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ANSI/CAN/UL/ULC 2271:2023

JOINT CANADA-UNITED STATES
NATIONAL STANDARD

STANDARD FOR SAFETY

Batteries for Use In Light Electric
Vehicle (LEV) Applications



ANSI/UL 2271-2023



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SCC FOREWORD

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UL Standard for Safety for Batteries for Use In Light Electric Vehicle (LEV) Applications,
ANSI/CAN/UL/ULC 2271

Third Edition, Dated September 14, 2023

Summary of Topics

This new edition of ANSI/CAN/UL/ULC 2271, Standard for Batteries for Use In Light Electric Vehicle (LEV) Applications, dated September 14, 2023 includes the following changes:

- ***Modification of the normal operation conditions and cycle number during Temperature Test; [5.2](#), [33.1](#), and [Table 33.1](#)***
- ***Clarification of the scope to better distinguish what is covered under UL/ULC 2271 versus UL/ULC 2580; [1.1](#), [1.4](#), [5.2](#), [6.1](#), [6.2](#), [6.14](#), [6.25](#), [6.29](#), [6.32](#), [6.40](#), [16.2](#), [16.3](#), and [16.8](#)***
- ***Updates to Functional Safety criteria; [6.34](#), [6.35](#), [6.36](#) and Section [15](#)***
- ***Additional guidance on protection of corrosion between dissimilar metals; [5.2](#), [8.1](#), [8.2](#), [8.4](#), Annex [B](#), [B.1](#), and [Table B.1](#)***
- ***Addition of requirements for when repurposed batteries are used; [5.2](#), Section [16](#), [16.8](#), Section [46](#), Annex [C](#), and [Table C.1](#)***
- ***Addition of a High Rate Charge Test that evaluates the safety when charging at a rate higher than the specified maximum level, [Table 18.1](#), Section [21](#), [21.2](#), [Table 21.1](#), and Section [24](#)***
- ***Addition of the Overload Under Discharge Test to replace the "soft short" in the Short Circuit Test; [6.32](#), [Table 18.1](#), [21.1](#), [21.2](#) and Section [26](#)***
- ***Addition of a Single Cell Failure Design Tolerance Test for large size batteries; [Table 18.1](#) section [Table 21.1](#) and Section [45](#).***
- ***Replaced reference to UL 60950-1 with UL 62368-1 throughout the Standard.***
- ***Replaced reference to ISO 12405-1 with ISO 6469-1 throughout the Standard.***
- ***Corrections to Manufacturing and Production Line Testing and inclusion of a 100% check on active controls relied upon for safety; [17.2](#), [17.4](#).***
- ***Addition of a normal operation limit check in Overcharge and Overdischarge Test; [23.3](#), [23.6](#), [27.2](#) and [27.5](#)***
- ***Addition of a grounding continuity test; Section [14](#) and Section [32](#)***
- ***Editorial revisions throughout the Standard.***

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated April 7, 2023 and July 14, 2023.

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ANSI/UL 2271-2023

SEPTEMBER 14, 2023



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ANSI/CAN/UL/ULC 2271:2023

Standard for Batteries for Use In Light Electric Vehicle (LEV) Applications

First Edition – December, 2013
Second Edition – September, 2018

Third Edition

September 14, 2023

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

The most recent designation of ANSI/UL 2271 as an American National Standard (ANSI) occurred on September 14, 2023. 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 September 14, 2023.

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Preface

This is the Third Edition of ANSI/CAN/UL/ULC 2271, Standard for Batteries for Use In Light Electric Vehicle (LEV) Applications.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO). ULC Standards is accredited by 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/ULC 2271 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 [B](#), and Annex [C](#) are identified as Normative, as such, form mandatory parts of this Standard.

Annexes [A](#) and [C](#) are identified as Informative for the United States.

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.

This joint American National Standard and National Standard of Canada is based on, and now supersedes, the Second Edition of UL/ULC 2271.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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This Edition of the Standard has been formally approved by the Technical Committee (TC) for Batteries for Use in Electric Vehicles, TC 2580.

This list represents the TC 2580 membership when the final text in this Standard was balloted. Since that time, changes in the membership may have occurred.

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Stankes, David	3M Austin Center	Supply Chain	USA
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Xiao, Jerry	SGS-CSTC Standards Technical Services Co Ltd	Testing and Standards	China
Xu, Hongbin	Guangzhou MCM Certification and Testing Co Ltd	Testing and Standards	China
Yu, Kihoon	SK On Co Ltd / SK Battery America Inc	Producer	Korea
Yun, Yonghee	Samsung SDI	Producer	Korea
Yunzheng, Zhu	ZHEJIANG LAB/Intelligent Robot Research Center	General	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.

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INTRODUCTION

1 Scope

1.1 These requirements cover electrical energy storage assemblies (EESAs) such as battery packs and combination battery pack-electrochemical capacitor assemblies and the subassembly/modules that make up these assemblies for use in light electric-powered vehicles (LEVs) as defined in this Standard. This Standard also covers a battery management system (BMS) that provides protection and control for the EESA.

1.2 This Standard does not evaluate the performance or reliability of these devices.

1.3 This Standard does not include requirements for the evaluation of EESAs intended for use in electric vehicles, such as on-road passenger vehicles and motorcycles intended for use on public roadways including highways, and starter batteries and heavy duty off road vehicles such as battery powered ride-on industrial trucks, earth moving or construction equipment, which are covered under the Standard for Batteries for Use in Electric Vehicles, UL/ULC 2580.

1.4 This Standard does not include requirements for evaluation of EESAs intended for use in stationary and motive auxiliary power applications, which are covered under the Standard for Batteries for Use in Stationary and Motive Auxiliary Power Applications, UL 1973.

1.5 These requirements do not cover equipment for use in hazardous locations as defined in the National Electrical Code, NFPA 70.

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. The values given in SI (metric) units shall be normative.

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 Throughout this Standard, the CSA and ULC standard references apply to products intended for use in Canada, while the UL standard references apply to products intended for use in the United States. Combined references are commonly separated by a slash ("/").

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.

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

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. 94.2, *Enclosures for Electrical Equipment, Environmental Considerations*

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

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

IEC 60068-2-30, *Environmental Testing – Part 2-30: Tests – Test Db: Damp Heat, Cyclic (12 h + 12 h Cycle)*

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

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: On-Board Rechargeable Energy Storage System (RESS)*

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

ISO 9227, *Corrosion Tests in Artificial Atmospheres – Salt Spray Test*

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*

ISO 26262-1, *Road Vehicles – Functional Safety (all parts)*

MIL-STD-1629A, *The 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)*

SAE J2464, *Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing*

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

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

UL 546, *Conductor Termination Compounds*

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 1973, *Batteries for Use in Stationary and Motive Auxiliary Power Applications*

UL 1974, *Évaluation pour la transformation des batteries*

UL 1989, *Standby Batteries*

UL 1998, *Software in Programmable Components*

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

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

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

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

6 Glossary

6.1 BATTERY MANAGEMENT SYSTEM (BMS) – A battery control circuit with active protection devices that monitors and maintains the cells within their specified operating region; and which prevents overcharge, overcurrent, overtemperature, under-temperature and overdischarge conditions of the cells.

6.2 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.

6.3 CASING – The container that directly encloses and confines the electrolyte, and electrodes of a cell or electrochemical capacitor.

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

6.5 CELL BANK – One or more cells connected in parallel.

6.6 CELL STRING – One or more cells connected in series.

6.7 CHARGING – The application of electric current to battery or capacitor terminals, which results in a Faradic reaction that takes place within the battery that leads to stored electro-chemical energy or in the case of the capacitor, due to electrical charge being stored without a chemical reaction taking place. For light electric vehicle applications, charging of the EESA can occur through one or more of the following methods:

- a) Regenerative braking which utilizes energy from regenerative brakes.
- b) Off board charging, which utilizes an ac-to-dc charger, a dc charger, or an inductive charger external to the vehicle.
- c) On board charging which utilizes a charger on the vehicle 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 CHARGING, CONSTANT VOLTAGE (CV) – Charging mode where voltage is held constant while charging current is allowed to vary.

6.10 DUT – Device under test.

6.11 ELECTRIC ENERGY STORAGE ASSEMBLY (EESA) – A battery pack, electrochemical capacitor pack or combination battery/electrochemical capacitor pack that provides electric energy for electric vehicle motive power. This assembly can include the cooling and ventilation systems and battery management systems.

6.12 **ELECTRIC MOTORCYCLE** – An electric motor vehicle having a seat or saddle for the use of the rider and designed to travel on not more than three wheels in contact with the ground, but excluding a tractor. An electric motorcycle is intended for use on public roadways including highways.

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

6.14 **ELECTRIC SCOOTER** - A device weighing less than one hundred pounds that:

- a) Has handlebars, a floorboard or a seat that can be stood or sat upon by the operator, and an electric motor;
- b) Can be powered by the electric motor and/or human power; and
- c) Has a maximum speed of no more than 20 mph on a paved level surface when powered solely by the electric motor.

6.15 **ELECTROCHEMICAL CAPACITOR** – An electric energy storage device where electrical charge is typically stored as a result of non-Faradaic reactions at the electrodes. (A subset of electrochemical capacitors referred to as an "asymmetric" type have non-Faradaic reactions at one electrode and Faradaic reactions at the other electrode.) The porous surface of the electrodes increases the surface area for holding charge resulting in much larger capacitance and energy density. Electrochemical capacitors differ from common electrolytic capacitors in that they employ a liquid rather than a solid dielectric with charge occurring at the liquid-solid interface of the electrodes when a potential is applied. Some other common names for an electrochemical capacitor are "double layer capacitor", "ultracapacitor", "electrochemical double layer capacitor" and "super capacitor".

6.16 **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.

6.17 **ENCLOSURE** – The outer cover of the EESA that provides protection to its contents.

6.18 **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.

6.19 **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.

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

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

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

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

6.24 **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.

6.25 LIGHT ELECTRIC VEHICLE (LEV) – A light duty on-road or off-road vehicle that uses electricity as its source of energy for motive power, which is not considered suitable for use on highway systems. The following are examples of LEVs:

- a) Electric bicycles;
- b) Electric scooters as defined in [6.14](#);
- c) Electric wheel chairs;
- d) Golf carts;
- e) All-terrain vehicles;
- f) Non-ride-on industrial material handling equipment;
- g) Unmanned aerial vehicles (UAVs);
- h) Ride-on floor care machines; and
- j) Personal e-mobility devices.

NOTE: A LEV is not limited to the examples given above. Any EESA used in an LEV that meets the above definition can be covered by this Standard unless there is a dedicated LEV standard specifying the requirements for its EESA.

6.26 MODULE – A subassembly consisting of a group of cells or cells and electrochemical capacitors connected together either in a series (cell string) and/or parallel configuration (cell bank) with or without protective devices and monitoring circuitry. A module is a component of a pack.

6.27 MONOBLOC BATTERY – A multi-cell battery design that contains a common pressure vessel construction, a single vent line assembly, and shared hardware.

6.28 MOSOC – Maximum operating state of charge. See [18.1](#).

6.29 MOTORCYCLE – A motor vehicle having a seat or saddle for the use of the rider and designed to travel on not more than three wheels in contact with the ground, but excluding a tractor. A motorcycle is intended for use on public roadways including highways.

6.30 NORMAL OPERATING REGION – That region of voltage, current and temperature within which a cell or electrochemical capacitor 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 normal 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/capacitor. 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/capacitor. This temperature is measured on the casing.
- c) END OF DISCHARGE VOLTAGE – Refer to [6.18](#).
- d) MAXIMUM DISCHARGING CURRENT – The maximum discharging current rate, which is specified by the cell/capacitor manufacturer.
- e) MAXIMUM CHARGING CURRENT – The maximum charging current in the normal operating region, which is specified by the cell/capacitor manufacturer. This value may vary with temperature.
- f) UPPER LIMIT CHARGING VOLTAGE – The highest charging voltage limit in the normal operating region specified by the cell/capacitor manufacturer. This value may vary with temperature.

6.31 PACK – General term for either a battery pack or capacitor pack as defined below. A pack can also consist of a hybrid systems containing both batteries and capacitors.

- a) PACK, BATTERY – Batteries that are ready for use in an LEV, contained in a protective enclosure, with protective devices, with a battery management system, and monitoring circuitry, with or without cooling systems.
- b) PACK, CAPACITOR – Electrochemical capacitors that are ready for use in an LEV, contained in a protective enclosure, with or without protective devices, cooling systems, and monitoring circuitry.

6.32 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.

6.33 PRIMARY OVERCURRENT PROTECTION – The safety device or circuit that is part of the safety control system intended to prevent an overcurrent hazard, and which typically operates before any secondary or supplemental protection operates, examples are fuses or circuit breakers.

6.34 PRIMARY SAFETY PROTECTION – The safety device or circuit that is part of the safety control system intended to prevent a hazard, and which operates before any secondary or supplemental protection operates.

6.35 PROTECTIVE DEVICES, ACTIVE – Devices provided to prevent hazardous conditions that require electrical energy in order to operate. An example of an active control would be a battery management system (BMS) that has monitoring and control functions.

6.36 PROTECTIVE DEVICES, PASSIVE – Devices provided to prevent hazardous conditions that do not require electrical energy in order to operate. Examples of passive protective devices would be fuses, thermal snap switches.

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