



JOINT CANADA-UNITED STATES
NATIONAL STANDARD

STANDARD FOR SAFETY

ANSI/CAN/UL-2272:2016, Electrical Systems for Personal E-Mobility Devices

ANSI/CAN/UL-2272:2016, Electrical Systems for Personal E-Mobility Devices



ANSI/UL 2272-2016



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

First Edition, Dated November 21, 2016

Summary of Topics

The First Edition of the Standard for Electrical Systems for Personal E-Mobility Devices, UL 2272, has been issued.

The new requirements are substantially in accordance with Proposal(s) on this subject dated April 15, 2016 and July 15, 2016.

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NOVEMBER 21, 2016

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UL 2272

Standard for Electrical Systems for Personal E-Mobility Devices

First Edition

November 21, 2016

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

The most recent designation of ANSI/UL 2272 as an American National Standard (ANSI) occurred on November 21, 2016. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This standard has been approved as a National Standard of Canada (NSC) by the Standards Council of Canada (SCC).

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Preface (UL)

This is the First Edition of the ANSI/CAN/UL 2272 Standard for Safety for Electrical Systems for Personal E-Mobility Devices.

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

This ANSI/CAN/UL 2272 Standard for Safety is under continuous maintenance, whereby each revision is ANSI/CAN approved upon publication. If no revisions occur, the initiation of the review of this Standard will commence within 5 years of the date of publication.

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 Electrical Systems for Self-Balancing Scooters, STP 2272.

This list represents the STP 2272 membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

STP 2272 Membership

Name	Representing	Interest Category*	Region
Bigler, Robert	Hoverboard Technologies	Producer	USA
Brueckner, Shawn	National Research Council Canada	Government	CANADA
Byczek, Rich*	Intertek	Testing and Standards	USA
Cassidy, Tim	Best Buy	Supply Chain	USA
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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 comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by 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 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 Standards

CSA-C22.2 No. 0.15
Adhesive Labels

CAN/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

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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

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

CAN/CSA-C22.2 No. 60529
Degrees of Protection Provided by Enclosures (IP Code)

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

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

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

IEC Standards

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 Standards

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

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ISO 12405-1

Electrically Propelled Road Vehicles – Test Specification for Lithium-Ion Traction Battery Packs and Systems – Part 1: High-Power Applications

SAE Standards

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 Standards

UL 50E

Enclosures for Electrical Equipment, Environmental Considerations

UL 94

Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

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

Rotating Electrical Machines – Impedance Protected Motors

UL 1004-3

Rotating Electrical Machines – Thermally Protected Motors

UL 1004-7

Rotating Electrical Machines – Electronically Protected Motors

UL 1012

Power Units other than Class 2

UL 1310

Class 2 Power Units

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UL 1642
Lithium Batteries

UL 1989
Standby Batteries

UL 1998
Software in Programmable Components

UL 2251
Plugs, Receptacles, and Couplers for Electric Vehicles

UL 2271
Batteries for Use In Light Electric Vehicle (LEV) Applications

UL 2580
Batteries for Use in Electric Vehicles

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

ULC Standards

CAN/ULC-S2271
Batteries for Use In Light Electric Vehicle (LEV) Applications

CAN/ULC-S2580
Batteries for Use in Electric Vehicles

US Department of Defense (DOD) Standards

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

6 Glossary

6.1 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.

6.2 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.

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

6.4 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.

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

6.6 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.

6.7 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.

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

6.9 DUT – Device under test.

6.10 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.

6.11 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.

6.12 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.

6.13 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.

6.14 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.

6.15 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.

6.16 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.

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

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

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

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

6.21 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.

6.22 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. This device may or may not be self-balancing.

6.23 ROOM AMBIENT – Considered to be a temperature in the range of $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$).

6.24 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.

6.25 SAFETY CRITICAL CIRCUITS/COMPONENTS – Those circuits or discrete components that are relied upon for safety as identified in the safety analysis of 16.2.

6.26 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 6.13. Also, see Figure 3.1 of the Standard for Lithium Batteries, 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.

6.27 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 6.14 shall comply with the applicable enclosure requirements outlined in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, Path III of the Enclosure Requirements in Table 4.1 or the Standard for Evaluation of Properties of Polymeric Materials, CAN/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 94V-1 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17.

Exception: The enclosure may alternatively be evaluated to the 20 mm end product flame test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or the Standard for Evaluation of Properties of Polymeric Materials, CAN/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;
- d) Severe conditions; and
- e) Mold-Stress Relief Distortion.

7.4 The polymeric materials employed for enclosures and insulation shall be suitable for anticipated temperatures encountered in the intended application. Enclosures shall have a Relative Thermal Index (RTI) with impact suitable for temperatures encountered in the application but no less than 80°C (176°F), as determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17.

7.5 The enclosure materials intended to be directly exposed to sunlight and rain in the end use application shall comply with the UV Resistance and the Water Exposure and Immersion tests in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17. This requirement may be waived if the personal e-mobility device is marked that it be stored indoors and user instructions also indicate that it not be left outdoors to be exposed to UV or rain. See 45.11 and Section 46.

7.6 Materials employed as electrical insulation in the assembly shall be resistant to deterioration that would result in an electrical shock, fire or other safety hazard. Compliance is determined by the tests of this standard. Materials employed for direct support of live parts at hazardous voltage, shall additionally meet the direct support insulation criteria outlined in the Material Property Considerations, Table 6.1, in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17, unless employed as part of a component that has been evaluated to a suitable component standard. Insulated wiring is subjected to the requirements outlined in Section 10, Wiring and Terminals.

7.7 Gaskets and seals relied upon for safety, shall be determined suitable for the environmental conditions and chemical substances they are anticipated to be exposed to in their end use.

8 Metallic Parts Resistance to Corrosion

8.1 Metal enclosures shall be corrosion resistant. A suitable plating or coating process can achieve corrosion resistance. Additional guidance on methods to achieve corrosion protection can be found in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E or in CSA-C22.2 No. 94.2.

8.2 Metal enclosures may be provided with an insulating liner to prevent shorting of live parts to the enclosure. If using an insulating liner for this purpose, the insulating liner shall consist of non-moisture absorbent materials that have a temperature rating suitable for temperatures during operation including charging.

8.3 Conductive parts in contact at terminals and connections shall not be subject to corrosion due to electrochemical action.