



IEEE Standard for Rechargeable Batteries for Portable Computing

IEEE Power Engineering Society

Sponsored by the
Stationary Batteries Committee

1625TM

IEEE
3 Park Avenue
New York, NY 10016-5997, USA
28 May 2004

IEEE Std 1625TM-2004

IEEE Standard for Rechargeable Batteries for Portable Computing

Sponsor

Stationary Batteries Committee
of the
IEEE Power Engineering Society

Approved 8 July 2004

American National Standards Institute

Approved 8 April 2004

IEEE-SA Standards Board

Abstract: Guidance for the designer/manufacturer/supplier in planning and implementing controls for the design and manufacture of lithium-ion (Li-ion) and lithium-ion polymer (Li-ion polymer) rechargeable battery packs used for portable computing is provided. This standard's provisions work together, and they define approaches to design, test, and evaluate a cell, battery pack, and host device to mitigate battery system failure in user environments. Additionally, this standard provides recommendations for end-user education and communication materials. This approach suggests the interfaces between subsystems (e.g., cell, battery pack, host device) and end users are as important to system reliability as is robust subsystem design and testing. This standard therefore includes subsystem interface design responsibilities for each subsystem designer/manufacturer/supplier, and it provides messaging and communication provisions for end-user awareness.

Keywords: battery, battery pack, cell, host device, lithium-ion (Li-ion), lithium-ion polymer (Li-ion polymer), notebook computer, pack, portable computer, portable computing, rechargeable battery, rechargeable battery packs

The Institute of Electrical and Electronics Engineers, Inc.
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Print: ISBN 0-7381-4011-2 SH95227
PDF: ISBN 0-7381-4012-0 SS95227

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Introduction

(This introduction is not part of IEEE Std 1625-2004, IEEE Standard for Rechargeable Batteries for Portable Computing.)

The Rechargeable Batteries for Portable Computing Working Group was formed to provide a platform based on the experience of industry leaders in cell, battery pack, and systems management, leading to design approaches for portable computing devices. The focus of the standard is on design approaches for reliable operation of portable computing devices and similar rechargeable battery-operated systems. This standard may be relevant to other devices but these were not expressly considered in its development.

Figure a presents the need for an approach involving all system components, including the user and environment. It is necessary to examine all design margins in combination to understand the effect of multiple fault response on the portable computing device. The standard addresses such questions as: What are the critical operational parameters and how do they change with time and environment? What are the effects of extremes in temperature, pressure, and impact? A total system view is required to protect the design margins in the various components. The goal of reliability and positive user experience require that design margins be maintained as user patterns, profiles, and duty cycles change.

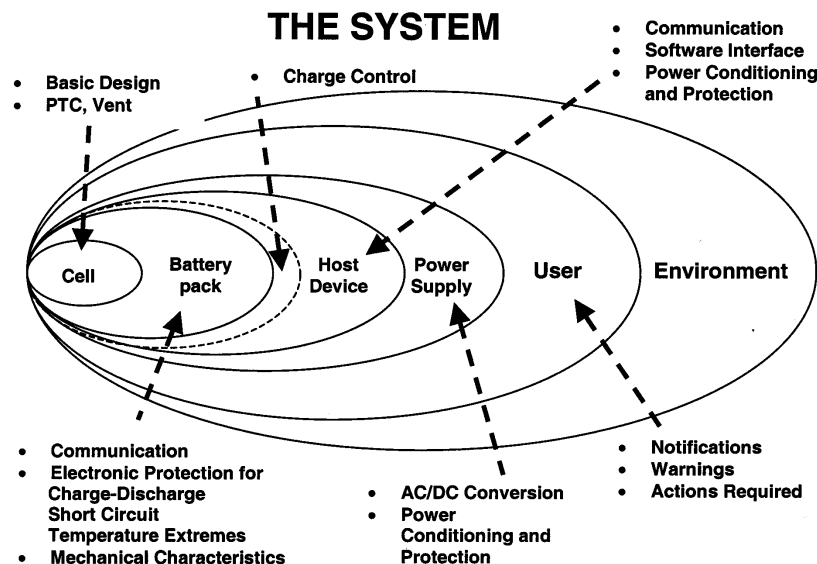


Figure a—Conceptual diagram of a mobile computing device and its user

This standard applies to rechargeable lithium-ion (Li-ion) and lithium-ion polymer (Li-ion polymer) batteries and battery packs for use in portable computing. Because of the nature of the interactions between the battery and the host device, a system approach must be used in developing an appropriate operating envelope for the system. The provisions of this standard are intended to provide considerations for design analyses to minimize the occurrence of failures leading to hazards.

This standard is a system level standard, as depicted in the conceptual diagram. Overall compliance is dependent on conformity to each and every subclause of the standard. Compliance with the standard cannot be achieved by any particular portable computing device or subsystem alone, without considering the conformity of all subsystems within the system as well as the user. It is incumbent upon the designers of the host device, battery pack, and cell to review thoroughly their designs, alone and in conjunction with other subsystems, to identify faults that could propagate hazards. Once it has been ascertained that the cell, battery pack, and host device all conform to all their particular subclause requirements, the overall system compliance is not finished until the designer completes a thorough design analysis [e.g., design failure mode

effect analysis (DFMEA)] to ensure their particular design does not allow two faults of any type to propagate a hazard.

Disclaimer

Compliance with the provisions of this standard does not imply compliance to the regulatory requirements that are applicable to cell, battery packs, and systems. Care must be used to observe and refer to the applicable regulatory requirements, as part of the intended design analyses, for this standard does not assure protection or safety. This standard sets forth recommendations for design analyses and certain testing procedures. The level of assurance for protection and safety resulting from applying this standard depends on the implementation by the manufacturer/supplier and the actions of the end user. Compliance with the standard does not guarantee safety in all circumstances.

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Current interpretations can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/interp/index.html>.

Participants

At the time this standard was completed, the Rechargeable Batteries for Portable Computing Working Group had the following entity membership:

Battery-Biz, Inc.	IBM Corporation	Samsung Electronics
Compal Electronics, Inc.	Inventec Corporation	Co., Ltd.
Dell Inc.	Matsushita Battery Industrial	Sanyo Electric Co., Ltd.
Dynapack International	Co., Ltd./Panasonic	Soletron Corporation
Technology Corporation	Motorola, Inc.	Sony Corporation
FEDCO Electronics, Inc.	National Semiconductor	Texas Instruments, Inc.
Hewlett Packard Company	Quanta Computer, Inc.	Wistron Corporation

The following entity members of the balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Battery-Biz, Inc.	IBM Corporation	Samsung Electronics
Compal Electronics, Inc.	Matsushita Battery Industrial	Co., Ltd.
Dell Inc.	Co., Ltd./Panasonic	Sanyo Electric Co., Ltd.
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FEDCO Electronics, Inc.	Quanta Computer, Inc.	Texas Instruments, Inc.
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The working group gratefully acknowledges the contributions of the following organizations and participants. Without their assistance and dedication, this standard would not have been completed.

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The working group thanks the Society of Automotive Engineers of Japan, Inc. for permission to reprint Figure E.1, Figure E.2, and Figure E.3 from the article “On Temperature Rise in Passenger Compartment in Summer,” which originally appeared in the Journal of the Society of Automotive Engineers of Japan, Inc. [B12].

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IEEE Standard for Rechargeable Batteries for Portable Computing

1. Overview

This standard is a guide for the manufacturer/supplier in planning and implementing the controls for the design and manufacture of lithium-ion (Li-ion) and lithium-ion polymer (Li-ion polymer) rechargeable battery packs used for portable computing.

This standard's provisions work together and they define approaches to design, test, and evaluate a cell, battery pack, and host device to mitigate battery system failure. Additionally, this standard provides recommendations for end-user education and communication materials. This approach suggests the interfaces between subsystems (e.g., cell, battery pack, host device) and end users are as important to system reliability as is robust subsystem design and testing. This standard therefore includes subsystem interface design responsibilities for each subsystem manufacturer/supplier, and it provides messaging and communication provisions for end-user awareness. Therefore, the responsibility for total system reliability is shared between the designers/manufacturers/suppliers of the subsystems and the end user. Compliance to this standard requires adherence to all the provisions of the standard.

1.1 Scope

This standard establishes criteria for design analysis for qualification, quality, and reliability of rechargeable battery systems for portable computing. It also provides methods for quantifying the operational performance of these batteries and their associated management and control systems, including considerations for end-user notification.

This standard covers rechargeable battery systems for mobile computing. The battery technologies covered are limited to Li-ion and Li-ion polymer, but future versions of this standard may include technologies that are not in general use at present. Also included are: battery pack electrical and mechanical construction; system, pack, and cell level charge and discharge controls; and battery status communications. The following are addressed: qualification process, manufacturing process control, energy capacity and demand management, levels of management and control in the battery systems, current and planned lithium-based battery chemistries, packaging technologies, and considerations for end-user notification.

1.2 Purpose

The purpose of this standard is to ensure reliable user experience and operation of batteries in portable computing environments. The battery industries need standardized criteria for design and qualification of rechargeable battery systems and for verifying the quality and reliability of those batteries.

This standard, and its accompanying annexes, provides no guarantee of protection or safety for battery users. This standard sets forth recommendations for design analyses and certain testing procedures. The level of assurance for protection and safety resulting from applying this standard depends on the implementation by the manufacturer/supplier and the actions of the end user. In the recommendations for design analyses contained herein, this standard contemplates reasonable intended use by the end user, but it does not provide a complete guarantee against hazards to the end user, such as fire, explosion, and leakage.

2. References

This standard shall be used in conjunction with the following publications. When the following specifications are superseded by an approved revision, the revision shall apply.

Guidance for Safe Usage of Portable Lithium-Ion Rechargeable Battery Pack, First Edition, March 2003, Battery Association of Japan.¹

IEC 60050-486:1991, International Electrotechnical Vocabulary—Chapter 486: Secondary Cells and Batteries.²

IEC 61000-2-4:2002, Electromagnetic Compatibility (EMC)—Part 2-4: Environment—Compatibility Levels in Industrial Plants for Low-Frequency Conducted Disturbances.

IEC 61960-1:2000, Secondary Lithium Cells and Batteries for Portable Applications—Part 1: Secondary Lithium Cells.

IEC 61960-2:2001, Secondary Lithium Cells and Batteries for Portable Applications—Part 2: Secondary Lithium Batteries.

IEC 62133:2002, Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes—Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made from Them, for Use in Portable Applications, Annexes A and B.

ISO 3864-1:2002, Graphical Symbols—Safety colors and safety signs—Part 1: Design principles for safety signs in workplaces and public areas.³

UN ST/SG/AC.10/11/Rev.4-2003, Recommendations on the Transport of Dangerous Goods—Manual of Tests and Criteria, Fourth Revised Edition.⁴

¹This publication is available from the Battery Association of Japan, Kikai Shinko-Kaikan, Suite 509, 5-8, Shibakoen 3-chome, Minato-ku, Tokyo 105-0011, Japan (<http://www.baj.or.jp>)(bajapan@hi-ho.ne.jp).

²IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

³ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iso.ch/>). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

⁴This publication available from United Nations Publications, Room DC2-853, 2 UN Plaza, New York, NY 10017, USA, or Publications des Nations Unies, Section des Ventes et Commercialisation, Bureau E-4, CH-1211 Geneva 10, Switzerland (<http://www.un.org>).

UL 1642-1995, Lithium Batteries, Third Edition.⁵

UL 2054-2003, Household and Commercial Batteries.

WARNING

Some of the tests specified herein can be dangerous to the persons carrying them out. All appropriate measures to protect personnel against possible chemical or explosion hazards should be taken.

3. Definitions and other terms

For the purposes of this standard the following terms and definitions apply. If not defined in this clause, English words are used in accordance with their definitions in the latest editions of *Merriam-Webster's Collegiate Dictionary* [B10].⁶ Electrical and electronic terms not defined in this clause or in the *Collegiate Dictionary* are used in accordance with their definitions in *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B7].

3.1 Definitions

3.1.1 abuse: Use of product in a way that is not intended by the supplier but which may result from unreasonable or malicious human behavior or unreasonably extreme conditions or environments.

3.1.2 active charger: A charger that has a communication channel and interacts with the host device.

3.1.3 adapter: A device that transforms the available power from an external source (e.g., ac wall outlet, airline or automobile outlets) to the power used by the portable computing device.

3.1.4 battery/battery pack: An assembly of any number of Li-ion or Li-ion polymer cells, associated electronics, battery packaging, and connector(s).

3.1.5 cell: Basic manufactured Li-ion or Li-ion polymer unit providing a source of electrical energy by direct conversion of chemical energy that consists of electrodes, separators, electrolyte, container, and terminals, and that is designed to be charged electrically.

3.1.6 cell block: Unit of cells connected in parallel.

3.1.7 charger: A charger is a device that imposes a voltage and current in the proper polarity on a cell or battery to return the battery to a higher state of charge.

3.1.8 charging algorithm: The set of rules and decisions used to determine the voltages and currents applied to the cell, cells, and/or battery pack as a function of time, temperature, or other parameters.

3.1.9 critical: (A) Of, relating to, or being a turning point or an especially important juncture; (B) relating to or being a state in which or a measurement or point at which some quality, property, or phenomenon suffers a definite change.

NOTE—Critical limits, critical steps, traceability plans, etc., may be considered to be critical design factors and these parameters are determined by the manufacturer/supplier.

⁵UL standards are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (<http://global.ihs.com/>).

⁶The numbers in brackets correspond to those of the bibliography in Annex F.

3.1.10 design analysis: The evaluation of a design to determine correctness with respect to stated requirements, conformance to design standards, system efficiency, and other criteria, including consideration of system aging and usage over the life of the product.

3.1.11 design failure mode effects analysis (DFMEA): A detailed engineering examination of the design before it is put into production to determine the effect(s) of failure(s) of a component and a subsystem on the host device.

3.1.12 embedded controller: A programmable microprocessor that has a dedicated function to control specific components of the computer architecture independent of the main processor.

3.1.13 electrostatic discharge (ESD): Electrical discharges of static electricity that build up on personnel or equipment, generated by interaction of dissimilar materials. The discharge may damage sensitive components and render them inoperative.

3.1.14 failure mode: The manner in which failure occurs, generally categorized as electrical, thermal, and contamination. It can be associated with a defect or use outside of specification.

3.1.15 failure mode effects analysis (FMEA): The identification of significant failures, irrespective of causes and consequences. This includes, but is not limited to, electrical and mechanical failures that could conceivably occur under specified service and use conditions and their effect, if any, on adjoining circuitry or mechanical interfaces displayed in a chart, table fault tree, or other format.

3.1.16 fault: A physical condition that causes a device, a component or an element to fail to perform in the required manner, for example, a short circuit, broken wire and an intermittent connection, or a software error.

3.1.17 hazard: An undesirable result of one or more faults that include: a forceful rupture of the battery pack and/or projectile emission; fire or flame outside of the battery enclosure; noticeable quantity of smoke; release of toxic, corrosive, or dangerous materials in excess of recognized health and safety standards; electric shock that exceeds accepted standards; systems or components generating untouchable surfaces; and leakage of liquid outside of system enclosure.

3.1.18 host (host device): A device powered by a battery and/or charges the battery. Portable computers and external chargers are examples of host devices.

3.1.19 intended use: Use of a product in accordance with specifications, instructions, and information provided by the supplier.

3.1.20 manufacturer/supplier: An entity that designs and/or assembles and/or markets finished portable computing devices or a cell, battery pack, and/or system, as appropriate.

3.1.21 open circuit voltage (OCV) (cell or battery pack): The voltage at its terminals when no appreciable current is flowing.

3.1.22 overcharge: The forcing of a current through a battery pack after it has been fully recharged. Overcharge may damage the normal operation of the cell or battery and/or induce a hazard.

3.1.23 overcurrent: A situation where the current to or from a cell or battery pack exceeds the manufacturer/supplier/suppliers rating or specifications. Overcurrent may damage the normal operation of the cell or battery and/or induce a hazard.

3.1.24 over-discharge: The forcing of current through a battery pack after it had been fully discharged. Over-discharge may damage the normal operation of the cell or battery and/or induce a hazard.

3.1.25 overvoltage: A situation where the voltage of a cell or battery pack exceeds the manufacturer/supplier rating or specifications. Overvoltage may damage the normal operation of the cell or battery and/or induce a hazard.

3.1.26 passive charger: A charger that does not have a communication channel with the host device.

3.1.27 portable computer: A portable computing device consisting of a processor and various input and output devices, capable of executing software programs on direction, and powered by a battery or by a connection to an external power source.

3.1.28 portable computing device: A notebook, laptop, tablet computer with processor, memory storage and I/O devices that can be powered either by a battery or by a connection to the utility grid.

3.1.29 positive temperature coefficient (PTC): A PTC resistor is a component that has the characteristic of a sudden large increase in resistance when the device reaches a specified temperature and/or current.

3.1.30 product lifetime: The actual period from initial operation to retirement of a system, structure, or component.

3.1.31 reasonable and foreseeable misuse: Use of a product in a way that is not intended by the supplier but may result from reasonable and foreseeable human behavior.

3.1.32 risk priority number (RPN): A number calculated by multiplying severity, occurrence likelihood, and likelihood of not detecting the fault in an FMEA analysis. The scale is typically 1 through 5, with 5 being highest and 1 being lowest.

3.1.33 system: The combined cell, battery pack, host device, power supply or adapter, user, and environment.

3.2 Other terms

3.2.1 may: The word *may* indicates a course of action permissible within the limits of the standard. See ISO/IEC Directive Part 2 [B8], Annex G.

3.2.2 shall: The word *shall* is used to indicate mandatory requirements strictly to be followed in order to conform to the standard. (The equivalent definition of ISO/IEC Directive Part 2 [B8]: Shall = is to; is required to; it is required that; has to; only...is permitted; it is necessary.)

3.2.3 should: The word *should* is used to indicate that among several possibilities one is recommended as particularly suitable without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in a negative form) a certain course of action is depreciated but not prohibited. (The equivalent definition of ISO/IEC Directive Part 2 [B8]: Should = is recommended that; ought to.)

4. System integration considerations

This clause sets forth provisions for conducting design analyses for cell, pack, and host devices and tying these together into an overall system level design analysis including the end user. The design analyses shall be conducted to minimize hazards from occurring as a result of one and two independent faults while in *intended use*. The design analysis shall also be conducted to minimize hazards from occurring due to *reasonable and foreseeable misuse*. Conditions beyond reasonable and foreseeable misuse are outside the

scope of this standard. While design analyses should be thorough, it is not practical to address every single conceivable scenario. Such an approach would prove onerous, unrealistic, and overly burdensome.

Examples of design analyses methods include the following:

- FMEA
- Fault tree analysis
- Empirical and/or destructive testing
- Reviewing company service records for failure modes and/or trends
- Fishbone analysis
- Detailed and extensive design reviews
- Reviews of prior design issues to ensure they are not repeated
- Reviews of industry standards and test methodologies

The following four design analyses shall be developed: Analysis 1 (cell), Analysis 2 (battery pack), Analysis 3 (host device), and Analysis 4 (combined cell, battery pack, and host device working together as a system and including the end user). Analysis 4 shall include interactions between Analyses 1, 2, and 3, as noted in Annex B, Annex C, and Annex D.

The design analyses shall identify the following:

- a) End-user responsibilities for reliable total system operation. See Clause 8 for information on the reliable total system operation.
- b) Manufacturer/supplier responsibilities for independent and/or distributed control schemes for reliable total system operation.

5. Cell considerations

This clause describes the precautions and considerations to include in the analysis of designing, manufacturing, and testing of rechargeable Li-ion and Li-ion polymer cells over their useful life. The objective is to identify the precautions for the cell design to reduce latent problems to a minimum and to increase reliable user experience.

5.1 Design process

Critical design factors that require careful attention include aspects of the manufacturing process from mixing of the active materials to the final evaluation for product release.

5.1.1

Materials specifications shall be developed and identify and limit impurities to below critical limits. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control

5.1.2

The thickness and choice of material quality of the separator shall prevent electrically conductive material from the penetrating separator and causing an internal short.

5.1.3

Separator material should ensure internal resistance increases within separator pores (electrical conductivity shutdown) when cell temperature rises above its shutdown point. The shutdown point of the separator should be lower than the temperature where thermal runaway initiates.

5.1.4

The width of the separator shall be designed to be wider than either positive or negative electrodes.

5.1.5

The electrode and lead wire whose polarity is opposite to that of the cell case should be insulated from the cell case to prevent shorting in the event the cell is subjected to shock and/or vibration.

5.1.6

Vent design or mechanism and specifications should be designed to operate within a very close tolerance.

5.1.6.1

Vent activation should perform within design specification.

5.1.6.2

The vent should operate immediately when pressure increases to design level.

5.1.6.3

The vent should be designed to activate when the cell is exposed to excessive overcharge and other internal pressure stress conditions.

5.1.7

The manufacturer/supplier should incorporate an overcurrent protector such as a PTC resistor or other protective device with each cell in the event of external short and overcharge.

5.1.8

There shall be no damage to the cell container, and critical cell design elements, during welding and other operations. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.2 General manufacturing considerations

5.2.1

Critical material for cell production shall have detailed specifications and shall have an incoming material quality control plan to ensure conformance to specification. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.2.2

All known and possible undesirable impurities in materials should be identified, specified, minimized, and controlled.

5.2.3

The appropriate electrode substrate material for the positive electrode and negative electrode shall be specified and verified by analysis. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.2.4

Coating and thickness of electrodes for the positive electrode and negative electrode shall be controlled to provide uniform thickness within tolerance set by cell specification. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.2.5

Burrs on any cut (slit) side of the electrodes or tab materials shall not exceed limits specified by manufacturer/supplier. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.2.6

Wrinkling, tearing, and/or deformation of the electrodes should be prevented and eliminated.

5.2.7

The manufacturing equipment should be designed to prevent any damage or modifications to the vent system during manufacturing operations.

5.3 Spiral winding process

5.3.1

The position of negative and positive tabs shall be staggered so they do not overlap each other. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.3.2

The external dimensions of the electrode core, which was spirally wound with the separator, shall be adjusted to maintain appropriate value. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.3.3

The winding tension of the electrode and separator during the winding process shall be properly adjusted to keep in design range and optimized to fit into the cell container. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.3.4

To prevent damage to or telescoping of the wound electrodes, the winding spindle removal mechanism should be controlled, or a means to verify winding deviation has not occurred during removal of winding stick shall be incorporated.

5.4 Assembly precautions

5.4.1

The introduction of metal contamination from equipment or process should be prevented.

5.4.2

The method of assembly for insulating material, whether for electrode, current collectors, or internal insulation, should provide reliable protection against latent shorts for the functional life of the product.

5.4.3

The positions of lead tabs in the cell should be verified and not be overlapping.

5.4.4

The integrity of wound electrodes should be verified through resistance or a continuity check or equivalent means.

5.4.5

If the cell has insulating plates, the insulating plates shall be securely positioned. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process.

5.4.6

A permeable X-ray may be used to inspect the cell structure for correct assembly, especially during the preliminary production setup.

5.4.7

OCV and/or impedance or other appropriate testing should be taken after critical steps in the manufacturing process where contamination could be introduced.

5.4.8

The cell manufacturing process shall have a traceability plan. This plan should include methods by which traceability can be implemented at any date during product functional life and after production to determine lot designation and performance data related to the cell. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.4.9

Manufacturer/supplier should develop and apply appropriate cell aging, grading, and/or sorting criteria for post-assembly screening of cells.

5.5 Critical testing practices

Preproduction testing and production sampling should be extensive to confirm the design and production process. These testing procedures are not all inclusive. Tests are designed to confirm that the cells have the desired performance characteristics and are robust enough to resist abuse conditions should they arise.

5.5.1

New cell designs shall pass specified tests which the manufacturer/supplier decided according to the contents of design change before qualification as production cells. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.5.2

Production cells shall pass tests which the manufacturer/supplier specifies. This process is performed at specified intervals to maintain compliance with the manufacturer/supplier's internal specification. Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.5.3

The specifications shall not exceed the manufacturer/supplier specified values after testing (except cells used for safety tests). Use manufacturer/supplier's specifications or documentation to ensure control of this criteria or process. Establish a verification process (e.g., ISO 9001) to ensure control.

5.5.4

OCV and/or impedance or other appropriate testing should be performed after critical steps in the manufacturing process where contamination could be introduced (winding, slitting, etc.).

5.5.5

Verification of final product performance and design specification conformance should be conducted through accelerated testing techniques and product inspection analysis.

5.5.6

There are several relevant cell testing standards. Manufacturer/suppliers should be familiar with these standards and should utilize one or more of these standards as part of their testing process. In certain cases, compliance with one or more of these standards may be necessary to meet regulatory requirements. Specifications that are relevant include UL 1642-1995,⁷ IEC 61960-1-2000, UL 60950-2000 [B15] plus derivative standards, IEC 60950-1-2001 [B6] plus derivative standards.

6. Battery pack considerations

This clause describes the precautions and considerations to include in the analysis of designing, manufacturing, and testing of rechargeable Li-ion and Li-ion polymer battery packs over their useful life. The objective is to identify the precautions for the battery pack design to reduce latent problems to a minimum and to increase reliable user experience.

⁷Information on references can be found in Clause 2.

6.1 Marking the battery pack

6.1.1

Each manufacturer/supplier shall have a traceability plan and each battery pack should carry markings of the production lot and/or date code on the label or contain the information in the battery pack or memory.

6.1.2

Each battery pack shall carry external markings providing the following information at a minimum.

6.1.2.1

Name or part number of the battery pack.

6.1.2.2

Voltage as rated by the manufacturer/supplier.

6.1.2.3

The chemistry type of the battery.

6.1.2.4

Name or identification code of the battery pack manufacturer/supplier.

6.1.2.5

User precautions as required by 8.1 of this standard.

6.2 Battery packs design guidelines

6.2.1

The battery pack shall be designed to mitigate hazards from contamination of electronic circuits by electrolyte from leaking cells.

6.2.2

The battery pack and connector shall be designed to minimize hazards from foreign objects and external sources of liquids.

6.2.3

In order to minimize the occurrence of an accidental short circuit, the following shall be implemented in the design of the circuit board and the assembling process of battery packs:

- a) Provide adequate runner spacing, soldering area size, and distance from each other, especially for power traces
- b) Provide adequate process control from solder balls, solder flashes, solder bridges, and foreign debris

6.2.4

All components used in the construction of the battery pack, such as connectors, cables, tabs, insulators, and circuit boards, shall have adequate electrical, thermal, and mechanical ratings for the application.

6.2.5

Individual unit cells in a battery pack shall be arranged in accordance with correct polarity.

6.3 External short-circuit precautions

6.3.1

The battery pack shall limit output current in the event of an external short circuit whether the battery pack is installed in or removed from the host device.

6.3.2

The battery pack shall have at least two independent methods to limit current. One may be at the cell level. One method may include connector structure to minimize the possibility of an external short circuit of the battery terminals.

6.3.3

Methods to limit output current may include protective circuits.

6.3.4

Battery pack connector designs shall be implemented to minimize the possibility of accidental external short circuit.

6.4 Overheating precautions

6.4.1

Temperature ranges for operation shall be set based on the operating temperature ranges recommended by the cell manufacturer/supplier, battery pack manufacturer/supplier, and host device manufacturer/supplier.

6.4.2

Temperature ranges shall consider ambient temperature as well as the effects of heat interactions between cell, battery pack, and host device.

6.4.3

Over-temperature protection shall be incorporated to prevent operation above maximum temperature and time limitations where hazards may occur.

6.4.3.1

The battery pack shall contain at least one thermal protection circuit or device independent of internal cell devices or mechanisms. The combination of cell, pack, and host device/charger shall have at least two independent thermal protection devices or mechanisms.

6.4.3.2

When temperature and time limitations are exceeded, the battery pack shall take action, which may include shutdown, or other protective action.

6.4.3.3

When temperature and time limitations are exceeded, the host device may take action, which may include shutdown, or other protective action.

6.5 Overcharge precautions (consult overcharge and over-discharge definitions)

6.5.1

The maximum charging voltage and current shall be set on the basis of an agreement made among the cell, battery pack, and host device manufacturer/suppliers and shall be based on the upper voltage and current limits of the cell, as specified by the cell manufacturer/supplier.

6.5.2

The charging system shall be designed to limit the charging voltage and current to their maximum specified values as specified in 6.5.1. The battery pack should include charging control circuitry or a device to prevent overcharging.

6.5.3

Charge control may be located in the battery pack.

6.5.4

The combination, consisting of cell, battery pack, and host device/charger shall have at least three independent overcharge protection functions.

6.5.4.1

At least one overcharge protection function method shall be overvoltage detection.

6.5.4.2

At least one of these protection functions should be in the battery pack (see 3.1.22 and 3.1.25).

6.5.5

The combination of cell, battery pack, and host device/charger shall detect the voltage of each cell block in the battery pack and shall control the charge if overvoltage occurs.

6.6 Over-discharge precautions

6.6.1

The minimum discharge voltage and current shall be set on the basis of an agreement made among the cell, battery pack, and host device manufacturer/suppliers and shall be based on the lower voltage and current limits of the cell, as specified by the cell manufacturer/supplier.