

UL 1642

ISBN 0-7629-1117-4

Lithium Batteries

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –

NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Lithium Batteries, UL 1642

Fourth Edition, Dated September 19, 2005

Revisions: This Standard contains revisions through and including August 9, 2007.

Summary of Topics

1. Effective Date Postponement for Internal Cell Protection Requirements

UL Standards for Safety are developed and maintained in the Standard Generalized Markup Language (SGML). SGML -- an international standard (ISO 8879-1986) -- is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Due to formatting differences resulting from the use of UL's new electronic publishing system, please note that additional pages (on which no requirements have been changed) may be included in revision pages due to relocation of existing text and reformatting of the Standard.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The following table lists the future effective dates with the corresponding reference.

Future Effective Date	References
February 2, 2009	Paragraphs 11.4, 11.9

The new and revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated July 17, 2007. The bulletin(s) is now obsolete and may be discarded.

The revisions dated August 9, 2007 include a reprinted title page (page1) for this Standard.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net/ulforeword.html>

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

UL's Standards for Safety are copyrighted by UL. Neither a printed copy of a Standard, nor the distribution diskette for a Standard-on-Diskette and the file for the Standard on the distribution diskette should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical, photocopying, recording, or otherwise without prior permission of UL.

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

UL will attempt to answer support requests concerning electronic versions of its Standards. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports the electronic versions of its Standards only if they are used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Purchasers of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

If a single-user version electronic Standard was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access.

If a multiple-user version electronic Standard was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer, or on an Intranet server. The number of concurrent users shall not exceed the number of users authorized.

Electronic Standards are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of an electronic Standard. Only one copy of the Standard may be printed for each authorized user of a multiple-user version of an electronic Standard. Because of differences in the computer/software/printer setup used by UL and those of electronic Standards purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

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 Listing, Recognition and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

Copyright © 2007 Underwriters Laboratories Inc.

This Standard consists of pages dated as shown in the following checklist:

Page	Date
1	August 9, 2007
2-4	August 2, 2006
5.....	September 19, 2005
6-6B	August 2, 2006
7-13.....	September 19, 2005
14-15	August 9, 2007
16-21.....	September 19, 2005
22	August 2, 2006
A1-A2.....	August 2, 2006
SR1-SR2.....	August 2, 2006

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

No Text on This Page

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

SEPTEMBER 19, 2005

(Title Page Reprinted: August 9, 2007)

1

UL 1642

Standard for Lithium Batteries

First Edition – October, 1985

Second Edition – November, 1992

Third Edition – April, 1995

Fourth Edition

September 19, 2005

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. 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>.

ISBN 0-7629-1117-4

COPYRIGHT © 1985, 2007 UNDERWRITERS LABORATORIES INC.

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

No Text on This Page

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

CONTENTS

INTRODUCTION

1 Scope	5
2 General	5
2.1 Units of measurement	5
2.2 Terminology	6
2.3 Components	6
3 Glossary	6

CONSTRUCTION

4 General	7
4.1 Casing	7
4.2 Electrolyte	7
4.3 Use	8

PERFORMANCE

5 General	8
5.1 Technician-replaceable batteries	8
5.2 User-replaceable batteries	9
5.3 Multicell installations	9
6 Samples	9
7 Conditioning of Samples	12
7.1 Discharge	12
7.2 Charge-discharge cycling	12
8 Important Test Considerations	12
9 Temperature Measurements	13

TESTS FOR TECHNICIAN-REPLACEABLE AND USER-REPLACEABLE BATTERIES

ELECTRICAL TESTS

10 Short-Circuit Test	13
11 Abnormal Charging Test	14
12 Forced-Discharge Test	15

MECHANICAL TESTS

13 Crush Test	16
14 Impact Test	16
15 Shock Test	17
16 Vibration Test	17

ENVIRONMENTAL TESTS

17 Heating Test	18
18 Temperature Cycling Test	18
19 Low Pressure (Altitude Simulation) Test	18

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

TESTS FOR USER-REPLACEABLE LITHIUM BATTERIES

20 Projectile Test	19
--------------------------	----

MARKING

21 General	20
------------------	----

APPENDIX A

Standards for Components.....	A1
-------------------------------	----

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

INTRODUCTION

1 Scope

1.1 These requirements cover primary (nonrechargeable) and secondary (rechargeable) lithium batteries for use as power sources in products. These batteries contain metallic lithium, or a lithium alloy, or a lithium ion, and may consist of a single electrochemical cell or two or more cells connected in series, parallel, or both, that convert chemical energy into electrical energy by an irreversible or reversible chemical reaction.

1.2 These requirements cover lithium batteries intended for use in technician-replaceable or user-replaceable applications.

1.3 These requirements are intended to reduce the risk of fire or explosion when lithium batteries are used in a product. The final acceptability of these batteries is dependent on their use in a complete product that complies with the requirements applicable to such product.

1.4 These requirements are also intended to reduce the risk of injury to persons due to fire or explosion when user-replaceable lithium batteries are removed from a product and discarded.

1.5 These requirements cover technician-replaceable lithium batteries that contain 5.0 g (0.18 ounce) or less of metallic lithium. A battery containing more than 5.0 g of lithium is judged on the basis of compliance with the requirements in this standard, insofar as they are applicable, and further examination and test to determine whether the battery is acceptable for its intended uses.

1.6 These requirements cover user-replaceable lithium batteries that contain 4.0 g (0.13 ounce) or less of metallic lithium with not more than 1.0 g (0.04 ounce) of metallic lithium in each electrochemical cell. A battery containing more than 4.0 g or a cell containing more than 1.0 g lithium may require further examination and test to determine whether the cells or batteries are acceptable for their intended uses.

1.7 These requirements do not cover the toxicity risk that may result from the ingestion of a lithium battery or its contents, nor the risk of injury to persons that may occur if a battery is cut open to provide access to the metallic lithium.

2 General

2.1 Units of measurement

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

2.2 Terminology

2.2.1 The terms "lithium battery(ies)" and "battery(ies)" refer to both user-replaceable and technician-replaceable lithium batteries.

2.3 Components

2.3 added August 2, 2006

2.3.1 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.

2.3.1 added August 2, 2006

2.3.2 A protective device investigated for the purpose is one that complies with the appropriate component standard for that device if one exists and is used within the ratings of the device. When there is no appropriate component standard for the protective device, it is to be evaluated in accordance with the performance requirements outlined in UL 1642.

2.3.2 added August 2, 2006

3 Glossary

3.1 For the purpose of this standard the following definitions apply.

3.2 BATTERY – General term for (1) A single cell, or (2) a group of cells connected together either in a series and/or parallel configuration. May be ready for use or may be an installed component.

3.3 BATTERY PACK – A battery which is ready for use, contained in a rigid enclosure, with or without protective devices.

3.4 BATTERY, PRIMARY – A battery which can only be discharged once. It is not designed to be rechargeable and must be protected from a charging current.

3.5 BATTERY, SECONDARY – A battery that is intended to be discharged and recharged many times in accordance with the manufacturer's recommendations.

3.6 BATTERY, TECHNICIAN-REPLACEABLE – A battery intended for use in a product in which service and replacement of the battery will be done only by a person who has been trained to service and repair the product.

3.7 BATTERY, USER-REPLACEABLE – A battery intended for use in a product in which service and replacement of the battery may be done by the user.

3.8 CELL, COMPONENT – The basic functional electrochemical unit containing an assembly of electrodes, electrolyte, container, terminals, and usually separators, that is a source of electrical energy by direct conversion of chemical energy. May be ready for use, or may be provided as a component of a battery pack.

3.9 CHARGED, FULLY – A battery is considered fully charged when the maximum amount of electrical capacity, as specified by the manufacturer, is stored in the battery.

3.10 COMPONENT, CURRENT-LIMITING – Any component employed to limit current during abnormal conditions. Current-limiting components include resistors, fuses, or thermal cutoffs.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

3.11 CURRENT, ABNORMAL CHARGING – Charging current to a primary cell or battery under fault condition.

3.12 DISCHARGE, FORCED – Discharge of a battery by connection in series with an external power source so as to drive the battery into polarity reversal.

3.13 DISCHARGED, FULLY – A battery is considered fully discharged if the closed circuit voltage is less than 0.2 volts, when connected to a 100-ohm resistive load and the short-circuit current has been reduced to less than 1 milliamperere.

3.14 DISCHARGED, HALF – A battery is considered half discharged when half of the battery's rated electrical capacity has been drained from it.

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –

NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

No Text on This Page

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

3.15 EXPLOSION – When the cell or battery contents are forcibly expelled and the cell or battery casing is torn or split into two or more pieces.

3.16 MATERIAL, TOXIC – Any material having a toxic hazard rating of 2, moderate, in the Sax Dangerous Properties of Industrial Materials reference book or related reference guide.

3.17 ROOM TEMPERATURE – Approximately 23°C (73°F).

3.18 VENTING – When the battery or cell electrolyte is emitted as a liquid, droplets, or vapor from a designed vent or through a seal.

CONSTRUCTION

4 General

4.1 Casing

4.1.1 The casing of a lithium battery shall have the strength and rigidity necessary to resist the abuses to which it may be subjected, without resulting in a risk of fire. The casing of a user-replaceable lithium battery shall have the strength and rigidity necessary to resist the abuses to which it may be subjected without resulting in a risk of injury to persons.

4.1.2 A cell of a user-replaceable battery shall be in a rigid casing of sufficient strength to prevent flexing. A tool providing the mechanical advantage of a pliers, screwdriver, or hacksaw shall be the minimum capable of opening the user-replaceable cell casing, if opening of the casing will expose metallic lithium.

Exception: This requirement does not apply to a cell containing less than 0.02 g (0.0007 ounce) of lithium metal.

4.2 Electrolyte

4.2.1 A user-replaceable battery shall not contain pressurized vapor or liquid that could spray materials into the eyes or leak more than 5 milliliters of liquid when the battery casing is punctured under normal laboratory conditions, 23 ±2°C (73 ±3.6°F).

4.3 Use

4.3.1 A lithium battery shall be protected from abnormal charging currents during use. A battery tested and found acceptable for the charging current, I_C (see Section 11), under fault conditions specified by the manufacturer, shall be protected from larger charging currents in the end product application by:

- a) Two blocking components, such as diodes, or
- b) One blocking component and one current limiting component, such as a resistor or a fuse.

The current limiting component shall limit the charging current to one-third the value used in the Abnormal Charging Test, Section 11.

Exception No. 1: Charge protection in the battery circuit is not required in end product applications where a battery cannot be subjected to a charging current, such as a battery operated device.

Exception No. 2: Protection components are not required for specific applications where a battery has been tested and found not to have a risk of explosion.

Exception No. 3: A rechargeable battery requires only a current limiting component, not a blocking component.

PERFORMANCE

5 General

5.1 Technician-replaceable batteries

5.1.1 Technician-replaceable lithium cells or batteries are to be tested as described in Sections 10 – 20. Section 12, Forced Discharge Test, is applicable only to cells intended to be used in multicell applications such as battery packs. For multicell installations, also see 5.3.1. No fire or explosion shall occur as a result of the Short-Circuit Test, Section 10, the Shock Test, Section 15, the Vibration Test, Section 16, the Temperature Cycling Test, Section 18 or the Altitude Simulation Test, Section 19. Also, the temperature of an exterior cell or battery casing shall not exceed 150°C (302°F) when tested in accordance with the Short-Circuit Test. When a fire or explosion occurs as a result of the Abnormal Charging Test, Section 11; Crush Test, Section 13; Impact Test, Section 14; or Heating Test, Section 17; the use of the technician replaceable cell or battery shall be restricted to applications in which it is not exposed to, or is protected from, any conditions shown to cause a fire or explosion. Cells and batteries subjected to the Shock Test, Section 15, Vibration Test, Section 16, Temperature Cycling Test, Section 18, and Altitude Simulation Test, Section 19 shall also not leak or vent. For these tests, unacceptable leakage is determined to have occurred when the resulting mass loss exceeds the values shown in Table 5.1, Venting and Leakage Mass Loss Criteria.

Table 5.1
Venting and leakage mass loss criteria

Mass of cell or battery	Maximum mass % loss
Not more than 1 gram	0.5
More than 1.0 gram and not more than 5.0 gram	0.2
More than 5.0 gram	0.1

5.2 User-replaceable batteries

5.2.1 User-replaceable lithium cells or batteries are to be tested as described in Sections 10 – 20. Section 12, Forced Discharge Test, is applicable only to cells intended to be used in multicell applications such as battery packs. In addition to complying with the requirements for a technician replaceable cell or battery as specified in 5.1.1, a user-replaceable cell or battery shall not explode or ignite when subjected to the Crush Test, Section 13, or the Impact Test, Section 14.

5.2.2 Sets of five specimens each are to be used for the Projectile Test, Section 20.3; see Table 6.3. When only one specimen from a set of five does not comply with the requirements, another set of five specimens is to be tested. All specimens from this second set shall comply with the requirements.

5.3 Multicell installations

5.3.1 A technician-replaceable or user-replaceable cell intended for use in multicell installations or battery packs shall also be tested as described in 10.3 and Section 12. No fire or explosion shall occur as a result of these tests. In addition, batteries subjected to the test described in 10.3 shall meet the requirements as described in 5.1.1 and 5.2.1 for a cell or battery subjected to the Short-Circuit Test, Section 10.

6 Samples

6.1 Fully charged primary cells or batteries and primary cells or batteries that have been conditioned by partial or complete discharge, or both, are to be used for the tests described in Sections 10 – 20. The number of samples to be used in each test for a primary technician-replaceable cell or battery is shown in Table 6.1. The number of samples to be used in each test for a primary user-replaceable cell or battery is shown in Table 6.3. When a group of cells or batteries of different sizes, but similar chemistries is involved, selected sizes representative of the range are to be tested.

6.2 Fully charged secondary cells or batteries and secondary cells or batteries that have been conditioned by charge-discharge cycling are to be used for the tests described in Sections 10 – 20. The number of samples to be used in each test for a secondary technician-replaceable cell or battery is shown in Table 6.2. The number of samples to be used in each test for a secondary user-replaceable cell or battery is shown in Table 6.4. When a group of cells or batteries of different sizes, and similar chemistries is involved, selected sizes representative of the range are to be tested.

Table 6.1
Number of batteries to be used in each test for primary technician-replaceable batteries

Test	Conditioning of batteries		
	Fully charged	One half discharged ^a	Complete discharged
Electrical Tests			
Short-Circuit ^b			
at room temp.	5	5	—
at 55°C (131°F)	5	5	—
Abnormal Charge	5	5	5
Forced Discharge ^c	5	5	5
Mechanical Tests			
Crush	5	5	—
Impact	5	5	—
Shock	5	5	5
Vibration	5	5	5
Environmental Tests			
Heating	5	5	—
Temperature Cycling	5	5	5
Altitude Simulation	5	5	5
^a Only cells with a liquid cathode, such as thionyl chloride or sulfur dioxide, are conditioned by one-half discharge. ^b For series or parallel use, see 10.3. ^c For series use, see 12.2.			

Table 6.2
Number of batteries to be used in each test for secondary technician-replaceable batteries

Test	Fully charged	Charge/discharge cycled
Electrical Tests		
Short-Circuit ^a		
at room temp.	5	5
at 55°C (131°F)	5	5
Abnormal Charge	5	5
Forced Discharge ^b	5	5
Mechanical Tests		
Crush	5	5
Impact	5	5
Shock	5	5
Vibration	5	5
Environmental Tests		
Heating	5	5
Temperature Cycling	5	5
Altitude Simulation	5	5
^a For series or parallel use, see 10.3. ^b For series use, see 12.2.		

Table 6.3
Number of batteries to be used in each test for primary user-replaceable batteries

Test	Conditioning of batteries		
	Fully charged	One half discharged ^a	Complete discharged
Electrical Tests			
Short-Circuit ^b			
at room temp.	5	5	—
at 55°C (131°F)	5	5	—
Abnormal Charge	5	5	5
Forced Discharge ^c	5	5	5
Mechanical Tests			
Crush	5	5	—
Impact	5	5	—
Shock	5	5	5
Vibration	5	5	5
Environmental Tests			
Heating	5	5	—
Temperature Cycling	5	5	5
Altitude Simulation	5	5	5
User Replaceable Lithium Battery Tests			
Projectile	5	—	—
^a Only cells with a liquid cathode, such as thionyl chloride or sulfur dioxide, are conditioned by one-half discharge. ^b For series or parallel use, see 10.3. ^c For series use, see 12.2.			

Table 6.4
Number of batteries to be used in each test for secondary user-replaceable batteries

Test	Fully charged	Batteries conditioned by charge-discharge cycling
Electrical Tests		
Short-Circuit ^a		
at room temp.	5	5
at 55°C (131°F)	5	5
Abnormal Charge	5	5
Forced Discharge ^b	5	5
Mechanical Tests		
Crush ^a	5	5
Impact	5	5
Shock	5	5
Vibration	5	5
Environmental Tests		
Heating	5	5
Temperature Cycling	5	5
Altitude Simulation	5	5
User Replaceable Lithium Battery Tests		
Projectile	5	—
^a For series or parallel use, see 10.3. ^b For series use, see 12.2.		

7 Conditioning of Samples

7.1 Discharge

7.1.1 Primary batteries are to be completely discharged by connecting their terminals through resistors that provide the desired level of discharge within 60 days. Completely discharged is considered to be the state in which the closed-circuit voltage has been reduced to less than 0.2 volts and the short-circuit current to less than 1.0 milliamperes. Batteries are to be discharged at room temperature. Cells with a liquid cathode such as thionyl chloride or sulfur dioxide, shall also be conditioned by one-half discharge.

7.1.2 For solid electrolyte and other types of primary lithium batteries that cannot be discharged within 60 days because of the small currents they inherently produce, longer discharge times plus discharge at higher temperatures may be used to obtain the desired level of discharge. The manufacturer's recommended discharge procedures are to be followed so as to obtain the required discharge level in the minimum time.

7.2 Charge-discharge cycling

7.2.1 Secondary cells are to be conditioned at 25°C (77°F). Cells are continuously cycled as per the manufacturer's specifications. The specification shall be such that the full rated capacity of the cell is utilized and the number of cycles accumulated shall be at least equal to 25 percent of the advertised cycle life of the cell or cycled continuously for 90 days, whichever is shorter. Cycling is to be done either individually or in groups. Cells are to be recharged prior to testing as indicated in Table 6.2 and Table 6.4.

8 Important Test Considerations

8.1 Some lithium batteries are capable of exploding when the tests described in Sections 10 – 20 are conducted. It is important that personnel be protected from the flying fragments, explosive force, sudden release of heat, and noise that results from such explosions. The test area is to be well ventilated to protect personnel from possible harmful fumes or gases.

8.2 As an additional precaution, the temperatures on the surface of the battery casings shall be monitored during the tests described in Sections 10, 12, 13, and 14. All personnel involved in the testing of lithium batteries are to be instructed never to approach a lithium battery while the surface temperature exceeds 90°C (194°F).

8.3 For protection, the Projectile Test, Section 20 is to be conducted in a room separate from the observer.

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

9 Temperature Measurements

9.1 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm²) and not smaller than 30 AWG (0.05 mm²) and a potentiometer-type instrument.

9.2 The temperature measurements on the batteries are to be made with the measuring junction of the thermocouple held tightly against the metal casing of the battery.

Exception: Placing the thermocouple on a thin piece of paper or label is an acceptable practice.

TESTS FOR TECHNICIAN-REPLACEABLE AND USER-REPLACEABLE BATTERIES

ELECTRICAL TESTS

10 Short-Circuit Test

10.1 Each test sample battery, in turn, is to be short-circuited by connecting the positive and negative terminals of the battery with a circuit load having a maximum resistance load of 0.1 ohm. The battery is to discharge until a fire or explosion is obtained, or until it has reached a completely discharged state of less than 0.1 volts and the battery case temperature has returned to $\pm 10^{\circ}\text{C}$ ($\pm 18^{\circ}\text{F}$) of ambient temperature.

10.2 Tests are to be conducted at $20 \pm 5^{\circ}\text{C}$ ($68 \pm 9^{\circ}\text{F}$) and at $55 \pm 5^{\circ}\text{C}$ ($131 \pm 9^{\circ}\text{F}$). The batteries are to reach equilibrium at $20 \pm 5^{\circ}\text{C}$ or $55 \pm 5^{\circ}\text{C}$, as applicable, before the terminals are connected.

10.3 A battery is to be tested individually unless the manufacturer indicates that it is intended for use in series or parallel. For series or parallel use, additional tests on five sets of batteries are to be conducted using the maximum number of batteries to be covered for each configuration.

10.4 When an overcurrent or thermal protective device that has been investigated for the purpose actuates during the test, the test shall be repeated with the battery supply connected to the maximum load that does not cause the protective device to open. A protective device that has not been investigated for the purpose shall be short-circuited.

10.5 The samples shall not explode or catch fire. The temperature of the exterior cell or battery casing shall not exceed 150°C (302°F).

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –

NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

11 Abnormal Charging Test

11.1 Primary cells or batteries shall comply with 11.2 – 11.7.

11.2 Cells or batteries conditioned in accordance with Tables 6.1 or 6.3, as applicable, are to be used for this test. The batteries are to be tested in an ambient temperature of $20 \pm 5^{\circ}\text{C}$ ($68 \pm 9^{\circ}\text{F}$).

11.3 Each test sample battery is to be subjected to a charging current of three times the current I_c , specified by the manufacturer by connecting it in opposition to a dc-power supply. The specified charging current is to be obtained by connecting a resistor of the specified size and rating in series with the battery. The test charging time is to be calculated using the formula:

$$t_c = \frac{2.5 C}{3(I_c)}$$

In which:

t_c is the charging time in hours,

C is the capacity of the cell/battery in ampere-hours, and

I_c is the maximum charging current, in amperes, specified by the manufacturer.

The minimum charging time is to be 7 hours.

Exception: At the manufacturer's discretion, test currents greater than the specified three times rated I_c can be applied to expedite the test timeframe.

11.4 When a non-resettable overcurrent or thermal protective device that has been investigated for the purpose operates during the test, the test is to be repeated at a charge current below the level that the protective device operates. When a resettable protective device operates during the test, the protector is allowed to reset to a total of 10 cycles; or until the appropriate charging time has been completed, but not less than 7 hours. A protective device that has not been investigated for the purpose is to be short-circuited. See 2.3.2.

Effective date for 11.4 changed from August 2, 2007 to February 2, 2009

11.5 The samples shall not explode or catch fire.

11.6 Secondary cells or batteries shall comply with 11.7 – 11.10.

11.7 Cells or batteries conditioned in accordance with Tables 6.2 or 6.4, as applicable, are to be used for this test. The batteries are to be tested in an ambient temperature of $20 \pm 5^{\circ}\text{C}$ ($68 \pm 9^{\circ}\text{F}$).

11.8 Each test sample battery is to be discharged at a constant current of 0.2 C/1 hour, to a manufacturer specified discharge endpoint voltage. The cell or battery is then to be charged with a constant maximum specified output voltage and a current limit of three times the maximum charging current, I_c , specified by the manufacturer. Charging duration is to be 7 hours or the time required to reach the manufacturer's specified end-of-charge condition, whichever is greater.

11.9 The cell/battery is to be tested without the assistance of overcurrent or thermal protective devices, unless such protective devices have been investigated for the purpose. When a non-resettable overcurrent or thermal protective device operates during the test, the test shall be repeated at an overcharging current below the level that the protection device operates. When a resettable protective device operates during the test, the protector is to be allowed to reset to a total of 10 cycles; or until the appropriate charging time has been completed, but not less than 7 hours. A protective device that has not been investigated for the purpose is to be short-circuited. See 2.3.2.

Effective date for 11.9 changed from August 2, 2007 to February 2, 2009

11.10 The samples shall not explode or catch fire.

12 Forced-Discharge Test

12.1 This test is intended for cells that are to be used in series-connected, multicell applications, such as battery packs.

12.2 A completely discharged cell is to be force-discharged by connecting it in series with fully charged cells of the same kind. The number of fully charged cells to be connected in series with the discharged cell is to equal the maximum number less one of the cells to be covered for series use. Five cells are to be completely discharged, at room temperature.

12.3 Once the completely discharged cell is connected in series with the specified number of fully charged cells the resultant battery pack is to be short circuited.

12.4 The positive and negative terminals of the sample are to be connected with a copper wire with a maximum resistance load of 0.1 ohm. The sample is to discharge until a fire or explosion is obtained, or until it has reached a completely discharged state of less than 0.2 volts and the battery case temperature has returned to $\pm 10^\circ\text{C}$ (18°F) of ambient temperature.

12.5 When an overcurrent or thermal protective device that has been investigated for the purpose operates during the test, the test shall be repeated with the battery supply connected to the maximum load that does not cause the protective device to open. A protective device that has not been investigated for the purpose shall be short-circuited.

12.6 The samples shall not explode or catch fire.

MECHANICAL TESTS

13 Crush Test

13.1 A battery is to be crushed between two flat surfaces. The force for the crushing is to be applied by a hydraulic ram with a 1.25 inch (32 mm) diameter piston. The crushing is to be continued until a pressure reading of 2500 psig (17.2 MPa) is reached on the hydraulic ram, applied force of 3000 pounds (13 kN). Once the maximum pressure has been obtained it is to be released.

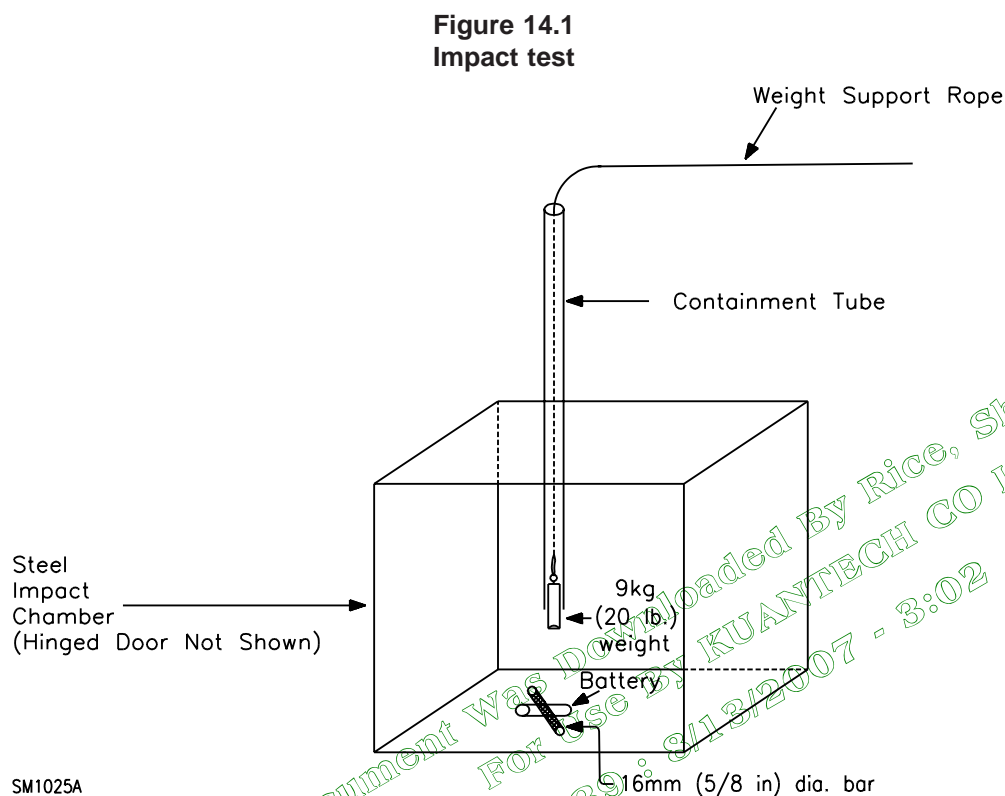
13.2 A cylindrical or prismatic battery is to be crushed with its longitudinal axis parallel to the flat surfaces of the crushing apparatus. A prismatic battery is also to be rotated 90 degrees around its longitudinal axis so that both the wide and narrow sides will be subjected to the crushing force. Each sample battery is to be subjected to a crushing force in only one direction. Separate samples are to be used for each test.

13.3 A coin or button battery is to be crushed with the flat surface of the battery parallel with the flat surfaces of the crushing apparatus.

13.4 The samples shall not explode or catch fire.

14 Impact Test

14.1 A test sample battery is to be placed on a flat surface. A 5/8 inch (15.8 mm) diameter bar is to be placed across the center of the sample. A 20 pound (9.1 kg) weight is to be dropped from a height of 24 ± 1 inch (610 ± 25 mm) onto the sample. (See Figure 14.1).



UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

14.2 A cylindrical or prismatic battery is to be impacted with its longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the 5/8 inch (15.8 mm) diameter curved surface lying across the center of the test sample. A prismatic battery is also to be rotated 90 degrees around its longitudinal axis so that both the wide and narrow sides are subjected to the impact. Each sample battery is to be subjected to only a single impact. Separate samples are to be used for each test.

14.3 A coin or button battery is to be impacted with the flat surface of the test sample parallel to the flat surface and the 5/8 inch (15.8 mm) diameter curved surface lying across its center.

14.4 The samples shall not explode or catch fire.

15 Shock Test

15.1 The cell is to be secured to the testing machine by means of a rigid mount which supports all mounting surfaces of the cell. Each cell shall be subjected to a total of three shocks of equal magnitude. The shocks are to be applied in each of three mutually perpendicular directions unless it has only two axes of symmetry in which case only two directions shall be tested. Each shock is to be applied in a direction normal to the face of the cell. For each shock the cell is to be accelerated in such a manner that during the initial 3 milliseconds the minimum average acceleration is 75 g (where g is the local acceleration due to gravity). The peak acceleration shall be between 125 and 175 g. Cells shall be tested at a temperature of $20 \pm 5^{\circ}\text{C}$ ($68 \pm 9^{\circ}\text{F}$).

15.2 The samples shall not explode or catch fire. In addition, the sample shall not vent or leak as described in 5.1.1.

16 Vibration Test

16.1 A battery is to be subjected to simple harmonic motion with an amplitude of 0.8 mm (0.03 inch) [1.6 mm (0.06 inch) total maximum excursion].

16.2 The frequency is to be varied at the rate of 1 hertz per minute between 10 and 55 hertz, and return in not less than 90 nor more than 100 minutes. The battery is to be tested in three mutually perpendicular directions. For a battery that has only two axes of symmetry, the battery is to be tested perpendicular to each axis.

16.3 The samples shall not explode or catch fire. In addition the sample shall not vent or leak as described in 5.1.1.

ENVIRONMENTAL TESTS

17 Heating Test

17.1 A battery is to be heated in a gravity convection or circulating air oven with an initial temperature of $20 \pm 5^{\circ}\text{C}$ ($68 \pm 9^{\circ}\text{F}$). The temperature of the oven is to be raised at a rate of $5 \pm 2^{\circ}\text{C}$ ($9 \pm 3.6^{\circ}\text{F}$) per minute to a temperature of $130 \pm 2^{\circ}\text{C}$ ($302 \pm 3.6^{\circ}\text{F}$) and remain for 10 minutes. The sample shall return to room temperature ($20 \pm 5^{\circ}\text{C}$) and then be examined.

17.2 The samples shall not explode or catch fire.

18 Temperature Cycling Test

18.1 The batteries are to be placed in a test chamber and subjected to the following cycles:

- a) Raising the chamber-temperature to $70 \pm 3^{\circ}\text{C}$ ($158 \pm 5^{\circ}\text{F}$) within 30 minutes and maintaining this temperature for 4 hours.
- b) Reducing the chamber temperature to $20 \pm 3^{\circ}\text{C}$ ($68 \pm 5^{\circ}\text{F}$) within 30 minutes and maintaining this temperature for 2 hours.
- c) Reducing the chamber temperature to minus $40 \pm 3^{\circ}\text{C}$ (minus $40 \pm 5^{\circ}\text{F}$) within 30 minutes and maintaining this temperature for 4 hours.
- d) Raising the chamber temperature to $20 \pm 3^{\circ}\text{C}$ ($68 \pm 5^{\circ}\text{F}$) within 30 minutes.
- e) Repeating the sequence for a further 9 cycles.
- f) After the 10th cycle, storing the batteries for a minimum of 24 hours, at a temperature of $20 \pm 5^{\circ}\text{C}$ ($68 \pm 9^{\circ}\text{F}$) prior to examination.

18.2 The samples shall not explode or catch fire. In addition, the samples shall not vent or leak as described in 5.1.1.

19 Low Pressure (Altitude Simulation) Test

19.1 Sample batteries are to be stored for 6 hours at an absolute pressure of 11.6 kPa (1.68 psi) and a temperature of $20 \pm 3^{\circ}\text{C}$ ($68 \pm 5^{\circ}\text{F}$).

19.2 The samples shall not explode or catch fire as a result of the Altitude Simulation Test. In addition, the samples shall not vent or leak as described in 5.1.1.

TESTS FOR USER-REPLACEABLE LITHIUM BATTERIES

20 Projectile Test

20.1 When subjected to the test described in 20.2 – 20.5 no part of an exploding cell or battery shall penetrate the wire screen such that some or all of the cell or battery protrudes through the screen.

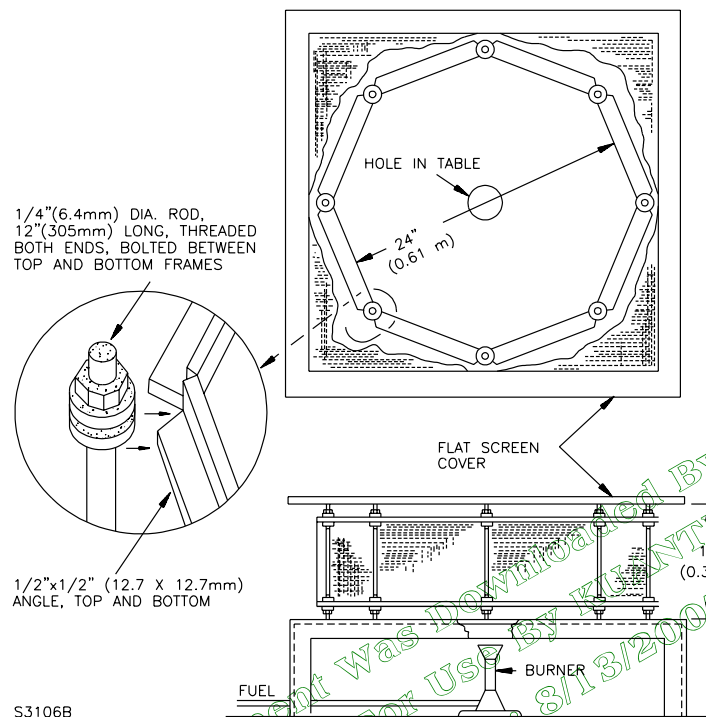
20.2 Each test sample cell or battery is to be placed on a screen that covers a 102 mm (4 inch) diameter hole in the center of a platform table. The screen is to be constructed of steel wire mesh having 20 openings per inch (25.4 mm) and a wire diameter of 0.017 inch (0.43 mm).

20.3 The screen is to be mounted 38 mm (1-1/2 inch) above a burner. The fuel and air flow rates are to be set to provide a bright blue flame that causes the supporting screen to glow a bright red.

20.4 An eight-sided covered wire cage, 610 mm (2 feet) across and 305 mm (1 foot) high, made from metal screening is to be placed over the test sample. See Figure 20.1. The metal screening is to be constructed from 0.25 mm (0.010 inch) diameter aluminum wire with 16 – 18 wires per inch (25.4 mm) in each direction.

20.5 The sample is to be heated and shall remain on the screen until it explodes or the cell or battery has ignited and burned out. It is not required to secure the sample in place unless it is at risk of falling off the screen before the test is completed. When required, the sample shall be secured to the screen with a single wire tied around the sample.

Figure 20.1
Test apparatus for projectile test



MARKING

21 General

21.1 A battery shall be legibly and permanently marked with:

- a) The manufacturer's name, trade name, or trademark or other descriptive marking by which the organization responsible for the product may be identified;
- b) A distinctive ("catalog" or "model") number or the equivalent;
- c) The date or other dating period of manufacture not exceeding any three consecutive months.

Exception No. 1: The manufacturer's identification may be in a traceable code if the product is identified by the brand or trademark owned by a private labeler.

Exception No. 2: The date of manufacture may be abbreviated; or may be in a nationally accepted conventional code or in a code affirmed by the manufacturer, provided that the code:

- a) Does not repeat in less than 10 years for a household product and less than 20 years for a commercial product, and*
- b) Does not require reference to the production records of the manufacturer to determine when the product was manufactured.*

21.2 A battery shall be marked with the word "WARNING" and the following or an equivalent statement: "Risk of fire, explosion, and burns. Do not recharge, disassemble, crush, heat above 100°C (212°F), or incinerate."

Exception No. 1: A cylindrical battery that is smaller in capacity than 300 milliampere hours and a coin, button, or pin battery is not required to be marked if the tests indicate these risks are not obtained.

Exception No. 2: A battery found not to present a risk under one or more of the conditions specified in Sections 8 – 20 need not be marked for those conditions.

Exception No. 3: A battery that is between 300 – 950 milliampere hours in capacity may be marked with the word "WARNING" and an abbreviated statement similar to the following: "Risk of explosion. Do not recharge, open, or incinerate." If space does not permit marking on the battery, this marking may be on the smallest unit package.

Exception No. 4: A user-replaceable battery may be marked with the word "CAUTION" in place of "WARNING."

Exception No. 5: A component cell intended to be shipped directly to a battery pack assembler for installation into a battery pack is not required to include the warning marking described in 21.2.

Exception No. 6: The "do not recharge" marking applies only to primary cells and batteries.

Exception No. 7: If space does not permit marking on the battery, the marking may be on the smallest unit package.

21.3 The packaging for a user-replaceable battery shall be marked with the word "CAUTION" and the following or equivalent statements:

"Risk of fire and burns. Do not recharge, disassemble, heat above 100°C (212°F), or incinerate. Keep battery out of reach of children and in original package until ready to use. Dispose of used batteries promptly according to local recycling or waste regulations. Never put batteries in mouth. If swallowed, contact your physician or local poison control center."

Exception No. 1: The last two sentences are applicable only for a cell or battery that is less than 1.25 inch (32 mm) diameter by 0.15 inch (3.8 mm) thick.

Exception No. 2: Packaging for a battery found not to present a risk under one or more of the conditions specified in Sections 8 – 20 need not be marked for those conditions.

Exception No. 3: The "do not recharge" marking applies only to primary cells and batteries.

21.4 The end product with a user-replaceable lithium battery shall be permanently marked adjacent to the battery:

"Replace battery with (battery manufacturers name or end product manufacturer's name, part number) only. Use of another battery may present a risk of fire or explosion. See owners manual for instructions."

Exception: If it is not feasible to include these instructions on the end product, the information may be included in the operating or maintenance instructions providing the battery or battery compartment is marked with the following:

"See operating or maintenance instructions for type of battery to be used."

21.5 The operating or maintenance instructions shall provide the user with complete instructions as to how to replace and dispose of a used battery. This information shall include the following:

a) A warning notice stating the following or the equivalent:

"CAUTION – The battery used in this device may present a risk of fire or chemical burn if mistreated. Do not recharge, disassemble, heat above 100°C (212°F), or incinerate. Replace battery with (battery manufacturers name or end product manufacturer's name and part number) only. Use of another battery may present a risk of fire or explosion."

Exception: The "do not recharge" marking applies only to primary cells and batteries.

b) Complete instructions as to how to replace the battery ending with the statement:

"Dispose of used battery promptly. Keep away from children. Do not disassemble and do not dispose of in fire."

21.6 If a manufacturer produces a battery at more than one factory, each battery package shall have a distinctive marking to identify it as the product of a particular factory.

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard – UL Standard Designation

Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1A

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

Low-Voltage Fuses - Part 14: Supplemental Fuses, UL 248-14

Thermal-Links - Requirements and Application Guide, UL 60691

Thermistor-Type Devices, UL 1434

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

No Text on This Page

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

**Superseded requirements for
the Standard for
Lithium Batteries**

UL 1642, Fourth Edition

The requirements shown are the current requirements that have been superseded by requirements in revisions issued for this Standard. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

11.4 When a non-resettable overcurrent or thermal protective device is either integral to the cell/battery construction or has been investigated for the purpose operates during the test, the test is to be repeated with the same calculated charging time, but with the cell/battery connected to the maximum load that does not cause the protective device to operate. If the protective device is resettable, the test is also to be conducted with the protector cycling until the appropriate charging time has been completed, but not less than 7 hours. The test is then to be repeated with the same calculated charging time, and with the cell/battery connected to the original load.

11.9 The cell/battery is to be tested without the assistance of overcurrent or thermal protective devices, unless such protective devices are integral to the cell construction or have been investigated for the purpose. When a resettable protective device operates during the test, the protector is to be allowed to reset as often as necessary and the test is to be continued until the appropriate charging time has been completed, but not less than 7 hours. A protective device that is not integral to the cell and that has not been investigated for the purpose is to be short-circuited.

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

No Text on This Page

Document Was Downloaded By Rice, Shi SHIMISHENG
For Use By KUANTECH CO LTD
12039 : 8/13/2007 - 3:02 AM
UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL