



ANSI/CAN/UL 2849:2020

JOINT CANADA-UNITED STATES
NATIONAL STANDARD

STANDARD FOR SAFETY

Electrical Systems for eBikes

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UL Standard for Safety for Electrical Systems for eBikes, ANSI/CAN/UL 2849

First Edition, Dated January 2, 2020

Summary of Topics

This First Edition of UL 2849, Standard for Electrical Systems for eBikes, has been issued to reflect the latest ANSI and SCC approval dates, and to incorporate the proposals dated September 6, 2019 and November 22, 2019.

The requirements are substantially in accordance with Proposal(s) on this subject dated September 6, 2019 and November 22, 2019.

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ANSI/UL 2849-2020

JANUARY 2, 2020



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ANSI/CAN/UL 2849:2020

Standard for Electrical Systems for eBikes

First Edition

January 2, 2020

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

The most recent designation of ANSI/UL 2849 as an American National Standard (ANSI) occurred on January 2, 2020. 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 January 2, 2020.

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Preface

This is the First Edition of the ANSI/CAN/UL 2849, Standard for Safety for Electrical Systems for eBikes.

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 2849 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 Electrical Systems for eBikes, STP 2849.

This list represents the STP 2849 membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

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International Classification for Standards (ICS): 43.150

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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 This Standard covers the electrical system of eBikes powered by a lithium-based, rechargeable battery. EBikes include both Electrically Power Assisted Cycle (EPAC – pedal assist) and non-pedal assist eBikes.

1.2 Electrical systems as referenced in [1.1](#), may include onboard components and off board components of eBikes. As a minimum, the electrical system consists of the drive unit, battery, battery management system (BMS), interconnecting wiring, and power inlet. Any additional components or systems required to demonstrate compliance are included based on the overall system application and risk.

1.3 Off board components include dedicated chargers for charging batteries that are removed from the eBike during charging or dedicated chargers for charging batteries that are in place on the eBike during charging.

1.4 This Standard does not cover the mechanical structure of the eBike unless specified otherwise.

2 Components

2.1 A critical safety component of a product covered by this Standard shall comply with the requirements for that component.

2.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this Standard; or
- b) Is superseded by a requirement in this Standard.

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

2.4 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.

3 Units of Measurement

3.1 The values given in SI (metric) units shall be normative. Any other values given shall be for information purposes only.

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 Definitions

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

5.2 BATTERY MANAGEMENT SYSTEM (BMS) – The electrical, electronic and software monitoring and control system of a battery that is often relied upon to maintain the battery and its component cells within their specified operating region for charge and discharge, and may be source of memory of the battery operation throughout its life.

5.3 CHARGER – A device that converts grid power to DC power for charging the battery.

5.4 eBIKE – A two or three wheeled electrical/mechanical device provided with functional pedals that includes one or more electric motors to either assist the rider when pedaling (EPAC versions) or provide motive power to the wheels when the rider is not pedaling.

5.5 ENCLOSURE – That portion of a unit that reduces the accessibility of a part that involves a risk of fire, electric shock or injury to persons, or reduces the risk of propagation of flame, sparks, and molten metal initiated by an electrical disturbance occurring within.

5.6 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.

5.7 EPAC – A version of an eBike, equipped with functional pedals and one or more auxiliary electric motors, which cannot be propelled exclusively by means of the auxiliary electric motors, except in the start-up assistance mode. The motors are designed to disengage their assist function when the rider stops pedaling, when a maximum predetermined speed is reached, or when the user applies the brakes (if the brakes are provided with cutoff functions).

5.8 LIVE PART – A conductive part, such as metal, within the unit that during intended use has a potential difference with respect to earth ground or any other conductive part.

5.9 FUNCTIONAL PEDALS – Assemblies provided on eBikes that are integrally part of the drive train motive system and are used by the rider to provide motive force to the wheel or wheels.

5.10 LOW VOLTAGE LIMITED ENERGY (LVLE) – A circuit that is supplied from an isolated secondary winding of a transformer, or other appropriate means, and that complies with the requirements in [8.3](#).

5.11 RISK OF ELECTRIC SHOCK – A potential for exposure of persons to hazardous voltage circuits (greater than 42.4 V peak ac or 60 V dc) through direct contact from openings in protective enclosures and/or insufficient insulation between hazardous voltage circuits and accessible parts.

6 Normative References

6.1 Products covered by this Standard shall comply with the referenced installation codes and standards noted in this clause 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 installation codes and standards for all countries where it is intended to be used.

6.2 Where reference is made to any Standards, such reference shall be considered to refer to the latest editions and revisions thereto available, unless otherwise specified.

6.3 The following publications are referenced in this Standard:

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

CSA C22.2 No. 0.8, *Safety functions incorporating electronic technology*

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

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

CSA C22.2 No. 5, *Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures*

CSA C22.2 No. 49, *Flexible Cords and Cables*

CSA C22.2 No. 77, *Motors With Inherent Overheating Protection*

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

CSA C22.2 No. 107.1, *Power Supplies*

CSA C22.2 No. 182.3, *Special Use Attachment Plugs, Receptacles and Connectors*

CSA C22.2 No. 223, *Power Supplies With Extra Low Voltage Class 2 Outputs – General Instruction No. 1*

CSA C22.2 No. 248.1, *Low-Voltage Fuses – Part 1: General Requirements*

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

CSA C22.2 No. 4248.1, *Fuseholders – Part 1: General Requirements*

CSA C22.2 E60730-1, *Automatic Electric Controls – Part 1: General Requirements*

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

CSA C22.2 No. 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*

CAN/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 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, *The Standard for Fault Tree Analysis (FTA)*

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

ISO 13849-1, *Safety of Machinery – Safety Related Parts of Control Systems – Part 1: General Principles for Design*

ISO 13849-2, *Safety of Machinery – Safety Related Parts of Control Systems – Part 2: Validation*

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

SAE J1739, *The 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 62, *Flexible Cords and Cables*

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

UL 248-1, *Low-Voltage Fuses – Part 1: General Requirements*

UL 489, *Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures*

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

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

UL 796, *Electrical Printed-Wiring Boards*

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

UL 969, *Marking and Labeling Systems*

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

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 1977, *Component Connectors for Use in Data, Signal, Control and Power Applications*

UL 1998, *Software in Programmable Components*

UL 2054, *Household/Commercial Batteries*

UL 2097, *Double Insulation Systems for Use in Electronic Equipment*

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

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

UL 2580/ULC-S2580, *Batteries for Use in Electric Vehicles*

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UL 4248-1, *Fuseholders – Part 1: General Requirements*

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*

CONSTRUCTION

7 General

7.1 The information provided in Sections [7](#) through [10](#) is essential for the proper evaluation of the products covered by this Standard. The concepts in these Sections will outline and define the evaluation path based on what is provided in the electrical system.

7.2 The concepts in Sections [7](#) through [10](#) are general in nature and could result in different methods of evaluation for each different product type dependent upon its overall design.

7.3 EBikes consist of both EPAC and non-EPAC types, but in all cases functional pedals shall be provided. For EPACs, motors shall disengage their assist function when the rider stops pedaling, when a maximum predetermined speed as specified by the manufacturer is reached, or when the user applies the brakes (if the brakes are provided with cutoff functions). For non-EPAC versions of the eBike, motors are not required to disengage when the user stops pedaling. A non-EPAC type eBike may be provided with an EPAC mode.

7.4 The electrical system located on the eBike, those subassemblies or components shall comply with all the requirements in this Standard at a maximum altitude of 2000 m (6562 feet) and over an ambient temperature range of 0°C to 40°C (32°F to 104°F) and be subjected to ingress protection tests. Equipment may be used at ambient temperature extremes for operation and battery charging that exceed the default limits above (e.g., -10 °C or +50 °C) when specified by the manufacturer and the equipment shall be provided with instructions in accordance with [46.3](#) (j) and (k), and [48.3](#).

8 Power Levels

8.1 General

8.1.1 For all products covered by this Standard, a specific power level will be associated with the eBike. This will require rated voltage and current levels to be assigned, but can also include voltages or currents that are available within the eBike being evaluated. Different approaches can be used based on the potential hazards associated with a given power level.

8.1.2 For the purposes of this Standard, different designations will be used. This includes hazardous voltage and/or hazardous current resulting in hazardous energy, and in all cases these designations indicate a voltage, current or energy level that is potentially dangerous to the user and means of protection are required. Additional designations cover Low Voltage, Limited Energy (LVLE) which indicates voltage and current levels that are not inherently hazardous to the user and the need for specific protection means may be reduced.

8.2 Hazardous Voltage and Hazardous Energy

8.2.1 Any accessible circuit or accessible part, as determined by the articulate probe in [Figure 18.1](#), that is operating at a voltage above 42.4 volts peak or 60 V dc is considered to be operating at a hazardous voltage. In these cases, the user must be protected against contact with the part or circuit by the use of an enclosure or proper insulation. The requirements for both enclosures and insulation are included in this Standard and shall be applied as appropriate in all cases where hazardous voltages exist.

8.2.2 Hazardous energy exists in any circuit or part that is operating with a stored energy level of 20 J or more, or has an available continuous power level of 240 VA or more, at a potential of 2 volts or more. In these cases, the user shall be protected against contact with the part or circuit by the use of an enclosure or proper insulation. The requirements for both enclosures and insulation are included in this Standard and shall be applied as appropriate in all cases where hazardous energy exist.

8.3 Low Voltage Limited Energy Circuits

8.3.1 A Low-Voltage Limited Energy Circuit (LVLE) shall comply with the limits in [Table 8.1](#).

8.3.2 The power limitations in [Table 8.1](#) may be obtained by the use of any of the following configurations:

- a) An inherently-limited transformer;
- b) A non-inherently-limited transformer coupled with an overcurrent protective device in the output circuit;
- c) A combination transformer and fixed impedance; or
- d) An arrangement determined to be equivalent to (a), (b), or (c).

Table 8.1
Low-voltage, limited-energy circuits

Inherently limited transformer (overcurrent protection not required)				Not-inherently-limited transformer (overcurrent protection required)			
Circuit voltage (volts) ^a	0 – 20 volts AC or DC ^b	Over 20 volts but not more than 30 volts AC or DC ^b	Over 30 volts but not more than 60 volts DC ^b	0 – 15 volts AC or DC ^b	Over 15 volts but not more than 20 volts AC or DC ^b	Over 20 volts but not more than 30 volts AC or DC ^b	Over 30 volts but not more than 60 volts DC ^b
Power limitation (volt-amperes) ^b	–	–	–	350	250	250	250
Current limitation (amperes) ^d	8	8	150/V ^a	1000/V ^a	1000/V ^a	1000/V ^a	1000/V ^a
Maximum overcurrent protection (amperes)	–	–	–	5	5	100/V ^a	100/V ^a

^a Maximum output voltage, regardless of load, with applied rated voltage.

^b The AC waveform shall sinusoidal.

^c Maximum volt-ampere output regardless of load, and overcurrent protection (if provided) bypassed.

^d Maximum output after 1 minute of operation under any noncapacitive load, including short circuit, and with overcurrent protection (if provided) bypassed.

8.3.3 A part or device, other than the battery pack, located in or supplied by an LVLE circuit need not be investigated. The secondary winding of the transformer, the fuse or circuit protective device, or the regulating network, and all wiring up to the point at which the current and voltage are limited shall be judged under the applicable requirements in this Standard.

8.3.4 The maximum load current is to be drawn under any condition of loading, including short circuit, using a resistor. The current is to be measured 60 seconds after the application of the load. The resistor is to be continuously readjusted during this 1 minute period to maintain maximum load current. The measured load current shall not exceed the value listed in [Table 8.1](#).

8.3.5 With reference to the voltage limit specified in [Table 8.1](#), measurement is to be made with the product connected to the intended source of supply and with all loading circuits disconnected.

8.3.6 The over-current protective device provided in the LVLE circuit used to limit the current shall be rated or set at not more than the values specified in [Table 8.1](#). The device shall not be of the automatically reset type.

8.3.7 If a regulating network is used to limit the output under any conditions, the LVLE current limitation in [Table 8.1](#) shall not be affected by malfunction of a single component, excluding resistors. The network shall comply with the value in [Table 8.1](#) when the current is measured after 5 seconds.

9 Combination of Battery, Battery Management System, and Charger

9.1 The battery management system (BMS) is used to control battery charging and discharging. For battery packs that are provided with an integral BMS, that BMS shall be evaluated as part of the battery pack in accordance with Battery Packs, Section [11](#). If the BMS, or a portion of the BMS, resides in components or circuits external to the battery pack, then the combination of the external components and the battery pack is critical to safety and shall be evaluated together in accordance with [9.2](#).

9.2 All testing of the system shall be performed with the actual battery/BMS and charger that is recommended by the manufacturer. Any protection circuits, or other external components or systems, can remain in place provided those circuits or systems are proven to be reliable in accordance with Sections [12](#) and [19](#).

10 User Protection While Charging

10.1 General

10.1.1 Charging of the battery may occur while the battery is installed on the eBike, with the battery removed from the eBike, or both options may apply based on user preference. If the battery is only intended to be charged when it is removed from the eBike, then an inherent means shall be provided to insure that this option is the only option for charging the battery. If no inherent means are provided, and it is possible to charge the battery while on the eBike, the battery shall be considered to be charged both on board and off board the eBike.

10.1.2 If the battery is intended to be charged while on the eBike, whether by inherent construction or user preference, then the requirements in [10.2](#) apply. If the battery is only intended to be charged when removed from the eBike, then the requirements in [10.2](#) do not apply.

10.1.3 The requirements in [10.1.1](#) and [10.1.2](#) are to be used in conjunction with the requirements in Section [8](#). If energy levels are such that no hazard exists, then protection means may be reduced.