



UL 2580

Underwriters Laboratories Inc. Standard for Safety

Batteries for Use in Electric Vehicles



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UL Standard for Safety for Batteries for Use in Electric Vehicles, UL 2580

First Edition, Dated October 13, 2011

Summary of Topics

The first edition of the Standard for Batteries for Use in Electric Vehicles, UL 2580 has been published and reflects the first time ANSI approval as an American National Standard.

The new requirements are substantially in accordance with Proposal(s) on this subject dated April 1, 2011 and August 26, 2011.

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OCTOBER 13, 2011

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ANSI/UL 2580-2011

UL 2580

Standard for Batteries for Use in Electric Vehicles

First Edition

October 13, 2011

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

The most recent designation of ANSI/UL 2580 as an American National Standard (ANSI) occurred on October 13, 2011. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or effective date information.

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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APPENDIX B

Electrochemical Potentials

INTRODUCTION

1 Scope

1.1 These requirements cover electrical energy storage assemblies such as battery packs and combination battery pack-electrochemical capacitor assemblies and the subassembly/modules that make up these assemblies for use in electric-powered vehicles as defined in this standard.

1.2 This standard evaluates the electrical energy storage assembly's ability to safely withstand simulated abuse conditions and prevents any exposure of persons to hazards as a result of the abuse. This standard evaluates the electric energy storage assembly and modules based upon the manufacturer's specified charge and discharge parameters at specified temperatures. It does not evaluate the assembly's interaction with other control systems within the vehicle.

1.3 This standard does not evaluate the performance or reliability of these devices.

1.4 This standard does not include requirements for the evaluation of batteries for light electric vehicles such as electrical assist bicycles, wheel chairs, electric scooters and similar devices as defined in the Outline of Investigation for Batteries for Light Electric Vehicles, Subject 2271.

2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 References and Components

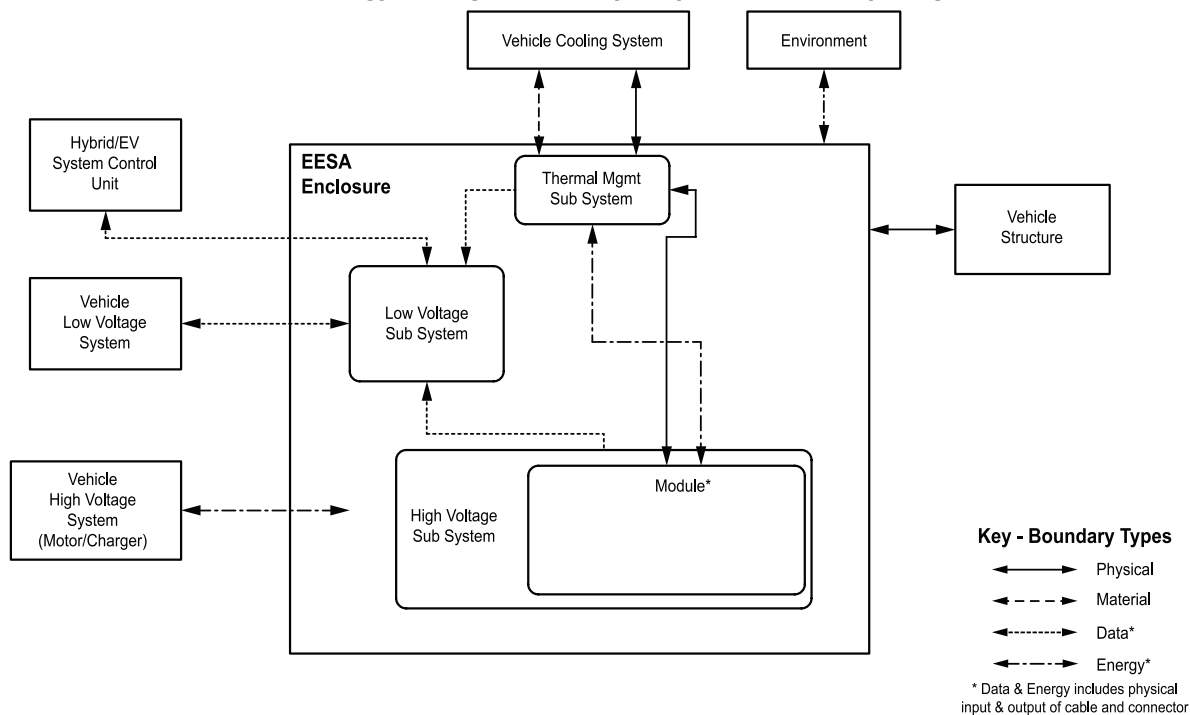
3.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

3.2 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.

4 Glossary

4.1 BATTERY PACK – Batteries that are ready for use in a electric powered vehicle, contained in a protective enclosure, with protective devices, with a battery management system, and monitoring circuitry, with or without cooling systems. See Figure 4.1.

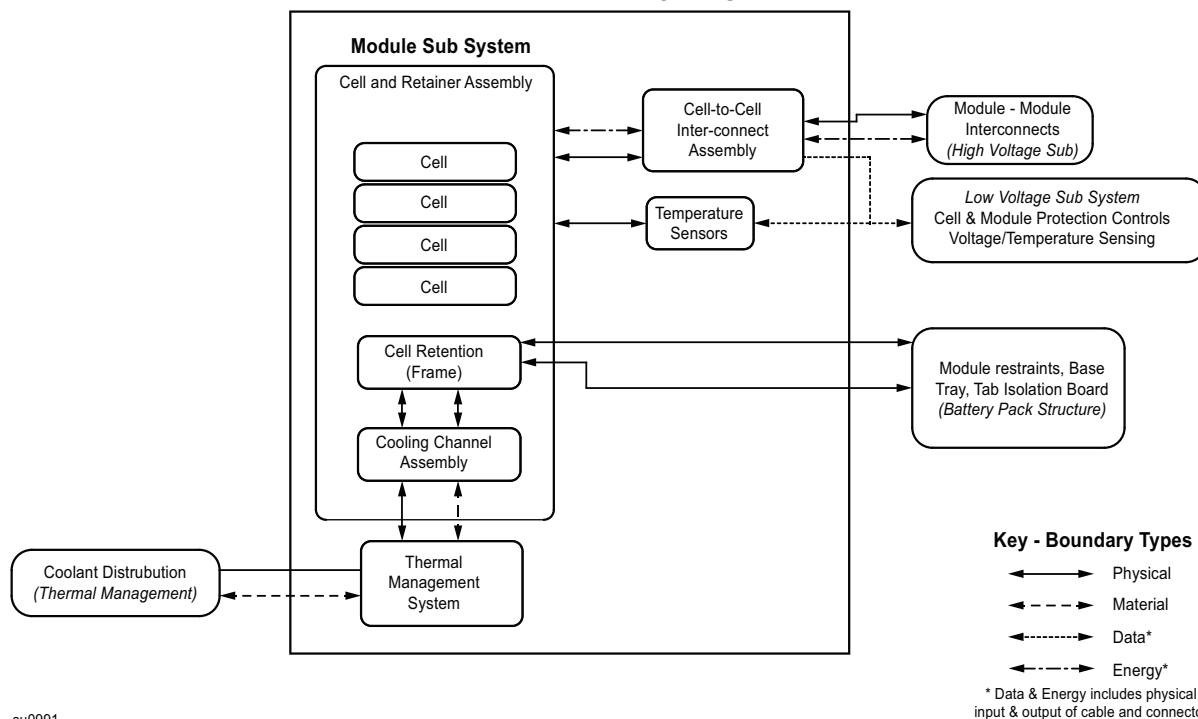
Figure 4.1
Electric energy storage assembly – system boundary diagram



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4.2 CAPACITOR PACK – Electrochemical capacitors that are ready for use in a electric powered vehicle, contained in a protective enclosure, with or without protective devices, cooling systems, and monitoring circuitry. See Figure 4.2.

Figure 4.2
Module – boundary diagram



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4.3 CAPACITY, RATED (C_n) – 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.

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

4.5 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.

4.6 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 electric vehicle applications, charging of the electric energy storage assembly 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 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. Charge energy can be provided external to vehicle or by an on board generator (termed Extended Range EV).

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

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

4.9 DUT – Device under test.

4.10 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. See Figure 4.1.

4.11 ELECTRIC POWERED VEHICLE – An on-road or off-road vehicle that uses electricity from batteries or other electric energy storage assemblies as a source of energy for motive power. Electric powered vehicles cover, but are not limited to, road passenger vehicles and heavy duty off road vehicles such as industrial trucks.

4.12 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 unique 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", "ultra capacitor", "electrochemical double layer capacitor" and "super capacitor".

4.13 ENCLOSURE – The protective outer cover of the electric energy storage assembly that provides mechanical protection to the assembly's contents.

4.14 END-OF-DISCHARGE VOLTAGE (EODV) (Cell) – The voltage, under a specified load, of the cell at the end of discharge. The EODV may be specified by the manufacturer, as in the case of a voltage-terminated discharge typical for lithium ion chemistries.

4.15 EODV MONITORING (Cell) – EODV monitoring is typically provided at the pack/electric energy storage assembly level by the battery management system.

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

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

4.18 FULLY CHARGED – An electric energy storage assembly, pack, module or cell which has been charged to its full state of charge (SOC) as specified by the manufacturer.

4.19 FULLY DISCHARGED – An electric energy storage assembly, pack, module or cell, which has been discharged to its end-of-discharge voltage (EODV) as specified by the manufacturer.

4.20 HAZARDOUS ENERGY – Available power level of 240 VA or more, having a duration of 60 s or more, or a stored energy level of 20 J or more, at a voltage of 2 V or more.

4.21 HAZARDOUS VOLTAGE – Voltage exceeding 42.4 V peak or 60 V dc.

4.22 INSULATION LEVELS – The following are levels of electrical insulation:

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

b) 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.

c) 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.

d) 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.

4.23 LEAKAGE – A condition where liquid electrolyte escapes through the opening of a designed vent as well as through a rupture or crack or other unintended opening and is visible external to the device under test.

4.24 LITHIUM ION CELL – A rechargeable cell where electrical energy is derived from the insertion/extraction reactions of lithium ions between the anode and the cathode. The lithium ion cell has an electrolyte that typically consists of a lithium salt and organic solvent compound in liquid or gel or solid form and has either a hard metal casing or a flexible polymeric pouch casing.

4.25 MANUFACTURING PRODUCTION LINE TESTING – Testing at the manufacturer's facilities used as a manufacturing check of their production. Depending upon the testing, it either can be a 100% production test, or can be a periodic check or sampling of production. This testing is sometimes referred to as routine testing.

4.26 MAXIMUM WORKING VOLTAGE – The highest voltage to which the insulation or component under consideration is or can be subjected to when the equipment is operated under conditions of normal use.

4.27 MODULE – A subassembly consisting of a group of cells or electrochemical capacitors connected together either in a series and/or parallel configuration (sometimes referred to as a block) with or without protective devices and monitoring circuitry. A module is a component of an electric energy storage assembly. See Figure 4.2.

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

4.29 MOSOC – Maximum Operating State of Charge. See 6.1.

4.30 NICKEL CELL – A general term for a nickel cadmium or nickel metal hydride rechargeable cell that has a nickel hydroxide positive electrode and either a cadmium metal or metal hydride negative electrode and that has a liquid alkaline (i.e. KOH) electrolyte.

4.31 NORMAL OPERATING REGION – That region of voltage, current, and temperature within which a cell or electrochemical capacitor can safely be 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.

4.32 PROTECTIVE COMPONENTS, 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).

4.33 PROTECTIVE COMPONENTS, PASSIVE – Devices provided to prevent hazardous conditions that do not require electrical energy in order to operate. An example of a passive protective device would be a fuse.

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

4.35 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.

4.36 SODIUM NICKEL CHLORIDE CELL – A rechargeable cell that has a sodium negative electrode, a positive electrode that consists of nickel, nickel chloride and sodium chloride and a ceramic beta alumina electrolyte. The normal operation of the cell is within a temperature range of 270°C – 350°C (518°F – 662°F) so that the active materials are in a molten state and to ensure ionic conductivity.

4.37 STATE OF CHARGE (SOC) – The available capacity in an electrical energy storage assembly, pack, module or cell expressed as a percentage of rated capacity.

4.38 TOXIC GAS RELEASE (Crash/Nonoperational Levels) – A release of vapor that is categorized as an Emergency Response Planning Guidelines (ERPG) level 2.

a) ERPG-2 defines this as: "The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action." Methods for determination of this limit are outlined in Section 11.

4.39 TOXIC GAS RELEASE (Operational Levels) – A release of vapor that results in a concentration in excess of the Occupational Safety and Health Administration (OSHA) 8-h time-weighted-average (TWA) permissible exposure limit, which corresponds to the National Institute of Safety and Health (NIOSH) 10-h per day 40-h per week permissible exposure limit. Methods for determination of this limit are outlined in Section 11.

4.40 VEHICLE, OFF ROAD – A motorized conveyance that is not intended for transporting persons and/or objects on public roads including the highway systems. Examples of such devices would be industrial trucks, farming equipment, construction equipment.

4.41 VEHICLE, ON ROAD – A motorized conveyance that is intended for transporting persons and objects on public roads including the highway systems. Examples of such devices would be passenger autos, trucks, buses, etc.

4.42 VENTING – A condition when the cell electrolyte and/or battery solvent is emitted as vapor, smoke or aerosol from a designed vent or through a sealing edge.

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CONSTRUCTION

5 General

5.1 Non-metallic materials

5.1.1 The materials employed for enclosures shall comply with the applicable enclosure and insulation requirements outlined in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, Path III of the table for Enclosure Requirements, Table 4.1, except as modified by this standard.

5.1.2 Polymeric materials employed for enclosures shall have a minimum flame rating of V-1 in accordance with the 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.

5.1.3 The following factors, items (a) – (e), shall be taken into consideration when an enclosure 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 distortion test.

- a) Resistance to impact;
- b) Crush resistance;
- c) Abnormal operations;
- d) Severe conditions; and
- e) Mold-Stress Relief Distortion.

5.1.4 The polymeric materials employed shall be suitable for temperatures encountered. Enclosures shall have a Relative Thermal Index (RTI) with impact suitable for temperatures encountered in the application, but no less than 100°C (212°F), as determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

5.1.5 Polymeric enclosure materials intended to be exposed to sunlight 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.

5.1.6 Materials employed as electrical insulation in the assembly shall be resistant to deterioration that would result in an electrical shock or other safety hazard. Compliance is determined by the tests of this standard. Insulated wiring is subjected to the requirements outlined in 5.4.