK HAZARD – A potential for exposure of persons to hazardous voltage circuits through direct contact from openings in protective enclosures and/or insufficient insulation between hazardous voltage circuits and accessible parts.

6.12 ELECTRICAL DRIVE TRAIN SYSTEM – The electrical components that power the personal e-mobility device's motion and would include the battery system; the electric motor(s); the protection, balance and control systems; and the circuitry and wiring to connect them together.

6.13 ELECTRICAL SYSTEM – All of the electrical components and circuits that are provided with the personal e-mobility device and would include the electrical drive train system, the internal or external charger used to recharge the battery and auxiliary electrical systems such as lighting, communications and audio that may be provided on the device.

6.14 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 in the casing or enclosure of a cell or capacitor and is visible external to the DUT.

6.15 ENCLOSURE – The outer cover of a device that provides protection to its contents to prevent a potential hazard, and may have one or more specific levels of protection as noted below:

- a) **ELECTRICAL ENCLOSURE** – Provides protection from access to hazardous voltage circuits and may serve as part of the electrical insulation.
- b) **FIRE ENCLOSURE** – Provides protection from the spread of fire from components within.
- c) **MECHANICAL ENCLOSURE** – Provides physical protection from damage to components and parts contained within and/or prevents access to hazardous moving parts.
- d) **ENVIRONMENTAL ENCLOSURE** – Provides protection from ingress of materials from the environment such as water that could damage internal components or introduce hazards. A rating such as the IP code provides the level of protection given by the enclosure.

6.16 END-OF-DISCHARGE VOLTAGE (EODV) – The voltage, under load, of the cell or battery at the end of discharge. The EODV may be specified, as in the case of a voltage terminated discharge, or simply measured in the case of a time-controlled discharge.

6.17 **EXPLOSION** – A violent release of energy that produces projectiles or an energy wave from the DUT and results in the DUT's contents being forcibly expelled through a rupture in the enclosure or casing.

6.18 **FIRE** – The sustained combustion of the DUT's contents as evidenced by flame, heat and charring or other damage of materials.

6.19 **FULLY CHARGED** – A battery which has been charged per the manufacturer's specifications to its full state of charge (SOC).

6.20 **FULLY DISCHARGED** – A battery, which has been discharged, according to the manufacturer's specifications, to its specified end of discharge voltage (EODV).

6.21 **HAZARDOUS VOLTAGE** – Voltage exceeding 30 Vrms/42.4 Vac peak or 60 Vdc.

6.22 **INSULATION LEVELS** – The following are levels of electrical insulation:

a) **BASIC** – A single level of insulation that provides protection against electric shock. Basic insulation alone may not provide protection from electric shock in the event of a failure of the insulation.

b) **DOUBLE INSULATION** – Insulation comprising both basic insulation and supplementary insulation.

c) **FUNCTIONAL INSULATION** – Insulation that is necessary only for the correct functioning of the equipment. Functional insulation by definition does not protect against electric shock. It may, however, reduce the likelihood of ignition and fire.

d) **REINFORCED INSULATION** – Single insulation system that provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this Standard. The term "insulation system" does not imply that the insulation has to be in one homogeneous piece. It may comprise several layers that cannot be tested as basic insulation and supplementary insulation.

e) **SUPPLEMENTARY INSULATION** – Independent insulation applied in addition to basic insulation in order to reduce the risk of electric shock in the event of a failure of the basic insulation.

6.23 **MAXIMUM CONTINUOUS CHARGING TEMPERATURE** – The maximum ambient temperature per the manufacturer's specifications that can continuously charge the battery at the maximum charging parameters to its full state of charge (SOC).

6.24 **MAXIMUM CONTINUOUS DISCHARGING TEMPERATURE** – The maximum ambient temperature per the manufacturer's specifications that can continuously discharge the battery at the maximum discharging parameters to its specified end of discharge voltage (EODV).

6.25 **PERSONAL E-MOBILITY DEVICE** – A consumer mobility device intended for a single rider with a rechargeable electric drive train that balances and propels the rider, and which may be provided with a handle for grasping while riding, but excludes motorized wheelchairs including mobility scooters for medical purposes. This device may or may not be self-balancing.

6.26 **ROOM AMBIENT** – Considered to be a temperature in the range of 25 ± 5 °C (77 ± 9 °F).

6.27 **RUPTURE** – A mechanical failure of the DUT's enclosure/casing from either internal or external causes, that results in spillage and/or exposure of internal contents of the DUT, but does not result in projectiles and violent energy release such as occurs during an explosion.

6.28 SAFETY CRITICAL CIRCUITS/COMPONENTS – Those circuits or discrete components that are relied upon for safety as identified in the safety analysis of [16.2](#).

6.29 SPECIFIED OPERATING REGION – That region of voltage, current and temperature within which a cell can be safely charged and discharged repetitively throughout its anticipated life. The manufacturer specifies these values, which are then used in the safety evaluation of the device and may vary as the device ages. The specified operating region may include transient values for voltage, current and temperature that are allowed under limited conditions specified by the cell manufacturer. The specified operating regions will include the following parameters for charging and discharging as specified by the manufacturer:

- a) CHARGING TEMPERATURE LIMITS – The upper and lower limits of temperature, specified by the manufacturer for charging of the cell. This temperature is measured on the casing.
- b) DISCHARGE TEMPERATURE LIMITS – The upper and lower limits of temperature, specified by the manufacturer for discharging the cell. This temperature is measured on the casing.
- c) END OF DISCHARGE VOLTAGE – Refer to [6.14](#). Also, see Figure 3.1 of UL 1642.
- d) MAXIMUM DISCHARGING CURRENT – The maximum discharging current rate, which is specified by the cell manufacturer.
- e) MAXIMUM CHARGING CURRENT – The maximum charging current in the specified operating region, which is specified by the cell manufacturer. This value may vary with temperature.
- f) UPPER LIMIT CHARGING VOLTAGE – The highest charging voltage limit in the specified operating region specified by the cell manufacturer. This value may vary with temperature.

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

CONSTRUCTION

7 Non-Metallic Materials

7.1 The materials employed for enclosures relied upon for safety per [6.15](#) shall comply with the applicable enclosure requirements outlined in UL 746C, Path III of the Enclosure Requirements Table or CSA C22.2 No. 0.17, except as modified by this Standard.

7.2 Polymeric materials employed for fire enclosures shall have a minimum flame rating of V-1 in accordance with UL 94, or CSA C22.2 No. 0.17.

Exception: The enclosure may alternatively be evaluated to the 20 mm end product flame test in accordance with UL 746C, or CSA C22.2 No. 0.17.

7.3 The following factors in (a) – (e) are taken into consideration when an enclosure employing nonmetallic materials is being judged. For a nonmetallic enclosure all of these factors are to be considered with respect to thermal aging. Dimensional stability of a polymeric enclosure is addressed by compliance to the mold stress relief test. Suitability to factors (a) – (e) below may be determined by the tests of this Standard.

- a) Resistance to impact;
- b) Crush resistance;
- c) Abnormal operations;