

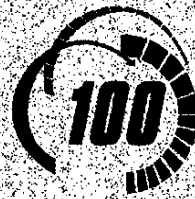
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Standard for Safety

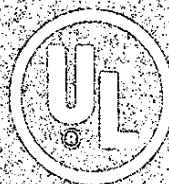
UL 1989

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Standby Batteries



a century of
public safety
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Standard

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Underwriters Laboratories Inc. (UL)
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UL Standard for Safety
for
Standby Batteries, UL 1989

Second Edition, Dated December 26, 1996

Revisions: This Standard contains revisions through and including April 2, 1998.

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The revisions dated April 2, 1998 include a reprinted title page (page 1) for this Standard.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Recognition and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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Page	Date
tr1, tr2	April 2, 1998
1	December 26, 1996 (Reprinted: April 2, 1998)
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UL 1989

Standard for

Standby Batteries

First Edition – November, 1992

Second Edition

December 26, 1996

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover instrument batteries, enclosed batteries, emergency lighting and power batteries and uninterruptible power supply batteries.

1.2 These requirements only address potential risks unique to the utilization of a battery supply in a product. Products employing a battery supply shall comply with the basic requirements contained in this standard applicable to the type of product and its intended use.

1.3 These requirements do not cover risks that may be unique to certain cell chemistries, such as the fire and explosion risks of lithium batteries. Additional investigations are required to evaluate such risks.

1.4 The investigation of a family or group of batteries may be based on the investigation of batteries representative of the family or group.

1.5 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with methods employed for development, revision, and implementation of this standard.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.1.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

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

2.1.4 Specific components are recognized as being 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 for which they have been recognized.

2.2 Units of measurement

2.2.1 If a value for measurement is followed by a value in other units in parentheses the first stated value is the requirement.

2.3 Undated references

2.3.1 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 Glossary

3.1 The following definitions apply for the purpose of this Standard.

3.2 BATTERY, ENCLOSED – A battery surrounded by a case or housing used to protect the contained battery and prevent personnel from accidentally contacting live parts. Additionally, the battery is to be of the secondary type providing a supply less than 60 volts, contained within telephone equipment on customers premises, up to approximately 27.2 kg (60 pounds) in weight, approximately 100 ampere-hours (20 hour rate), and typically lead-acid type.

3.3 BATTERY, INSTRUMENT – A small primary or secondary battery, up to 4.54 kg (10 pounds) in weight, used within telephone instruments. Typical types are:

- a) Primary (dry) cells such as (1) carbon zinc cells (LeClanche and zinc chloride cells), or (2) alkaline (manganese-dioxide) cells.
- b) Secondary (rechargeable) cells such as nickel cadmium.

3.4 BATTERY, NICKEL-CADMIUM STORAGE:

- a) VALVE REGULATED – An alkaline storage battery in which the positive active material is nickel oxide and the negative contains cadmium and the venting of the products of electrolysis is controlled by a reclosing pressure sensitive valve.
- b) VENTED – An alkaline storage battery in which the positive active material is nickel oxide and the negative contains cadmium and the products of electrolysis and evaporation are allowed to escape freely to the atmosphere. These batteries are commonly referred to as flooded.

3.5 BATTERY GROUP – A group or family of battery types that exhibit similar physical characteristics with respect to cell chemistry, cell construction, cell structure, and case (enclosure), and that are rated such that all batteries in the group demonstrate equivalent performance characteristics. Batteries belonging to the same group or family differ only in capacity or physical dimensions, or both.

3.6 BATTERY SUPPLY – One or more unitcell or multicell batteries that together supply power to a battery-operated product. A battery supply may consist of a collection of individual and separately replaceable unitcell or multicell batteries in a series and/or parallel array of permanently interconnected and not separately replaceable unitcell or multicell batteries (for example, a "battery pack").

3.7 BATTERY SUPPLY ENCLOSURE - A surrounding case or housing used to protect the battery supply and prevent personnel from accidentally contacting live parts. The battery supply enclosure may be part of the battery-operated product, or in the case of an external battery supply a separate structure housing the battery supply.

3.8 CAPACITY - Generally, the total number of ampere-hours that can be withdrawn from a fully charged battery at a specific discharge rate and electrolyte temperature, and to a specific cutoff voltage.

3.9 CELL - The basic electrochemical unit, characterized by an anode and a cathode used to receive, store, and deliver electrical energy.

3.10 CHARGE AND DISCHARGE CURRENT (OR RATE) - The rate, in amperes, at which current is delivered to (charge) or by (discharge) a battery expressed in multiples of the value C, which is the rated capacity of the cell or battery in ampere-hours as stated by the manufacturer. For example, 0.1C amperes designates that the value of the charge or discharge current in amperes is 0.1 times the numerical value of the rated capacity in ampere-hours. In terms of charge and discharge rates, 0.1C amperes corresponds to a 10 hour (charge or discharge) rate ($C/10 = 0.1C$ amperes).

3.11 CHARGING - The conversion of electrical energy into chemical energy within the cell or battery. Note: This restoration of the active materials is accomplished by maintaining an unidirectional current in the cell or battery in the opposition direction to that during discharge; a cell or battery that is stated to be charged is understood to be fully charged.

3.12 CONTROLLED CURRENT CHARGE - A method of charging a battery by controlling the charger current to the battery; that is, constant current, taper current, trickle current, and the like.

3.13 CONTROLLED VOLTAGE CHARGE - A method of charging a battery by controlling the charger voltage to the battery; that is, constant voltage, multilevel voltage, float voltage, and the like.

3.14 CURRENT RATING - The discharge capacity in amperes obtainable from a battery for 1-1/2 hours at a constant discharge rate. The current rating is specified by the battery manufacturer.

3.15 DISCHARGE - Withdrawal of electrical energy from a cell or battery.

3.16 DRY CELL (OR BATTERY) - A cell (or battery) in which the electrolyte is immobilized.

3.17 EFFECTIVE INTERNAL RESISTANCE (R_e) - The resistance to the flow of an electric current within a cell or battery.

3.18 ELECTROLYTE - A conducting medium in which the flow of electric current takes place by migration of ions. Note: Many physical chemists define electrolyte as a substance that when dissolved in a specific solvent, usually water, produces an ionically conducting solution.

3.19 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.

3.20 JAR (OR CASE) – The container that directly encloses and confines the electrolyte, anode and cathode of a cell or battery.

3.21 LEAD ACID BATTERY:

a) VALVE REGULATED – A storage battery, the electrodes of which are made of lead (negative electrode) and lead dioxide (positive electrode) and the electrolyte consists of a solution of sulfuric acid in which the venting of the products of electrolysis is controlled by a reclosing pressure-sensitive valve. These batteries have commonly been referred to as maintenance-free, starved electrolyte.

b) VENTED – A storage battery the electrodes of which are made of lead and the electrolyte consists of a solution of sulfuric acid in which the products of electrolysis and evaporation are allowed to escape freely to the atmosphere. These batteries have commonly been referred to as flooded or wet.

3.22 MULTICELL BATTERY – A battery consisting, internally, of a series and/or parallel array of two or more cells.

3.23 PRIMARY CELL (OR BATTERY) – A cell (or battery) that produces electric current by electrochemical reactions without regard to the reversibility of those reactions. Some primary cells are reversible to a limited extent.

3.24 RATED CAPACITY – The ampere-hour capacity assigned to a storage cell by its manufacturer for a given discharge time, at a specified electrolyte temperature and specific gravity, to a given end-of-discharge voltage.

3.25 RATED VOLTAGE – The nominal terminal voltage delivered by the cell or battery during normal discharge, and normally marked on the battery jacket.

3.26 SECONDARY CELL (OR BATTERY) – A cell (or battery) that produces electric current by reversible electrochemical reactions.

3.27 UNITCELL BATTERY – A battery consisting of a single cell. For example, size N, AAA, AA, C, and D "flashlight" batteries.

3.28 WET CELL (OR BATTERY) – A cell (or battery) whose electrolyte is in liquid form.

CONSTRUCTION

4 General

4.1 Lead acid type batteries shall have transparent or translucent jackets unless they are of the maintenance free type.

4.2 A vented cell or battery shall be equipped with a flame arrester designed to prevent an external flame from propagating into the cell when the byproducts of electrolysis (which are vented through the arrester) are ignited.

4.3 A sealed cell or battery shall be equipped with a pressure-release vent to prevent excessive accumulation of gas pressure, or the battery/cell shall be constructed to prevent scatter of cell parts in the event of a cell explosion. See Pressure Release Test.

4.4 The case material of batteries used in a uninterruptible power supply shall be classed as 94V-2, 94HF-2, or less flammable in accordance with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: Materials need not be classed as 94V-2, 94HF-2, or less flammable if they comply with the enclosure flammability - 3/4-inch (19-mm) flame test described in the Standard for Polymeric Materials - Use in Electrical Equipment Evaluations, UL 746C.

PERFORMANCE

5 General

5.1 A battery shall be tested as described in Sections 6 - 12 to determine if any fire or explosion is obtained under these test conditions. If a fire or explosion is obtained, the use of these batteries in products shall be restricted to applications in which the batteries will not be exposed to, or will be protected from, any conditions shown to cause a fire or explosion.

EMERGENCY LIGHTING AND POWER BATTERIES

6 Pressure Release Test

6.1 A sample of the battery/cell is to be submerged in a container of mineral oil. For large batteries only the vents need to be submerged. A charging current shall be caused to flow at an increased rate (to be specified by the manufacturer) until bubbles are observed to rise from the pressure release device openings. Results are acceptable if battery gas is released normally and the battery/cell case is not ruptured.

Exception: Rupture of the battery/cell case is acceptable if the rupture closely follows the design contours of a nonresealable single operation release device.

7 Flame Arrester Vent Cap Tests

7.1 General

7.1.1 After the various exposures as described in 7.2.2 there shall be no evidence of impairment or damaging effects to any of the eight samples and no evidence of a vent cap popping out of the simulated battery cover.

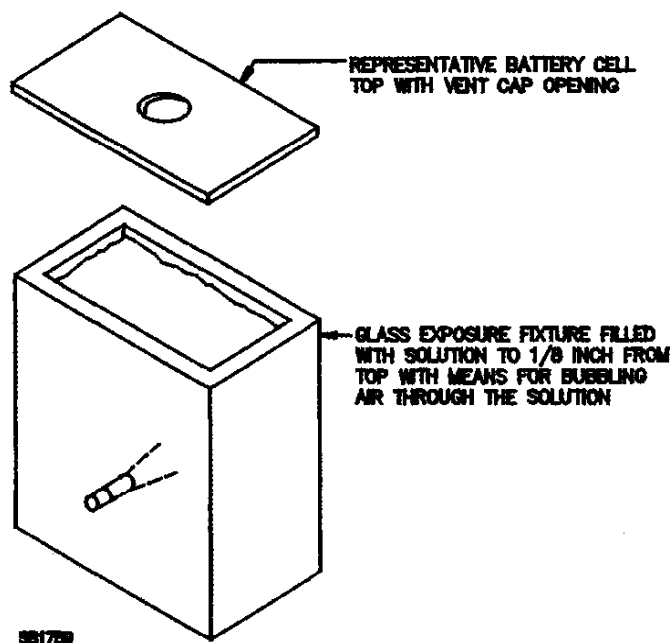
7.1.2 At least six vent caps (three sets of two each) and three simulated battery covers, to which the vent caps are intended to be attached, are to be provided for the conditioning procedure and vent cap tests as described in 7.2.1 - 7.6.3.

7.2 Conditioning

7.2.1 The conditioning apparatus is to consist of:

- a) A circulating-air oven,
- b) A humidity conditioning chamber, and
- c) A wetting-exposure fixture as shown in Figure 7.1.

Figure 7.1
Wetting exposure fixture



7.2.2 Prior to testing – two vent caps for each conditioning – are to be exposed to the following conditions:

- a) 48 hours at $23 \pm 2^{\circ}\text{C}$ ($73 \pm 3.6^{\circ}\text{F}$) and 50 ± 5 percent relative humidity.
- b) 168 hours at 70°C (158°F) in a circulating-air oven.
- c) While attached to simulated battery covers that are assembled on the top of the wetting fixture, one set of vent caps is to be exposed for 24 hours to an airflow of twice the maximum total flow (H_2 and O_2 combined) indicated by the four sets of flow rates in Table 7.1 for the appropriate battery capacity rating. If the vent cap is intended for use with a lead acid battery the airflow is to be bubbled through a 50 percent aqueous solution of sulfuric acid and vented through the cap. If the vent cap is intended for use with a nickel cadmium battery the airflow is to be bubbled through a 30 percent aqueous solution of potassium hydroxide and vented through the cap.

Table 7.1
Gas flow rates for battery vent caps

Battery capacity (ampere-hours)	Flow rate for hydrogen and oxygen, cc/min.							
	Flow rate number 1		Flow rate number 2		Flow rate number 3		Flow rate number 4	
	H_2	O_2	H_2	O_2	H_2	O_2	H_2	O_2
50	27	14	21	10.5	14	7	7	3.5
100	56	28	49	24.5	28	14	14	7
150	84	42	49	24.5	28	14	14	7
200	112	56	105	52.5	49	24.5	21	10.5
C^a	$\text{C}/1.8$	$\text{C}/3.6$	$\text{C}/2.5$	$\text{C}/5.0$	$\text{C}/5.0$	$\text{C}/10$	$\text{C}/10$	$\text{C}/20$

^a C is the capacity of the battery in ampere-hours (use this row if C is greater than 200)

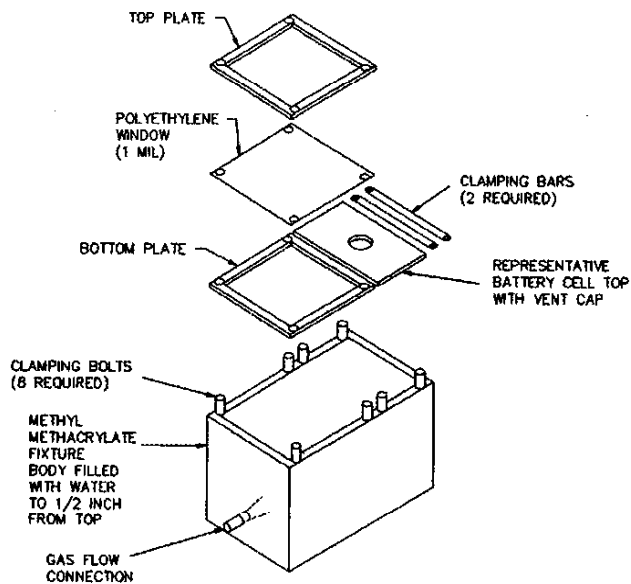
7.3 Vent cap tests

7.3.1 The conditioned samples are to be tested as described in 7.4.1 – 7.6.3.

7.3.2 The test apparatus is to consist of the following:

- a) A heavy wall plexiglass hydrogen test fixture as shown in Figure 7.2.
- b) Equipment capable of supplying, monitoring and mixing hydrogen and oxygen in stoichiometric proportions.
- c) A spark ignition source produced across a 6.4 mm (1/4 inch) gap in the 10 kilovolt, 23 milliamperes secondary of a transformer.
- d) A test enclosure as shown in Figure 7.3.
- e) An outer test chamber as shown in Figure 7.4 is to be used as needed for safety.

Figure 7.2
Hydrogen Test Fixture



SC1761

Figure 7.3
Test Enclosure
Clear Plastic with Ventilation Openings
Shown (1 in² opening area/500 in³ volume)

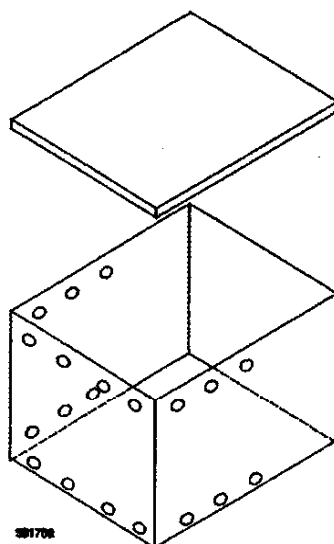
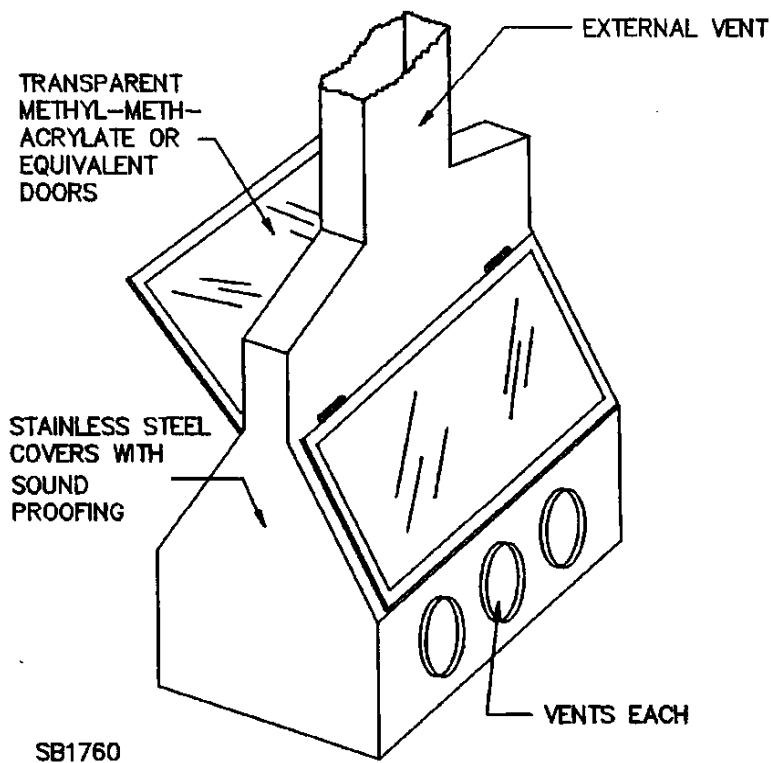


Figure 7.4
Outer Test Chamber



7.4 Back pressure test

7.4.1 Air shall be vented through a flame arrester vent at a rate equal in cubic centimeters per minute to the ampere-hour capacity of the battery divided by 13.5. The back pressure obtained shall be 15 millimeters of water or less.

7.5 Test for sustained burning

7.5.1 As a result of the testing described in 7.5.2 there shall be no sustained burning of vented gas that results in impairment to the vent cap.

7.5.2 One each of the conditioned samples are to be installed in the hydrogen test fixture, described in Figure 7.2 located inside the test enclosure, described in Figure 7.3, without the cover in place. The test fixture and enclosure are to be located in the outer test chamber, Figure 7.4, as considered necessary for safety purposes. A mixture of hydrogen and oxygen gas is to be caused to flow through the fixture and vent cap and is to be adjusted to the appropriate maximum value as indicated in Table 7.1. Six attempts are to be made to ignite the gas mixture venting from the cap using the spark ignition source. Since hydrogen gas can burn without visible flame, sustained burning is to be determined by using paper as an indicator.

7.6 Test for flame propagation

7.6.1 After the test described in 7.5.2 for sustained burning, one of each of the conditioned vent caps is to be installed as described in 7.5.2 with the test enclosure cover in place. The gas mixture is to be allowed to flow into the test fixture. Six attempts are to be made to ignite the gas venting from the cap, approximately 12.7 mm (1/2 inch) from the vent cap opening, using the spark ignition source located in the path of the gas flow. There is to be a 10 second interval between each ignition attempt.

7.6.2 The test described in 7.6.1 is to be repeated for each of the samples at each of the appropriate gas mixture flow rates as indicated in Table 7.1.

7.6.3 The results are not acceptable if there is evidence of flame propagation through the vent cap to within the fixture, as determined by rupture of the 0.025 mm (1 mil) polyethylene-film window in the top of the test fixture.

8 Capacity Rating Tests

8.1 A storage battery shall be capable of supplying and maintaining the maximum total load, at a specific temperature range, for a period not less than that indicated in the marking, but in no case for less than 1-1/2 hours and not less than 87.5 percent rated battery voltage.

8.2 The following data is to be supplied by the battery manufacturer:

- a) Battery type and rated voltage.
- b) Charging system to be used, either:
 - 1) Controlled voltage,
 - 2) Controlled current, or
 - 3) A combination controlled voltage and controlled current.

c) Range of charging rates:

- 1) Voltage (maximum and minimum), or
- 2) Current (maximum and minimum), or both.

d) Current rating is to be a 1-1/2 hour constant discharge current, resulting in an end-of-discharge voltage no less than 87.5 percent and no greater than 100 percent of rated voltage.

e) Whether the battery is to be used at room temperature, $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$) or within an expanded temperature range.

f) Electrolyte maintenance instructions.

8.3 The charging and discharging tests are described in Table 8.1. The required sequence is as follows:

- a) Controlled current charge test: I, II, III, IV, I, V, I, II.
- b) controlled voltage charge test: VI, II, VII, IV, VI, V, VI, II.
- c) Combination controlled current charge and controlled voltage charge test: I, II, III, IV, VII, IV, VI, V, I, V, VI, II.

Table 8.1
Charge/discharge tests

Test	Test mode	Duration of test (hour)	Load current	Measurements to be taken ^d
I	Charge @ I (controlled current) ^c	168 ^a	–	I_1, T_c, V_1
II	Discharge (constant current)	1-1/2	I_2	I_2, T_d, V_2
III	Charge @ I (controlled current) ^c	24 ^b	–	I_c, I_1, T_c, V_c, V_1
IV	Discharge (constant current)	1	I_2	I_2, T_d, V_2
V	Discharge (constant current)	24 ^c	I_2	I_2, T_d
VI	Charge @ V (controlled voltage) ^c	168 ^a	–	I_1, T_c, V_1
VII	Charge @ V (controlled voltage)	24 ^b	–	I_1, T_c, V_1

^a The charge period may be less than 168 hours if requested by the manufacturer.

^b The charge period may be less than 24 hours if requested by the manufacturer.

^c The 24-hour discharge period may be reduced if a sensing circuit is provided that disconnects the battery in a shorter time. The discharge period may be no less than 1-1/2 hours in any case.

^d The measurements symbolized are:

I_c – Specified charge current range (maximum and minimum).

I_1 – Battery charger current during battery charge cycle.

I_2 – Battery current rating.

T_c – Temperature on battery case during charge cycle.

T_d – Temperature on battery case during discharge cycle.

V_c – Specified charger voltage range (maximum and minimum).

V_1 – Battery terminal voltage during charge cycle.

V_2 – Closed circuit voltage at battery terminals at end of discharge cycle.

8.4 The battery may be subjected to a conditioning program specified by the manufacturer prior to the charging and discharging tests described in 8.3 and Table 8.1. The program may not:

- Exceed 168 hours, or
- Recharge the battery outside the manufacturer's recommended minimum or maximum rates.

8.5 The applicant has the option of having the battery tested for use at room temperature or within an expanded temperature range. Batteries shall be rated for the ambient temperature or temperature range in which the equipment they are to be installed in is intended to operate. For batteries intended to operate at temperatures other than $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$) the lower limit of the range shall be 10°C (50°F) or a lower temperature than 10°C in 10°C (18°F) increments. The upper limit of the range shall be 40°C (104°F) or a higher temperature than 40°C in 10°C (18°F) increments. Room temperature test conditions are specified in 8.6 and temperature range test conditions are given in 8.7.

8.6 All tests are to be conducted at an ambient temperature of $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$).

8.7 Each test is to be conducted after 24 hours of either condition A or B and while maintained at the specified condition. The total time of exposure to the environmental conditions will depend on the specified initial charge and recharge times for the Capacity Rating Test. The applicant has the option of using the same battery for testing under both A and B conditioning. However, the battery must undergo a full conditioning for each condition it is tested under. Conditions A and B are specified below. The test temperatures for both conditions A and B are not to vary from the rated value by more than $\pm 2^\circ\text{C}$ ($\pm 3.6^\circ\text{F}$).

a) Condition A: 24 hours at 5°C (9°F) greater than the rated upper limit of the ambient temperature range, but not less than 40°C (104°F), and 88 ± 2 percent relative humidity.

b) Condition B: 24 hours at 5°C (9°F) less than the lower limit of the rated ambient temperature range, but not greater than 10°C (50°F).

8.8 The specified test sequence is to be repeated so that data can be collected at the maximum and minimum manufacturer-specified battery charger voltages or currents, or both.

UNINTERRUPTIBLE POWER SUPPLY BATTERIES

9 Pressure Relief Valve and Vent Cap Tests

9.1 A valve regulated (sealed) battery shall comply with Section 6.

9.2 A vented battery shall comply with Section 7.

10 Battery Enclosure Flammability Tests

10.1 Flammability tests are to be conducted on the battery enclosure. The flammability tests are to be in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

INSTRUMENT AND ENCLOSED BATTERIES

11 Overcharge and Discharge Test

11.1 General

11.1.1 A battery supply shall be investigated to determine that rapid discharging (including short circuit) or overcharging will not result in:

- a) Cracking, rupturing, or bursting of the battery supply jacket, if such damage could result in user contact with battery electrolyte.
- b) Explosion of the battery supply, if such explosion could result in a risk of injury to persons.
- c) Emission of flame or expulsion of molten metal outside the battery-operated product.

11.1.2 If the overcurrent protective device referred to in 11.2.2 and 11.3.1 consists of a fuse, then the maximum rated fuse that can be installed in the fuseholder is to be used for the Overcharge and Discharge Tests.

Exception: If the product is marked in accordance with 13.2 then the maximum marked fuse rating is to apply.

11.2 Overcharge test

11.2.1 Three samples of a fully charged secondary battery supply are to be subjected to 7 hours of overcharging using the charger or charging circuit provided with or identified for use with the battery-operated product. Any user adjustable controls associated with the charger or charging circuit are to be adjusted for the most severe charging rate. Unless considered acceptable for the purpose, any current or voltage limiting components, or both, in the charger or charging circuit is to be open- or short-circuited, one component at a time, or otherwise adjusted for the most severe charging rate.

11.2.2 The most severe charging rate referred to in 11.2.1 is the maximum charging rate that does not cause a thermal or overcurrent protective device, or any other circuit element, to open.

11.3 Discharge test

11.3.1 The terminals of three samples of a primary or secondary battery supply shall be short-circuited continuously until ultimate results are obtained. The batteries shall be in a fully charged state prior to the test. The batteries shall be short circuited by connecting them with a minimum length of No. 16 AWG (1.31 mm²) copper wire. Tests are to be conducted at room temperature. The short circuit may be applied at the load side of an overcurrent or thermal protective device if:

- a) The device has been investigated for the purpose, and
- b) Circuitry between the battery supply and the protective device has been investigated to preclude short-circuiting.

11.3.2 If an overcurrent or thermal protective device that has been investigated for the purpose opens during the test, then the test shall be repeated with the battery supply connected to the minimum resistive load that will not cause the protective device to open. A protective device that has not been investigated for the purpose shall be short-circuited.

12 Battery Enclosure Tests

12.1 General

12.1.1 A battery enclosure shall be assembled so as to prevent externally caused mechanical damage if such damage might result in user contact with battery electrolyte, fire, or explosion when the battery is subjected to the tests in 12.2.1 – 12.6.2 as applicable in accordance with Table 12.1.

Table 12.1
External battery supply enclosure test schedule

Battery supply type	Drop test 12.2	Ball impact test 12.3	Crush test 12.4	Rod pressure test 12.5	Oven conditioning 12.6
Hand-held or body-supported during use	Yes	No	Yes ^a	Yes	Yes ^b
Counter, table or floor supported during use	No	Yes	Yes ^a	Yes	Yes ^b
^a If likely to be sat or stood upon during use.					
^b If a polymeric material is relied upon to contain battery electrolyte.					

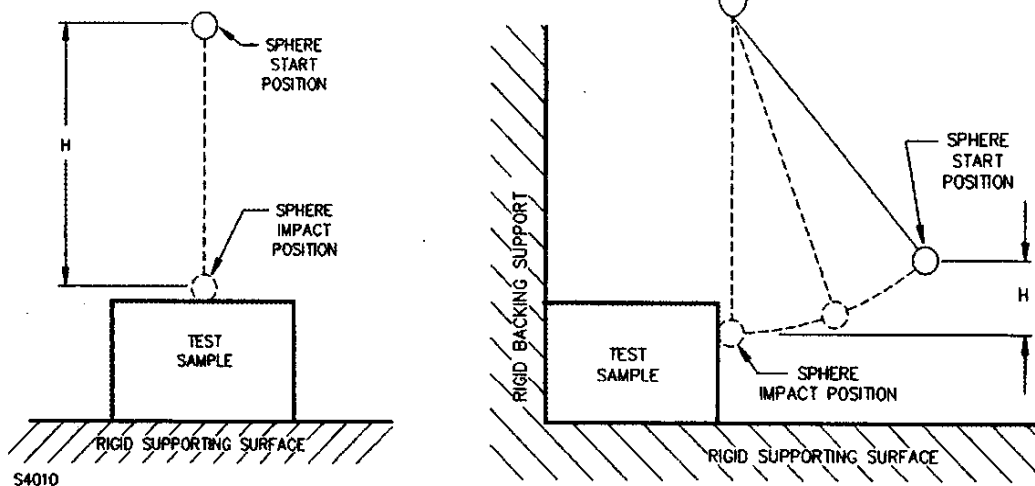
12.2 Drop impact test

12.2.1 Each of three samples is to be dropped from a height of 0.92 m (3 feet) to strike a hardwood surface in the position most likely to produce the adverse results described in 12.1.1. Each sample is to be dropped three times. The hardwood surface is to consist of a layer of nominal 25-mm (1-inch) tongue-and-groove oak flooring mounted on two layers of nominal 19-mm (3/4-inch) plywood. The oak flooring is to be nominally 19 mm thick (actual size: 19 x 57 mm or 3/4 x 2-1/4 inches). The assembly is to rest on a concrete floor or an equivalent nonresilient floor during the test. Except that a battery-operated product intended to be used outdoors, or in a garage, or a similar environment is to be dropped on a concrete surface.

12.3 Ball impact test

12.3.1 Each of three samples is to be subjected to a single impact of 6.8 Joules (5 foot-pounds) on any surface that can be exposed to a blow during intended use. The impact is to be produced by dropping a steel sphere, 50.8 mm (2 inches) in diameter, and weighing 535 g (1.18 pounds) from a height, H, of 1.29 m (50.8 inches). For surfaces other than the top of an enclosure, the steel sphere is to be suspended by a cord and swung as a pendulum, dropping through the vertical height of 1.29 m, with the product being impacted placed against a restraining vertical wall. See Figure 12.1.

Figure 12.1
Ball impact tests



- 1 - H in figure indicates the vertical distance the sphere must travel to produce the desired impact, 1.29 m (50.8 inches).
- 2 - For the ball-pendulum impact test the sphere is to contact the test sample when the string is in the vertical position as shown.
- 3 - The supporting surface is to consist of a layer of tongue-and-groove oak flooring mounted on two layers of 19-mm (3/4-inch) plywood. The oak flooring is nominally 3/4-inch thick (actual size 19 by 57 mm or 3/4 by 2-1/4 inches). The assembly is to rest on a concrete floor. An equivalent nonresilient supporting surface may be used.
- 4 - The backing surface is to consist of 19-mm (3/4-inch) plywood over a rigid surface of concrete.

12.4 Crush test

12.4.1 Three samples shall withstand for 1 minute a crushing force of 1112 N (250 pound force) applied to a 930 cm² (1 square foot) area in any direction at right angles to its major axis. The enclosure is to be tested between two 12.7 mm (1/2 inch) or thicker parallel flat maple blocks. The crushing force is to be applied gradually.

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12.5 Rod pressure test

12.5.1 The enclosure of a sample shall withstand a steady force of 111 N (25 pound-force) for 1 minute. The force is to be applied by means of a 12.7 mm (1/2 inch) diameter rod with a hemispherical end.

12.6 Oven conditioning test

12.6.1 After its careful removal from the oven and return to room temperature, following the conditioning described in 12.6.2 the sample shall have no evidence of mechanical damage, such as cracking of the battery jacket or leakage of electrolyte.

12.6.2 One complete sample is to be placed in a full-draft circulating-air oven maintained at a uniform temperature of 70°C (158°F). The sample is to remain in the oven for 7 hours.

MARKING

13 General

13.1 Each battery shall be permanently marked with the following:

- a) The manufacturer's name, trade name or trademark, model designation, and month and year of manufacture.
- b) The statement "Warning: Risk of fire, explosion, or burns. Do not recharge, disassemble, heat above XX°C, or incinerate."

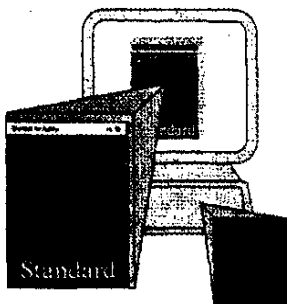
Exception: For a rechargeable battery the reference to recharging is omitted.

- c) Battery type and rated voltage and capacity.
- d) If rechargeable, the type of charging system to be used and the rate of charging.
- e) Any applicable installation or maintenance instructions.
- f) Positive and negative leads indicated by (+) and (-).

13.2 Unless tested with the maximum size fuse that can be accommodated by the fuseholder, a battery employing overcurrent protection in accordance with 11.1.2 shall be permanently marked, where readily visible during fuse replacement, with "CAUTION" and the following or equivalent wording "FOR CONTINUED PROTECTION AGAINST RISK OF (identification of risk), REPLACE ONLY WITH (maximum fuse rating, manufacturer and identification of special fuse, and the like) FUSE."

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UL's Standards Related Services and Binders



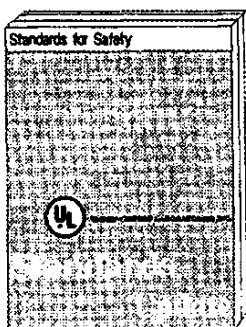
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