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JOINT CANADA-UNITED STATES
NATIONAL STANDARD

STANDARD FOR SAFETY

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



ANSI/UL 2271-2018



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

Second Edition, Dated September 7, 2018

Summary of Topics

The Second Edition of UL/ULC 2271 has been issued to reflect the latest ANSI and SCC approval dates, and to incorporate the the following changes in requirements:

Correction of Cell Criteria and Tolerance Information.

Vibration Endurance Test Revisions.

Revision of marking and instruction requirements for EESAs that are not removed when charging.

Addition of Production Quality Control Criteria in 17.4.

Clarifications to the functional safety criteria.

Clarification of connections to battery cells.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated December 22, 2017 and May 25, 2018.

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SEPTEMBER 7, 2018

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UL/ULC 2271

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

First Edition – May, 2018

Second Edition

September 7, 2018

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

The most recent designation of ANSI/UL 2271 as an American National Standard (ANSI) occurred on September 7, 2018. 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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CONTENTS

Preface	5
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INTRODUCTION

1 Scope	8
2 Components	8
3 Units of Measurement	8
4 Undated References	9
5 Reference Publications	9
6 Glossary	12

CONSTRUCTION

7 Non-Metallic Materials	15
8 Metallic Parts Resistance to Corrosion	16
9 Enclosures	17
10 Wiring and Terminals	18
11 Fuses	20
12 Handles	20
13 Electrical Spacings and Separation of Circuits	20
14 Insulation Levels and Protective Grounding	21
15 Protective Circuit and Safety Analysis	22
16 Cells and Electrochemical Capacitors	24
17 Manufacturing and Production Line Testing	25

PERFORMANCE

18 General	26
19 Combustible Concentrations	27
20 Measurement Equipment Accuracy	28
21 Post Test Cycle	28
22 Results Criteria	29

ELECTRICAL TESTS

23 Overcharge Test	29
24 Short Circuit Test	30
25 Overdischarge Test	31
26 Temperature Test	32
27 Imbalanced Charging Test	34
28 Dielectric Voltage Withstand Test	35
29 Isolation Resistance Test	37
29.1 Isolation resistance method for systems rated 120 V and above	37
29.2 Isolation resistance method for systems rated below 120 V (insulation resistance method)	38

MECHANICAL TESTS

30	Vibration Endurance Test	38
31	Shock Test	40
32	Crush Test	41
33	Drop Test	42
	33.1 Drop test for EESAs intended to be removable by the user	42
	33.2 Drop test for EESAs intended for service handling only	43
34	Mold Stress Relief Test	44
35	Handle Loading Test	45
36	Roll Over Test	45
37	Strain Relief Tests (Cord Anchorages)	46
	37.1 General	46
	37.2 Strain relief pull test	46
	37.3 Push-back test	46

ENVIRONMENTAL TESTS

38	Immersion Test	47
39	Water Exposure Test (IP Code Rating)	48
40	Thermal Cycling Test	49
41	Label Permanence Test	50

MARKINGS

42	General	50
----	---------------	----

INSTRUCTIONS

43	General	52
----	---------------	----

ANNEX A (NORMATIVE)

A1	Component Standards	A1
----	---------------------------	----

ANNEX B (NORMATIVE) Corrosion Chart

Preface

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

This joint American National Standard and National Standard of Canada is based on, and now supersedes, the First Edition of UL 2271 and the First Edition of CAN/ULC-S2271-13.

UL 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 A and Annex B are identified as Normative, as such, form mandatory parts of this Standard.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

Comments or proposals for revisions on any part of the Standard may be submitted at any time. Proposals should be submitted via a Proposal Request in the On-Line 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 UL Standards Technical Panel (STP) on Batteries for Use in Electric Vehicles, STP 2580.

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

STP 2580 Membership

Name	Representing	Interest Category	Region
Archambault, Alec	Blue Solutions Canada Inc	Producer	Canada
Arora, Pankaj	DuPont	Supply Chain	USA
Bender, Curtis A.	Tennant Company	Supply Chain	USA
Byczek, Rich	Intertek	Testing and Standards	USA
Chatwin, Troy D.	General Electric	Producer	USA
De Lucia, Thomas M.	NEC Energy Solutions	Producer	USA
Del Rosario, Jerome	City of Winnipeg	AHJ	Canada
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Michot, Christian J.	INERIS	Testing and Standards	France
Pinon, James O.	Hybrid Design Services, Inc.	General Interest	USA
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Ryu, ShinHwan	TUV Rheinland Korea	Testing and Standards	Korea
Shen, Edmund	Tesla Motors, Inc.	Producer	USA
Shih, Guan-Ting	Automotive Research Testing Center	General Interest	Taiwan
Spataru, Alex	The ADEPT Group, Inc.	Commercial/Industrial User	USA
Theivanayagam, Murali Ganth	The Dow Chemical Co	Supply Chain	USA
Tsen, Maoee	Phoenix Silicon International Corp	Producer	Taiwan
Van Heirseele, Megan	Underwriters Laboratories Inc.	Project Manager (Non-Voting)	USA
Weaver, John H	C&M Corporation	Supply Chain	USA
Weidner, Gary G.	GW Technical Services Inc.	General Interest	USA
Wong, Anthony	ATL	Producer	USA
Wu, Donald P.H.		Producer	Taiwan
Yun, Yonghee	Samsung SDI	Producer	Korea

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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.

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 intended for use on public roadways including highways and heavy duty off road vehicles such as battery powered ride-on industrial trucks, which are covered under the Standard for Batteries for Use in Electric Vehicles, UL 2580 / ULC-S2580.

1.4 This standard does not include requirements for evaluation of EESAs intended for use in light electric rail (LER) applications, which are covered under the Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications, UL 1973.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this Standard shall comply with the requirements for that component. See Annex A for a list of Standards covering components generally used in the products covered by this Standard. A component shall comply with the Standards of CSA or UL Standards as appropriate for the country where the product is to be used.

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.

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 Reference 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.

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 1642

Lithium Batteries

UL 1973

Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications

UL 1989

Standby Batteries

UL 1998

Software in Programmable Components

UL 2054

Household and Commercial Batteries

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UL 2251

Plugs, Receptacles and Couplers for Electric Vehicles

UL 2580

Batteries for Use in Electric Vehicles

UL 60730-1

Automatic Electrical Controls – Part 1: General Requirements

UL 60950-1

Information Technology Equipment – Safety – Part 1: General Requirements

ULC Standards

ULC-S2580

Batteries for Use in Electric Vehicles

CSA Group Standards

CAN/CSA-C22.2 No. 0.17

Evaluation of Properties of Polymeric Materials

CSA-C22.2 No. 0.2

Insulation Coordination

CAN/CSA-C22.2 No. 94.2

Enclosures for Electrical Equipment, Environmental Considerations

CAN/CSA-C22.2 No. 60950-1

Information Technology Equipment Safety – Part 1: General Requirements

CSA-E60730-1

Automatic Electrical Controls for Household and Similar Use – Part 1: General Requirements

IEC Standards

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)

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IEC 61508-1

Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems Part 1: General Requirements

ISO Standards

ISO No. 7010

Graphical symbols – Safety Colours and Safety Signs – Registered Safety Signs

ISO 6469-1

Electrically Propelled Road Vehicles – Safety Specifications – Part 1: On-Board Rechargeable Energy Storage System (RESS)

ISO 12405-1

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

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)

SAE Standards

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

US Department of Defense (DOD) Standards

MIL-STD-1629A

The Procedures for Performing a Failure Mode, Effects, and Criticality Analysis

6 Glossary

6.1 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.

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

6.3 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.

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

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

6.6 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.

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

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

6.9 DUT – Device under test.

6.10 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.

6.11 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.

6.12 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".

6.13 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 the EESA that provides protection to its contents.

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

6.19 FULLY DISCHARGED – An EESA, 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 **LIGHT ELECTRIC VEHICLE (LEV)** – A light duty on-road or off-road vehicle that uses electricity as its source of energy for motive power. With the exception of motorcycles, an on road LEV is typically not considered suitable for use on highway systems. The following are considered LEVs:

- a) Electric bicycles;
- b) Electric scooters and motorcycles;
- c) Electric wheel chairs;
- d) Golf carts;
- e) All-terrain vehicles;
- f) Non-ride-on industrial material handling equipment;
- g) Ride-on floor care machines and lawnmowers; and
- h) Personal mobility devices.

6.23 **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.

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

6.25 **MOSOC** – Maximum operating state of charge. See 18.1.

6.26 **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 6.15.
- 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.

6.27 **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.

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

6.29 **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.

6.30 **SAFETY CRITICAL CIRCUITS/COMPONENTS** – Those circuits or discrete components that are relied upon for safety as identified in the safety analysis of 15.2.

6.31 **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 shall comply with the applicable enclosure requirements outlined in the Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, Path III of the Enclosure Requirements Table, except as modified by this standard.

7.2 Polymeric materials employed for enclosures shall have a minimum flame rating of V-1 in accordance with the Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

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.

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;

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- 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. EESA 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 Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

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 Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

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 in the Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C 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.

7.7 Gaskets and Seals of the EESA 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 EESA 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, CAN/CSA-C22.2 No. 94.2 / UL 50E.

8.2 Metallic EESA 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 within the pack during operation.

8.3 Conductive parts in contact at terminals and connections shall not be subject to corrosion due to electrochemical action. Combinations above the line in Table B.1 of Annex B shall be avoided.

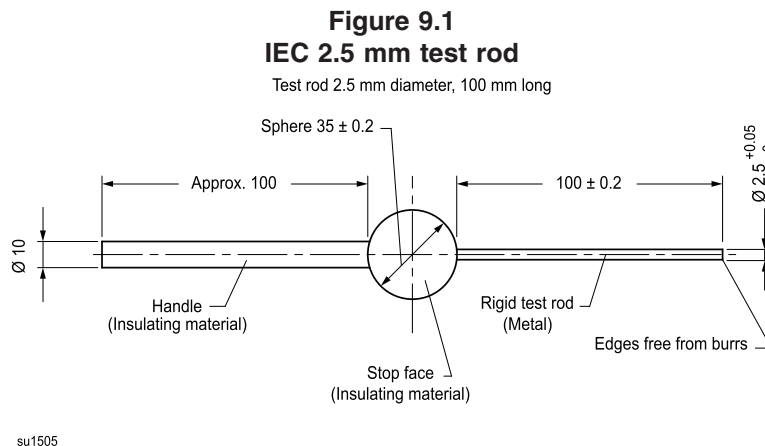
9 Enclosures

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

9.2 A tool providing the mechanical advantage of a pliers, screwdriver, or similar tool, shall be the minimum mechanical capability required to open the enclosure.

9.3 Openings in the enclosure of an electric energy storage assembly shall be designed to prevent inadvertent access to hazardous parts as installed in the vehicle. Compliance is determined by the "Tests for Protection Against Access to Hazardous Parts Indicated by the First Characteristic Numeral, Clause 12" of the Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529, for a minimum IP rating of IP3X with consideration of the device as it is installed in the vehicle. Evaluation per the Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529, Clause 12, consists of the use of the 2.5 mm Test Rod, shown in Figure 9.1, applied with a force of $10\text{ N} \pm 10\%$.

Exception: For EESAs that are intended for removal from the vehicle for external charging or replacement with a charged EESA by the user rather than being charged while installed in the vehicle, compliance is determined on the electric energy storage assembly with and without consideration of the device as it is installed in the vehicle.



Note: The handle dimensions ($\varnothing 10$ and 20) are not critical.

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