UL 2595

STANDARD FOR SAFETY

General Requirements for Battery-Powered Appliances

UL Standard for Safety for General Requirements for Battery-Powered Appliances, UL 2595

Second Edition, Dated September 9, 2015

Summary of Topics

This new Bi-National Standard for ANSI/UL 2595, Standard for General Requirements for Battery-Powered Appliances Resulting includes the following changes:

- ***Revisions to Add References to the Applicable CSA Standards;***
- ***New and Clarified Definitions;***
- ***Clarifications and New Requirements for Markings and Instructions;***
- ***Clarification of Requirements for Harnesses;***
- ***Clarification that All Cells Shall Comply with the Requirements of UL 62133; and***
- ***Revision of indent G Instructions Providing Guidance that the End Product Standard be Revised to Also Include a Statement that UL 2595 Functional Safety Requirements for an Electronic Safety Control Circuit Fulfills the Requirements of the End-Product Standard.***

The new requirements are substantially in accordance with Proposal(s) on this subject dated February 13, 2015 and May 15, 2015.

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CSA C22.2 No. 0.23
First Edition

Underwriters Laboratories Inc.
UL 2595
Second Edition

General Requirements for Battery-Powered Appliances

September 9, 2015

ANSI/UL 2595-2015

Commitment for Amendments

This standard is issued jointly by the Canadian Standards Association (operating as "CSA Group") and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to CSA Group or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of CSA Group and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue.

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This Standard is subject to review five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquires@csagroup.org and include ″Proposal for change″ in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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This ANSI/UL Standard for Safety consists of the Second Edition. The most recent designation of ANSI/UL 2595 as an American National Standard (ANSI) occurred on September 9, 2015. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

CONTENTS

PREFACE

This is the harmonized CSA Group and UL standard for General Requirements for Battery-Powered Appliances. It is the first edition of CSA C22.2 No. 023, and the second edition of UL 2595. This edition of UL 2595 supersedes the previous edition published on May 22, 2013.

This harmonized standard was prepared by the CSA Group and Underwriters Laboratories Inc. (UL).

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

This standard was reviewed by the CSA Subcommittee on Batteries and Battery Systems, under the jurisdiction of the CSA Technical Committee on General Requirements, CE Code, Part II and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

This standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of Harmonization

This standard is published as an identical standard for CSA Group and UL.

An identical standard is a standard that is exactly the same in technical content except for national differences resulting from conflicts in codes and governmental regulations. Presentation is word for word except for editorial changes.

Reasons for Differences From IEC

This standard is the result of many source documents including IEC 60745-1 Ed. 4.0 b:2006 and IEC 62841-1 Ed. 1.0. This standard is not based on a single IEC document.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

IEC Copyright

For CSA Group, the text, figures, and tables of International Electrotechnical Commission Publication IEC 60745-1 Ed. 4.0b:2006, Hand-Held Motor-Operated Electric Tools — Safety — Part 1: General Requirements and IEC 62841-1 Ed. 1.0: 2014, Standard for Safety for Electric Motor-Operated Hand-Held Tools, Transportable Tools And Lawn And Garden Machinery – Safety – Part 1: General Requirements, copyright 2006 and 2014 respectively, are used in this standard with the consent of the International Electrotechnical Commission.

For UL, parts of this text have been taken from or adapted from IEC 60745-1 Ed. 4.0b:2006, Hand-Held Motor-Operated Electric Tools — Safety — Part 1: General Requirements and IEC 62841-1 Ed. 1.0: 2014, Standard for Safety for Electric Motor-Operated Hand-Held Tools, Transportable Tools And Lawn And Garden Machinery – Safety – Part 1: General Requirements, copyright 2006 and 2014 respectively are used in this standard with the consent of the IEC and the American National Standards Institute (ANSI). The IEC copyrighted material has been reproduced with permission from ANSI. Additional information regarding the permission from ANSI can be found in Annex F. ANSI should be contacted regarding the reproduction of any portion of the IEC material. Copies of IEC Publication 60745-1 and 62841-1 may be purchased from ANSI, 25 West 43rd Street, 4th Floor, New York, New York, 10036, (212) 642- 4900.

1 Scope

1.1 This standard applies to battery operated appliances. This standard applies to appliances incorporating detachable, integral and separable battery packs. The maximum rated voltage for appliances and battery packs is 75 V d.c.

1.2 This standard also applies to battery-powered appliances that are also operated and/or charged directly from the mains or a non-isolated source, including appliances provided with integral battery chargers. The additional considerations for these constructions are contained in Additional Requirements for Battery Operated Appliances with a Connection to Mains or a Non-isolated Source, Clause 22.

1.3 These requirements are structured so as to be used in conjunction with an end product standard. These requirements are not intended to provide comprehensive evaluation of a battery operated appliance independent of an end-product standard.

1.4 These requirements only address the potential risks unique to the utilization of a battery supply in a product. With the exception of appliances that also have a mains or non-isolated source, these requirements replace or modify the requirements associated with risk of fire and electric shock for mains powered versions of the appliance in the end product standard. See Indent A in Table D1.1.

1.5 Conditions of use of the product that are the basis for test and other evaluations in the standard are retained and applied, as far as practicable, to these products employing a battery supply.

1.6 Battery operated appliances not able to be connected to mains connected power covered by this standard are not considered to be grounded (class I) or double-insulated (class II), appliances and therefore are not required to have basic, supplementary or reinforced insulation. Electric shock hazard is considered to exist only between parts of opposite polarity.

1.7 Battery packs for appliances covered under this standard intended to be charged by a non-isolated charger are to be evaluated by this standard and the requirements for protection against electric shock of the end-product standard. When evaluating a battery pack for protection against electric shock, the construction and test requirements are to be assessed with the battery fitted to the intended charger.

1.8 When evaluating the risk of fire associated with detachable battery packs, consideration has been given to the fact that these battery packs are unattended energy sources and have been evaluated as such in this standard. Detachable battery packs evaluated by this standard are therefore considered to fulfill an effective protection against the risk of fire equivalent to that of the end-product standard.

1.9 Since battery packs for appliances are submitted to different use patterns (such as rough use, high charging and discharging currents) their safety can be evaluated only by this standard and not by using other standards for battery packs, such as the Standard for Household and Commercial Batteries, UL 2054, unless otherwise indicated in this standard.

1.10 This standard does not apply to the safety of battery chargers themselves. However, this standard covers the safe functioning of lithium-ion battery systems.

1.11 This standard also addresses requirements covering the use of lithium-ion cells employed in battery systems in appliances. The following is considered within the context of these requirements:

a) These requirements address the risk of fire or explosion of these batteries but do not cover any possible hazards associated with toxicity nor potential hazards associated with transportation or disposal.

b) Battery systems covered by these requirements are not intended to be serviced by the end user.

c) These requirements are intended to provide comprehensive evaluation of a battery only if used in products covered by this standard.

d) These requirements refer to and require parameters supplied in reference to the cells that establish conditions for safe use of those cells. Those parameters form the basis of acceptance criteria for a number of tests contained herein. This standard does not independently evaluate the safety of cells. These parameters, taken as a set, constitute the "Specified Operating Region" for a cell. There may be several sets of specified operating region(s).

1.12 This standard is not intended to apply to appliances using general purpose batteries installed by the user, and this standard alone will not be sufficient to ensure all hazards are considered for these products' "battery packs".

1.13 These requirements do not consider the effect of special applications (such as medical appliances) or special environments (such as hazardous locations).

1.14 These requirements have not been assessed for their suitability for product categories other than appliances such as information technology equipment, telecommunications, laboratory equipment, fire alarm, security systems, emergency lighting, and audio-video apparatus, and may be incomplete with respect to those categories.

1.15 These requirements address the safety of battery systems during storage and use including discharge and charge. These requirements are only considered to be supplementary requirements with respect to the risk of fire and electric shock in battery chargers. The safety of battery chargers for appliances are covered by other standards such as the Standard for Power Units Other Than Class 2, UL 1012, the Standard for Battery Chargers, CAN/CSA C22.2 No. 107.2, the Standard for Class 2 Power Units, UL 1310, the Standard for Power Supplies With Extra-Low-Voltage Class 2 Outputs, CAN/CSA C22.2 No. 223, or the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 and CAN/CSA C22.2 No. 60950-1.

1.16 These requirements make frequent reference to the conditions and tests of the end-product standard while also providing minimum conditions or severity of tests. These minimum conditions are not to be construed to imply equivalence to end-product requirements. Conditions or requirements of end-product standards are to prevail over the conditions or requirements of this standard, unless otherwise indicated in this standard.

1.17 This standard is not intended to cover appliances using lithium-metal type cells, and this standard alone will not be sufficient to ensure all hazards are considered for these types of cells. Lithium-ion cells are not lithium-metal cells.

2 General

2.1 Units of measurement

2.1.1 The values given in SI (metric) units shall be normative. Any other values given shall be for information purposes only.

2.2 Normative references

2.2.1 The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.2.2 For products intended for use in Canada, general requirements are given in CAN/CSA-C22.2 No. 0.

CSA Group Standards

CAN/CSA C22.2 No. 0
General Requirements – Canadian Electrical Code, Part I

CAN/CSA C22.2 No. 0.17
Evaluation of Properties of Polymeric Materials

CSA C22.2 No. 14
Industrial Control Equipment

CSA C22.2 No. 66.1
Low Voltage Transformers – Part 1: General Requirements

CSA C22.2 No. 66.2
Low Voltage Transformers – Part 2: General Purpose Transformers

CSA C22.2 No. 66.3
Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers

CSA C22.2 No. 107.1
General Use Power Supplies

CAN/CSA C22.2 No. 107.2
Battery Chargers

CAN/CSA C22.2 No. 223
Power Supplies With Extra-Low-Voltage Class 2 Outputs

CAN/CSA C22.2 No. 60950-1
Information Technology Equipment – Safety – Part 1: General Requirements

CAN/CSA E60384-14
Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification - Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains

CAN/CSA E62133
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

CSA Component Acceptance Notice No. 5A
Component Acceptance Service for Optocouplers and Related Devices

CSA TIL No. CA-3A
Component Acceptance Requirements for PTC Thermistors for Overcurrent Protection in Electrical and Electronic Equipment

UL Standards

UL 94
Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 508
Industrial Control Equipment

UL 969
Marking and Labeling Systems

UL 1012
Power Units Other Than Class 2

UL 1310
Class 2 Power Units

UL 1434
Thermistor-Type Devices

UL 1577
Optical Isolators

UL 2054
Household and Commercial Batteries

UL 2089
Vehicle Battery Adapters (2011 edition)

UL 5085-1
Low Voltage Transformers – Part 1: General Requirements

UL 5085-2
Low Voltage Transformers – Part 2: General Purpose Transformers

UL 5085-3
Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers

UL 60384-14
Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains

UL 60950-1
Information Technology Equipment – Safety – Part 1: General Requirements

UL 62133
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

IEC Standards

IEC 60065
Audio, Video, and Similar Electronic Apparatus-Safety Requirements

IEC 60384-14
Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification – Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains

IEC 60384-16
Sectional Specification: Fixed Metallized Polypropylene Film Dielectric D.C. Capacitors

IEC 60695-2-11
Fire Hazard Testing – Part 2-11: Glowing/Hot-Wire Based Test Methods - Glow-Wire Flammability Test Method for End-Products

IEC 60695-2-13
Fire Hazard Testing – Part 2-13: Glowing/Hot-Wire Based Test Methods – Glow-Wire Ignition Temperature (GWIT) Test Method for Materials

IEC 60695-10-2
Fire Hazard Testing – Part 10-2: Abnormal Heat – Ball Pressure Test

IEC 60695-11-10
Fire Hazard Testing – Part 11-10: Test Flames – 50 W Horizontal and Vertical Flame Test Methods

IEC 60730-1:2010
Automatic Electrical Controls – Part 1: General Requirements

IEC 61000-4-2
Electromagnetic Compatibility (Emc) – Part 4-2: Testing and Measurement Techniques – Electrostatic Discharge Immunity Test

IEC 61032
Protection of Persons and Equipment by Enclosures – Probes for Verification

IEC 61056-1
General Purpose Lead-Acid Batteries (Valve-Regulated Types) – Part 1: General Requirements, Functional Characteristics – Methods of Test

IEC 61951-1
Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Portable Sealed Rechargeable Single Cells – Part 1: Nickel-Cadmium

IEC 61951-2
Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Portable Sealed Rechargeable Single Cells – Part 2: Nickel-Metal Hydride

IEC 61960
Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Secondary Lithium Cells And Batteries For Portable Applications

ISO Standards

ISO 3864-2
Graphical Symbols – Safety Colours and Safety Signs – Part 2: Design Principles For Product Safety Labels

ISO 7000
Graphical Symbols For Use On Equipment – Registered Symbols

ISO 12100
Safety of Machinery – General Principles for Design – Risk Assessment and Risk Reduction

ISO 13849-1
Safety of Machinery – Safety-Related Parts of Control Systems – Part 1: General Principles for Design

3 Terms and Definitions

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

3.2 APPLIANCE – A product, which is not a component of another product, whose primary output consists of heat, light, mechanical motion, or the movement of air. Within these requirements, appliance is assumed to refer to an appliance that derives its operating power from a battery. Appliances do not include products or vehicles intended for the transport of people or cargo.

3.3 BATTERY – Assembly of one or more cells intended to provide electrical current to the appliance.

3.4 BATTERY, INTEGRAL – Battery which is contained within the appliance and is not removed from the appliance for charging purposes. A battery that is to be removed from the appliance for disposal or recycling purposes only is considered to be an integral battery.

3.5 BATTERY PACK, DETACHABLE – Battery which is contained in a separate enclosure from the appliance and is intended to be removed from the appliance for charging purposes.

3.6 BATTERY PACK, SEPARABLE – Battery which is contained in a separate enclosure from the appliance and is connected to the appliance by a cord.

3.7 BATTERY SYSTEM – Combination of a battery, the charging system, the appliance and the interfaces between them as existing during operation of the appliance or during charging.

3.8 C_5 RATE – Current, in amperes, that a cell or battery can be discharged at for 5 h to the voltage cut-off point specified by the cell manufacturer. This is equal to the C_5 capacity divided by 5 hours where C_5 is measured in accordance with Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Secondary Lithium Cells and Batteries for Portable Applications, IEC 61960; Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Portable Sealed Rechargeable Single Cells – Part 1: Nickel-Cadmium, IEC 61951-1; or Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Portable Sealed Rechargeable Single Cells – Part 2: Nickel-Metal Hydride, IEC 61951-2.

3.9 CELL – 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.

3.10 CELL, SEALED – Cell where the gases generated from within the cell may not escape to the atmosphere under normal use although they may escape under abnormal conditions through a pressure sensitive vent. Also known as “valve regulated cell”.

3.11 CELL, VENTED – Cell where the gases generated from within the cell may escape to the atmosphere under normal use. Also known as “flooded cell”.

3.12 CHARGER – Part or all of the charging system contained in a separate enclosure. As a minimum, the charger includes some of the power conversion circuitry. Not all charging systems include a separate charger as in the case where an appliance may be charged utilizing a mains supply cord or may incorporate a plug for attachment to a mains receptacle.

3.13 CHARGING SYSTEM – Combination of circuitry intended to charge, balance and/or maintain the state of charge of the battery.

3.14 CLASS I (GROUNDED) APPLIANCE – Appliance in which protection against electric shock does not rely on basic, double or reinforced insulation only, but which includes an additional safety precaution in that conductive accessible parts are connected to the protective grounding (earthing) conductor in the fixed wiring of the installation in such a way that conductive accessible parts cannot become live in the event of a failure of the basic insulation. Also considered as class I appliances are appliances with double insulation and/or reinforced insulation throughout, but also having a grounding (earthing) terminal or grounding (earthing) contact.

3.15 CLASS II (DOUBLE INSULATED) APPLIANCE – Appliance in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective grounding (earthing) or reliance upon installation conditions.

3.16 CLEARANCE (SPACING THROUGH AIR) – Shortest distance between two conductive parts, or between a conductive part and the outer surface of the enclosure, considered as though metal foil were pressed into contact with accessible surfaces of insulating material, measured through air. Examples of the evaluation of clearances are given in Annex A.

3.17 CREEPAGE DISTANCE (SPACING OVER SURFACE) – Shortest path between two conductive parts, or between a conductive part and the outer surface of the enclosure, considered as though metal foil were pressed into contact with accessible surfaces of insulating material, measured along the surface of the insulating material. Examples of the evaluation of creepage distance are given in Annex A.

3.18 DETACHABLE PART – Part which can be removed or opened without the aid of a tool, or a part which is removed in accordance with the instruction for use, except externally accessible brush caps, even if removal requires the use of a tool.

3.19 DUTY CYCLE – Intended operating cycle of an appliance, each cycle being composed of an “on” period of operation followed by an “off” period with the appliance switched off.

3.20 ELECTRONIC COMPONENT – Part in which conduction is achieved principally by electrons moving through a vacuum, gas or semiconductor, with the exclusion of neon indicators. Examples of electronic components are diodes, transistors, triacs, and monolithic integrated circuits. Resistors, capacitors and inductors are not considered electronic components.

3.21 EXPLOSION – Failure that occurs when an appliance enclosure or a detachable or separable battery pack opens violently and major components are forcibly expelled in a manner that could result in injury.

3.22 FIRE – Emission of flames from a battery.

3.23 FULLY CHARGED – Cell or battery charged to the maximum state of charge permitted by the battery charging system intended for use with the appliance and in accordance with the manufacturer’s instructions.

3.24 FULLY DISCHARGED BATTERY/CELL – Battery or cell that has been discharged at C_5 rate until one of the following conditions occurs: discharge terminates due to protective circuitry or the battery (or cell) reaches a total voltage with an average voltage per cell equal to the end-of-discharge voltage for the cell chemistry being used, unless a different end of discharge voltage is specified by the manufacturer. The end-of-discharge voltages for common cell chemistries are provided in General Conditions for the Tests, Clause 5.

3.25 GENERAL PURPOSE BATTERIES/CELLS – Batteries and cells available from a variety of manufacturers, through a variety of outlets intended for a variety of different manufacturers’ products. A 12-V automotive battery and AA, C, and D alkaline cells are examples of general purpose.

3.26 HAZARDOUS VOLTAGE – Voltage between parts having an average value exceeding 60 V d.c. or exceeding 42.4 V peak when the peak-to-peak ripple exceeds 10% of the average value. This value is 30 V d.c. or 21.2 V peak when the peak-to-peak ripple exceeds 10% of the average value for those appliances where the user’s skin is likely to be wet a majority of time in use. See Indent B in Table D1.1.

3.27 HEATING ELEMENT – A device that produces heat as part of the normal, intended function of an appliance. Devices that produce heat as secondary effect of other functions are not considered heating elements.

3.28 ISOLATED SOURCE – Voltage source in which the output is isolated from the mains supply by means of safety isolation complying with the Standard for Power Units Other Than Class 2, UL 1012, the Standard for Battery Chargers, CAN/CSA C22.2 No. 107.2, the Standard for Class 2 Power Units, UL 1310, the Standard for Power Supplies With Extra-Low-Voltage Class 2 Outputs, CAN/CSA C22.2 No. 223, or the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 and CAN/CSA C22.2 No. 60950-1.

3.29 MAINS – The general purpose AC power distribution external to the equipment, provided within the premises to a service disconnecting means at least one pole of which is intended to be referenced to earth ground.

3.30 MAXIMUM CHARGING CURRENT – Highest current that a lithium-ion cell is permitted to pass during charging for a specified range of temperatures in the Standard for 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, CAN/CSA E62133 or Standard for 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, UL 62133.

3.31 MEAN TIME TO DANGEROUS FAILURE (MTTFd) – A measure of system reliability expressed as an expectation of the mean time to failures that would result in loss of a safety critical function.

3.32 NO LOAD – Operation of the appliance with no additional loading being applied external to the appliance.

3.33 NON-ISOLATED SOURCE – Voltage source in which the output is not conductively isolated from the mains supply by means of a safety isolating transformer.

3.34 NON-SELF-RESETTING THERMAL CUT-OUT – Thermal cut-out which requires a manual operation for resetting, or replacement of a part, in order to restore the current. Manual operation also includes operation of the power switch.

3.35 PROTECTIVE DEVICE – Device, the operation of which prevents a hazardous situation under abnormal operation conditions.

3.36 PROTECTIVE IMPEDANCE – Impedance connected between live parts and accessible conductive parts, and of value so that the current is limited to a safe value.

3.37 SAFETY CRITICAL FUNCTION (SCF) – Function(s) required by this standard, the loss of which would cause the appliance to function in such a manner as to expose the user to a risk that is in excess of the risk that is permitted by this standard or the end product standard under abnormal conditions.

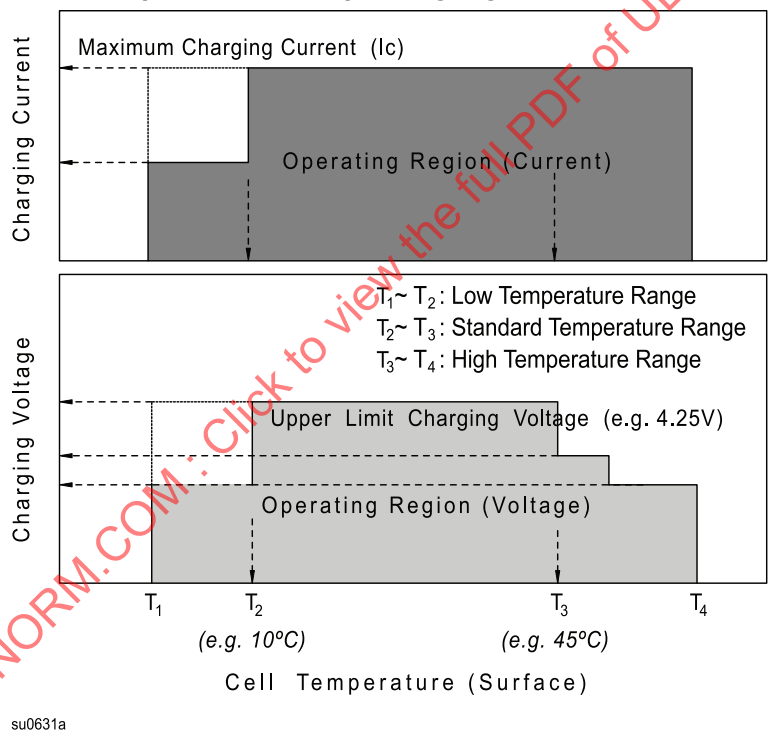
3.38 SAFETY ISOLATING TRANSFORMER – Transformer, the input winding of which is electrically separated from the output winding by an insulation at least equivalent to double insulation or reinforced insulation, and which is intended to supply a distribution circuit, an appliance or other equipment at safety extra-low voltage.

3.39 SINGLE CHANNEL – A structure in which a single functional means is used to execute specified operations.

3.40 SPECIFIED OPERATING REGION – Range of permissible operation of lithium-ion cells, expressed by cell parameter limits.

3.41 SPECIFIED OPERATING REGION FOR CHARGING – Conditions for voltage and current during charging in which the lithium-ion cell is permitted to operateas specified by the cell manufacturer and evaluated in accordance with in the Standard for 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, CAN/CSA E62133 or Standard for 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, UL 62133. In general, the permissible ranges of voltage and current are dependent upon temperature (see Figure 3.1).

Figure 3.1
Example schematic operating region of Li-ion cell



3.42 TEMPERATURE LIMITER – Temperature-sensing device, the operating temperature of which may be either fixed or adjustable, and which, during normal operation, operates by opening or closing a circuit when the temperature of the controlled part reaches a predetermined value. It does not reverse this operation of opening or closing a circuit during the normal duty cycle of the appliance.

3.43 THERMAL CUT-OUT – Device which, during abnormal operation, limits the temperature of the controlled part by automatically opening the circuit, or by reducing the current, the setting of which cannot be altered by the user.

3.44 THERMAL LINK – Thermal cut-out which operates only once, and then requires partial or complete replacement.

3.45 UPPER LIMIT CHARGING VOLTAGE – Highest voltage that a lithium-ion cell is permitted to attain during normal charging for a specified range of temperatures in in the Standard for 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, CAN/CSA E62133 or Standard for 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, UL 62133.

3.46 VENTING – Condition that occurs, when a cell releases excessive internal pressure intended by design to preclude explosion.

4 Classification

4.1 LOW TEMPERATURE (LT) – Detachable or Separable battery pack evaluated for resistance to impact under low ambient temperatures as described in Mechanical Strength, Clause 15. See Indent C in Table D1.1.

4.2 EXTRA LOW TEMPERATURE (ELT: *t*) – Detachable or Separable battery pack, evaluated for resistance to impact under extreme low ambient temperatures as described in Mechanical Strength, Clause 15 shall be evaluated to a particular temperature below 0°C and shall be designated ELT: *t*, where *t* is the test temperature. (e.g. ELT: -35°C). See Indent C in Table D1.1.

5 General Conditions for the Tests

5.1 Some of the tests may result in fire or explosion. It is therefore important that personnel be protected from the flying fragments, explosive force, sudden release of heat, chemical burns, intense light and noise that may result from such explosions. The test area shall be well ventilated to protect personnel from possible harmful fumes or gases.

5.2 Appliances having more than one rated voltage shall be tested on the basis of the most unfavorable voltage.

5.3 Unless otherwise specified, a fully charged battery pack shall be used for each test.

5.4 When measuring voltage, the peak value of any superimposed ripple exceeding 10% of the average value shall be included. Transient voltages are ignored, such as a temporary increase in voltage, for example after the battery pack is removed from the charger.

5.5 Measurements of cell voltages during the tests of lithium-ion systems shall be made using a single pole resistive-capacitive low pass filter with a cut-off frequency of 5 kHz ±500 Hz. If charging voltages have been exceeded, the peak value of the voltage measured after this network shall be used. The measurement shall have measurement tolerance within ±1%.

5.6 Unless otherwise specified, all batteries shall be fully conditioned as follows:

a) Batteries shall be either discharged at a rate not to exceed ten times the C_5 rate to the end of discharge voltage or,

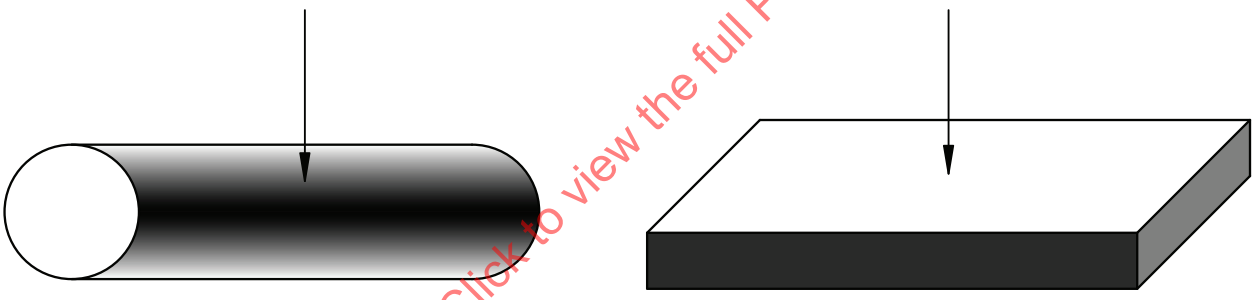
b) If discharged in the appliance, until the appliance ceases normal operation and then charged in accordance with the manufacturer's instructions.

The sequence shall be repeated one more time with an interval of at least two hours after each discharge.

5.7 The tests shall be made in a draught-free location and at an ambient temperature of 20 ±5°C (68 ±9°F), unless otherwise specified. All test samples shall be stabilized to the ambient temperature prior to the test. If the temperature attained by any part is limited by a temperature sensitive device, the ambient temperature shall be, in case of doubt, maintained at 23 ±2°C (73.4 ±3.6°F).

5.8 The location of thermocouples for lithium-ion cell temperature measurements shall be on the outer surface, half way along the longest dimension, of the cell that results in the highest temperature. Refer to Figure 5.1 for typical cell configurations and thermocouple locations.

Figure 5.1
Thermocouple location on cell



su0526

5.9 Temperatures shall be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2) and a potentiometer-type instrument.

5.10 Currents measured during battery charging shall be average current with an averaging period of 1 – 5 s.

5.11 If not otherwise specified, a fully charged battery shall be used. After removal from the charging system and before starting a test, the fully charged battery shall be allowed to rest for at least 2 h but no more than 6 h at an ambient temperature of 20 ±5°C (68 ±9°F) prior to use and after removal from the charging system.

5.12 When a battery comprised of a single cell is employed, instructions in this standard referring to special preparations of a cell in a series configuration shall be ignored.

5.13 For battery designs where there is a series arrangement of parallel clusters of cells, the cluster shall be treated as a single cell for those tests that require altering the amount of charge on a single cell prior to conducting the test.

5.14 Wherever ″cheesecloth″ is mentioned in the abnormal tests, the cloth shall be bleached cheesecloth, running 26 – 28 m^2/kg (approximately 14 – 15 yd^2/lb) and having what is known in the trade as a ″count of 32 by 28″, that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 in the other direction).

5.15 The end of discharge voltages are 0.9 V/cell for nickel cadmium or nickel metal-hydride, 1.75 V/cell for lead acid and 2.5 V/cell for lithium-ion unless the cell manufacturer specifies a different voltage.

6 Markings

Advisory Note: In Canada, there are two official languages, English and French. Annex E lists acceptable French translations of the markings specified in this standard. All markings required by this standard might have to be in other languages to conform with the language requirements where the product shall be used.

6.1 In addition to the safety warnings required in accordance with the applicable end-product standard, a battery-operated appliance shall comply with the applicable marking requirements in Clauses 6.2 – 6.8.

6.2 If battery operated appliances and detachable or separable battery packs are marked with voltage information as one means of complying with the requirements of Clause 6.6, the markings shall be as follows:

a) Voltage(s) or voltage range(s), in volts;

b) Symbol for nature of supply, either “DC” or the following symbol direct current for battery sources

⎓ – symbol for direct current (symbol 5031 of IEC 60417)

6.3 Appliances shall be marked with “WARNING – To reduce the risk of injury, user must read instruction manual” or the equivalent. The warning marking shall not be on a detachable part of the appliance and shall be clearly discernible from the outside of the appliance with any detachable battery pack installed.

6.4 The word “WARNING” shall be in capital letters not less than 2.4 mm (0.1 in) high and shall not be separated from the cautionary statement. It may be preceded by alert symbol 0434A or 0434B of the Standard for Graphical symbols for use on equipment – Registered symbols, ISO 7000. The term “operator’s manual” or “user guide” may be used for the term “instruction manual”.

6.5 If the end product standard has a similar required warning, then that may be used to comply with the requirement of Clause 6.3. Additional markings are allowed in addition to required markings, provided they do not give rise to misunderstanding.

6.6 A battery-operated appliance provided with a detachable battery pack or a separable battery pack shall be marked: ″For use only with ____ battery (battery pack, etc.),″ or the equivalent where the underlined space is completed with the manufacturer’s name or trademark, catalog number, series identification, or the equivalent of the battery pack. Alternatively, the statement “See Instruction Manual for Additional Battery Packs,” or the equivalent may be employed in addition to at least one battery pack referenced by catalog number.

6.7 A detachable battery pack, a separable battery pack, or a battery-operated appliance provided with an integral battery shall be marked ″For use only with ____ charger,″ or the equivalent where the underlined space is completed with the manufacturer’s name or trademark, catalog number, series identification, or the equivalent of the charger. Alternatively, the statement “See Instruction Manual for Additional Chargers,” or the equivalent may be employed in addition to at least one charger referenced by catalog number.

6.8 Detachable or separable battery packs shall be marked with additional information as follows:

a) The manufacturer’s name, trade name, or trademark, which may be in a traceable code when the appliance is identified by the brand or trademark owned by a private labeler;

b) A distinctive catalog number or the equivalent; and

c) The date or other dating period of manufacture not exceeding any three consecutive months. A date-code repetition time cycle shall not be less than 10 years. The date of manufacture may be abbreviated or in an established accepted code, or a code affirmed by the manufacturer. The code shall not require reference to the manufacturer’s records to determine when the appliance was produced.

6.9 Separable and detachable battery packs shall also be marked with additional information as follows:

a) The capacity assigned by the manufacturer in Ah or mAh , based on the rated capacity of the cells determined in accordance with General Purpose Lead-Acid Batteries (Valve-Regulated Types) – Part 1: General Requirements, Functional Characteristics – Methods of Test, IEC 61056-1; Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Secondary Lithium Cells and Batteries for Portable Applications, IEC 61960; Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Portable Sealed Rechargeable Single Cells – Part 1: Nickel-Cadmium, IEC 61951-1; or Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Portable Sealed Rechargeable Single Cells – Part 2: Nickel-Metal Hydride, IEC 61951-2, as applicable;

b) For alkaline or other non-acid electrolyte batteries, the type of battery such as Li-Ion, NiCd and NiMH.

6.10 Markings required by this standard for detachable or separable battery packs shall be legible and durable. Signs shall be in contrast such as color, texture, or relief, to their background such that the information or instructions provided by the signs are clearly legible when viewed with normal vision from a distance of (500 + 50) mm. Signs need not be in accordance with the blue color requirements of ISO 3864-2.

6.11 Compliance with Clause 6.10 shall be checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit. After the tests, the marking shall be easily legible, and it shall not be easily possible to remove markings. The petroleum spirit to be used for the test shall be a reagent grade hexane with a minimum of 85% as n-hexane. The designation “n-hexane” is the chemical nomenclature for a “normal” or straight chain hydrocarbon. An example of this petroleum spirit is also known as a certified ACS (American Chemical Society) reagent grade hexane (CAS #110-54-3).

6.12 In considering the durability of the marking, the effect of normal use shall be taken into account. Thus, for example, marking by means of paint or enamel other than vitreous enamel on containers that are likely to be cleaned frequently is not considered to be durable.

6.13 If a marking required by this standard for detachable or separable battery packs has an adhesive backing, the adhesive backing shall be durable.

6.14 Compliance with Clause 6.13 shall be checked by either meeting the requirements in the Standard for Marking and Labeling Systems, UL 969 under the conditions of occasional exposure to oil, humidity and water, and appropriate for the surface to which it is applied, or by the following tests, (a) – (c).

a) Three labels applied to the tools or a panel of the test surface material shall be placed in an oven for a minimum of 24 h with the oven is maintained at a temperature of 120 ±2°C (248 ±3.6°F), or alternatively for a minimum of 200 h at a temperature of 90 ± 2°C.

b) Six additional labels applied to the tool or a panel of the test surface material shall be placed in a controlled atmosphere maintained at 21°C to 30°C (69.8°F to 86°F) with a relative humidity of minimum 45% for at least 24 h. After this conditioning, immerse three labels in water and the other three labels in IRM 903 oil at a temperature of 21°C to 30°C (69.8°F to 86°F) for 48 h.

c) Three additional labels applied to the tool or a panel of the test surface material shall be placed in a controlled atmosphere maintained at 21°C to 30°C (69.8°F to 86°F) with a relative humidity of minimum 45% for 72 h.

6.15 After these conditionings in Clause 6.14 (a) – (c), it shall not be easy to remove the label by scraping across the label with a flat steel blade of 0.8 mm (0.03 in) thickness and any convenient width, held at right angles, and the label shall show no signs of curling.

7 Instructions

7.1 A battery-operated appliance and detachable or a separable battery pack shall be provided with operating instructions in the instruction manual or the equivalent. The instruction manual shall contain the specific applicable instructions described in Clauses 7.2 – 7.6 in addition to the instructions required in the end-product standard. The lettering height used for the signal word “WARNING,” and the other wording of the instructions shall be in accordance with the requirements of the end-product standard as applicable to basic cautionary type instructions.

7.2 Instructions shall be legible and contrast with the background. They shall include the name and address of the manufacturer or supplier or any other agent responsible for placing the appliance or battery on the market.

7.3 Instructions may be provided on a blister pack packing card provided the product can be removed without damaging the card containing the instructions.

7.4 The instructions in Clause 7.5 shall be grouped together and be preceded with “WARNING: Read all safety warnings and instructions. Failure to follow the warnings and instructions may result in electric shock, fire and/or serious injury.” or equally definitive statement.

7.5 The instruction manual for all battery-operated appliances shall contain the following or equivalent warnings as applicable immediately following any other safety instructions required by the end-product standard. The term “appliance” may be substituted with the name of the actual type of product.

a) Prevent unintentional starting. Ensure the switch is in the off-position before connecting to battery pack, picking up or carrying the appliance. Carrying the appliance with your finger on the switch or energizing appliance that have the switch on invites accidents.

b) Disconnect the battery pack from the appliance before making any adjustments, changing accessories, or storing appliance. Such preventive safety measures reduce the risk of starting the appliance accidentally.

Note: This warning is not applicable for batteries that cannot be disconnected from the appliance in normal use.

c) Recharge only with the charger specified by the manufacturer. A charger that is suitable for one type of battery pack may create a risk of fire when used with another battery pack.

d) Use appliances only with specifically designated battery packs. Use of any other battery packs may create a risk of injury and fire.

e) When battery pack is not in use, keep it away from other metal objects, like paper clips, coins, keys, nails, screws or other small metal objects, that can make a connection from one terminal to another. Shorting the battery terminals together may cause burns or a fire.

f) Under abusive conditions, liquid may be ejected from the battery; avoid contact. If contact accidentally occurs, flush with water. If liquid contacts eyes, additionally seek medical help. Liquid ejected from the battery may cause irritation or burns. (This advice is considered correct for conventional NiMh, NiCd, lead acid and lithium-ion cell types. If this advice is incorrect for a cell design that differs from these, then the correct advice may be substituted.)

g) Do not use a battery pack or appliance that is damaged or modified. Damaged or modified batteries may exhibit unpredictable behavior resulting in fire, explosion or risk of injury.

h) Do not expose a battery pack or appliance to fire or excessive temperature. Exposure to fire or temperature above 130°C may cause explosion. The temperature of 130°C can be replaced by the temperature of 265°F.

i) Follow all charging instructions and do not charge the battery pack or appliance outside of the temperature range specified in the instructions. Charging improperly or at temperatures outside of the specified range may damage the battery and increase the risk of fire.

j) Have servicing performed by a qualified repair person using only identical replacement parts. This will ensure that the safety of the product is maintained.

k) Do not modify or attempt to repair the appliance or the battery pack (as applicable) except as indicated in the instructions for use and care.

7.6 The instruction manual shall contain the following information:

a) Instructions regarding battery charging, information regarding ambient temperature range for appliance and battery use and storage, and the recommended ambient temperature range for charging system during charging.

b) For a battery-operated appliance intended for use with a detachable battery pack or a separable battery pack: instructions indicating the appropriate battery packs for use, such as by a catalog number, series identification or the equivalent.

c) Instructions indicating the appropriate charger(s) for use, such as by a catalog number, series identification or the equivalent.

d) For an appliance provided with a quick release system for a battery harness as required in Clause 16.6, instructions regarding the operation of the quick release system.

8 Protection Against Electric Shock

8.1 Battery operated appliances and battery packs shall be so constructed and enclosed that there is adequate protection against electric shock.

8.2 Compliance with Clause 8.1 shall be checked by Clauses 8.3 – 8.4.

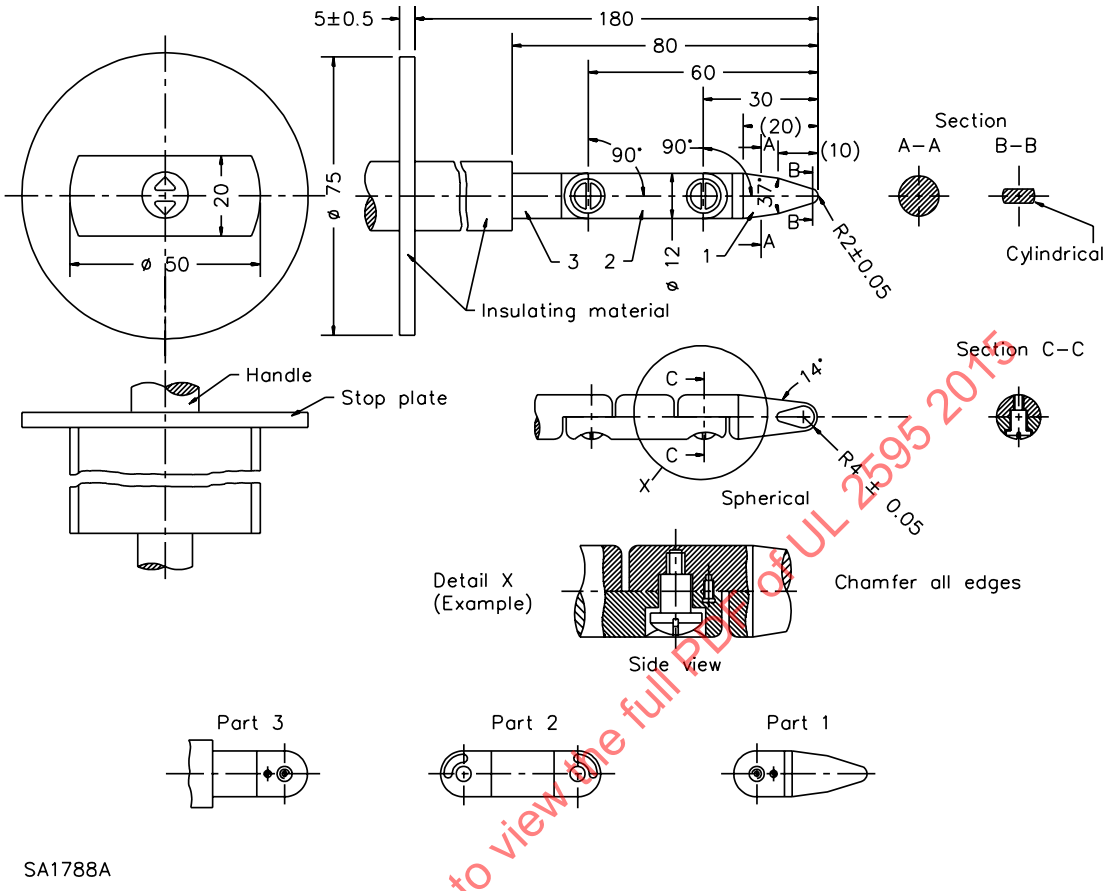
8.3 It shall not be possible to have two conductive, simultaneously accessible parts where the voltage between them is hazardous unless they are provided with protective impedance.

8.4 Compliance with Clause 8.3 shall be checked by applying test probe illustrated in Figure 8.1 to each conductive part in accordance with Clause 8.5.

8.5 The test probe shall be applied with a force not exceeding 5 N (1.1 lbf) through openings to any depth that the test probe will permit, and shall be rotated or angled before, during and after insertion to any position.

8.6 If an opening does not allow entry of the test probe specified in Clause 8.5, then the probe shall be unarticulated and applied to each opening with a force of 20 N (4.5 lbf). If the unarticulated probe can be made to widen the opening, then the test in Clause 8.5 shall be repeated with a separate probe inserted into the widened opening in accordance with Clause 8.5.

Figure 8.1
IEC articulate probe



(IEC test probe B of IEC 61032)

Linear dimensions in millimeters

Tolerances on dimensions without specific tolerance:

on angles: +0', -10'

on linear dimensions:

up to 25 mm: +0 mm, -0.05 over 25 mm: ±0.2 mm

Material of finger: for example heat-treated steel

Both joints of this finger may be bent through an angle of 90°, with a 0 to +10° tolerance, but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason dimensions and tolerances of these details are not given in the drawing. The actual design must ensure a 90° bending angle with a 0 to +10° tolerance.

8.7 In the test of Clause 8.4, contact with the test probe shall be determined with all detachable parts removed and the appliance operated in any possible position of normal use.

8.8 In the test of Clause 8.4 lamps located behind detachable covers are not removed, providing the lamp may be de-energized by means of a user operable plug, battery pack disconnection or a switch.

8.9 In the case of protective impedance the short circuit current between the parts shall not exceed 2 mA for d.c. or 0.7 mA peak for a.c. and there shall not be more than 0.1 µF capacitance directly between the parts.

8.10 Protective impedance shall consist of at least two separate components. If any one of the components is short-circuited or open-circuited based upon the components anticipated failure modes, the values specified in Clause 8.9 shall not be exceeded. A single Y1 or Y2 capacitor complying with one of the following shall be considered to fulfill this requirement:

a) Fixed Capacitors for Use in Electronic Equipment Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, IEC 60384-14;

b) Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14; or

c) Fixed Capacitors for Use in Electronic Equipment Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, CSA E60384-14.

8.11 Resistors shall be operated at half of their voltage and power ratings. All components are anticipated to fail in the open mode but, thin film, thick film and wire-wound resistors as well as metalized capacitors complying with:

a) Fixed Capacitors for Use in Electronic Equipment Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, IEC 60384-14;

b) Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14;

c) Fixed Capacitors for Use in Electronic Equipment Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, CSA E60384-14; or

d) Fixed Capacitors for Use in Electronic Equipment – Part 16: Sectional Specification: Fixed Metallized Polypropylene Film Dielectric D.C. Capacitors, IEC 60384-16

are not anticipated to fail in the shorted mode. All other components are anticipated to fail in the shorted mode.

8.12 All components relied upon for compliance with Clause 8.9 shall have sufficient voltage, current and power ratings to withstand the additional stress that they may encounter when components fail in their anticipated failure mode, one by one.

8.13 Materials providing insulation from electric shock from hazardous voltages shall comply with the test referenced in Clauses 8.14 and 8.15.

8.14 The test in Clause 8.15 shall apply only to materials which, if they were to fail to insulate, would subject the user to a shock hazard from a hazardous voltage. This test shall not apply to materials that provide only a physical barrier to contact. As such, an uninsulated energized part shall be within 1.0 mm (0.04 in) of the material surface to be considered for this requirement.

8.15 Compliance with Clause 8.13 shall be checked by subjecting the insulating material to an electric strength test for one minute without breakdown the application of a 50 Hz or 60 Hz essentially sinusoidal potential of 750 V. This provision does not exclude the testing of the material as situated within the appliance, providing care is taken to ensure that materials not under consideration are not subjected to the test voltage.

9 Heating

9.1 Battery operated appliances and battery packs shall not attain excessive temperatures under the following conditions.

9.2 Compliance with Clause 9.1 shall be checked by determining the temperature rise of the various locations. The appliance is operated at no-load until maximum temperature shall be reached or the appliance no longer operates due to the battery being discharged. Appliances that are designed to automatically cycle during use are permitted to operate as intended. Appliances marked with a duty cycle for use shall be operated using the duty cycle as marked. See Indent D in Table D1.1.

9.3 For appliances, not completely hand-held in use that may be powered by isolated sources not of hazardous voltage during operation, the test shall be conducted with these sources connected and energized. In these cases, the test shall be terminated when surface temperatures are stabilized or when the appliance stops operating due to the battery pack being discharged, whichever occurs first.

9.4 During the test, protective devices shall not operate. The temperature rises shall not exceed the values shown in Table 9.1. See Indent E in Table D1.1.

Table 9.1
Maximum outside surface temperature rises, K

Location	Composition of surfaces[a]		
	Metallic	Nonmetallic	Porcelain or Vitreous material
1. Handles, knobs, grips, and the like which, in normal use, are continuously held or in continuous contact.	25	35	30
2. Handles, knobs, grips, and the like which, in normal use, are held for short periods only (e.g. selector switches and adjustments).	35	60	45
3. Accessible external surfaces of detachable and separable battery packs.	60	60	60
4. Other accessible external surfaces subject to casual contact.	45	70	55
[a] A handle, knob or the like made of a material other than metal that is plated or clad with metal, having a thickness of 0.13 mm (0.005 in) or less, is judged as a nonmetallic part.			

9.5 The external surfaces of a detachable or separable battery pack shall not be subjected to heat from a heating element or heated discharge air that would be present during normal operation such that the temperature rise of the battery surface would exceed the maximum temperatures specified in Table 9.1.

10 Normal Charging of Lithium-ion Systems

10.1 Charging a lithium-ion battery under normal conditions shall not exceed the specified operating region for charging of the cell.

10.2 Compliance with Clause 10.1 shall be checked by the following tests in Clauses 10.3 – 10.7.

10.3 The battery shall be charged in accordance with the charging system instructions starting with a fully discharged battery. Testing shall be carried out at an ambient temperature of 20 ±5°C (68 ±9°F) and:

a) If the appliance is recommended to be operated at a minimum temperature lower than 4°C (39.2°F), the test shall also be conducted at that minimum temperature +0/−5°C (+0/−9°F); or

b) If the appliance is recommended to be operated at a maximum temperature greater than 40°C (104°F), the test shall also be conducted at that maximum temperature +5/−0°C (+9 /−0°F).

10.4 All individual cell voltages, temperatures according to Clause 5.8 and the charging current (or multiple current measurements as in the case of parallel configurations unless analysis makes this unnecessary) shall be monitored. Cells shall not experience conditions outside their specified operating region for charging (e.g. limits of voltage and current). See an example result of such analyses in (a) below.

a) The charging current for each branch of a parallel connection would not need to be monitored, if the maximum deliverable current of the charger did not exceed the maximum charging current of a single cell.

10.5 For batteries employing series configurations, the test shall be repeated with a deliberately imbalanced battery. The imbalance shall be introduced into a fully discharged battery by charging one cell to approximately 50% of full charge.

10.6 With reference to Clause 10.5, if it can be demonstrated through testing and/or design evaluation that an imbalance less than 50% would actually occur in normal use, then this lower imbalance may be used. See examples of testing and design in (a) and (b) below.

a) An example for testing is repeated charging and discharging a battery in accordance with the manufacturer's instructions until its capacity has decreased to 80% of the rated capacity, using the imbalance at the end of the test.

b) Those designs that employ circuitry intended for maintaining balance between cells in the battery pack. Systems with a small number of cells in series may be shown to exhibit limited imbalance in practice, if the product ceases to operate with a battery prepared with a smaller initial imbalance.

10.7 Battery systems intended for use with appliances which may be left on, such as flashlights, adhesive guns, and fans shall additionally be tested with their battery discharged by allowing the appliance to remain on for at least 12 h prior to recharging.

11 Abnormal Operation

11.1 Appliance systems

11.1.1 All appliances when operating under battery power and their battery packs shall be so designed that the risk of fire or electric shock as a result of abnormal operation is obviated as far as is practical. Compliance is checked by applying the abnormal conditions of Clause 11.1.6 (a) – (f) following the test method of Clauses 11.1.2 – 11.1.5.

11.1.2 The cumulative stress resulting from successive tests on electronic circuits or the battery shall be avoided. Additional samples may be used as necessary.

11.1.3 The battery operated appliance, battery pack, and the cords of Clause 11.1.6 (d) and (e), as appropriate, shall be placed on a soft wood surface covered by two layers of tissue paper; the sample shall be covered by one layer of untreated 100% cotton medical gauze or cheesecloth. For the tests (b), (c) and (f), the appliance shall be operated at no-load. The test shall be conducted until failure or until the test sample returns to within 5 K of the ambient temperature or, if neither of these occurs, until at least 3 h has elapsed. A new sample may be used for each fault listed below. No explosion shall occur during the test. There shall be adequate protection against electric shock as defined in Protection Against Electric Shock, Clause 8. No charring or burning of the medical gauze, cheesecloth or tissue paper shall result. Venting of the cells is permitted. See Indent F in Table D1.1.

11.1.4 Charring is defined as a blackening of the medical gauze or cheesecloth caused by combustion. Discoloration of the medical gauze or cheesecloth caused by smoke is acceptable. The resistance for the short in Clause 11.1.6 (a), (b), (d), (e) and (f) shall not exceed 10 mΩ. Charring or igniting of the tissue paper, medical gauze or cheesecloth from the shorting means is not considered a failure.

11.1.5 Fuses, thermal cut-outs, non-self resetting thermal cut-out, thermal links, temperature limiters, electronic devices or any component(s) or conductor(s) that interrupt the discharge current may operate during the above tests. If these devices are relied upon to pass the test, then, the same test shall be repeated two more times, using two additional samples, and shall open the circuit in the same manner, unless the test is otherwise satisfactorily completed . Alternatively, the test may be repeated with the open-circuited device bridged. However, protective electronic circuits whose function is relied upon to pass a test shall be regarded as providing a safety critical function and comply with Abnormal Operation – Safety Critical Function Circuits, Clause 11.6 with a PL = a. If a user adjustable temperature limiter operates, the test shall be repeated with the temperature limiter set to the most unfavorable setting and then repeated at this setting with two additional samples.

11.1.6 The abnormal conditions are as follows:

a) Combinations of exposed terminals of a detachable battery pack are shorted so as to produce the worst result. Battery pack terminals that can be contacted using either test probe of Figure 8.1 or Figure 11.1 shall be considered exposed. The means of shorting shall be selected or positioned such that charring or ignition of the tissue paper or gauze is not influenced. See Clause 21.1.7.

b) The terminals of each motor or other electrical load are shorted one at a time.

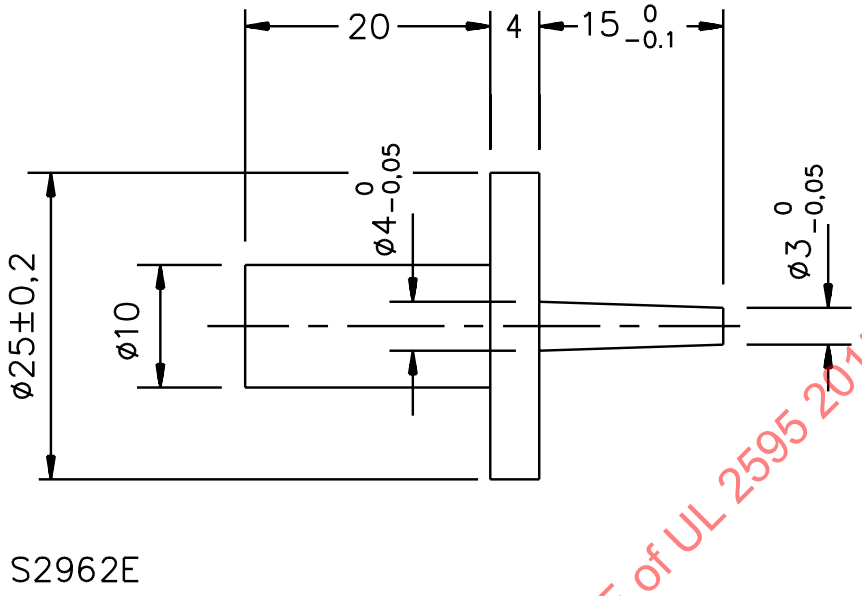
c) The rotor of each motor is locked one at a time.

d) Any cord provided between the separable battery pack and the appliance shall be shorted at the point likely to produce the most adverse effects.

e) Any cord provided between the appliance and the charger shall be shorted at the point likely to produce the most adverse effects.

f) A short is introduced between any two uninsulated parts of opposite polarity not in accordance with the spacings given in Creepage Distance, Clearances, and Distances Through Insulations, Clause 20 unless this has been evaluated to Abnormal Operation – Electronic Circuit Evaluations, Clause 11.2. A circuit analysis may be used to determine where a short shall or shall not be applied. The test shall not be conducted on uninsulated parts that are encapsulated.

Figure 11.1
Test Pin



Test probe 13 of IEC 61032

11.2 Electronic circuit evaluations

11.2.1 Electronic circuits shall be so designed and applied so that a fault condition will not render the appliance unsafe with regard to electric shock, fire hazard or accessibility to moving parts due to excessive heat.

11.2.2 Compliance with Clause 11.2.1 shall be checked by evaluation of the fault conditions specified in Abnormal Operation – Electronic Circuit Fault Conditions, Clause 11.3 for all circuits or parts of circuits. Examination of the appliance and its circuit diagram will reveal the fault conditions which have to be simulated through circuit analysis, so that testing can be limited to those cases which may be expected to give the most unfavorable result.

11.2.3 The appliance containing the circuit shall be placed on a soft wood surface covered by two layers of tissue paper; the sample shall be covered by one layer of untreated 100% cotton medical gauze or cheesecloth. The appliance shall be operated with a fully charged battery. A new sample can be used for each fault listed in Abnormal Operation – Electronic Circuit Fault Conditions, Clause 11.3.

11.2.4 No explosion shall occur during the test. No charring or burning of the medical gauze, cheesecloth or tissue paper shall result. Charring is defined as a blackening of the medical gauze or cheesecloth caused by combustion. Discoloration of the medical gauze or cheesecloth caused by smoke is acceptable. Charring or igniting of the tissue paper, cheesecloth or medical gauze from the means that is used to create the short is not regarded as a failure.

11.2.5 Protection against electric shock as specified in Protection Against Electric Shock, Clause 8 shall be maintained. Protection against accessibility to mechanical hazards as specified in the end product standard shall be maintained.

11.2.6 If a circuit fulfills the requirements of a low power circuit as described in Annex B and there is no risk of electric shock or loss of a safety critical function as defined in Safety Critical Function Circuits, Clause 11.6, then this evaluation shall not be performed.

11.2.7 If the circuit is encapsulated with an insulating material with a minimum thickness of 0.5 mm (0.02 in), and there is no risk of loss of a safety critical function, then the circuit may be evaluated by open-circuiting of any connection and short-circuiting of any two connections to the encapsulated circuit. Encapsulation is not necessary to fully cover electrolytic capacitors. (In general, encapsulation effectively limits the likelihood of the spread of fire within the encapsulated circuit. Electrolytic capacitors often require an unobstructed surface to allow venting under fault conditions.)

11.2.8 Fuses, thermal cut-outs, thermal links, temperature limiters, electronic devices or any component(s) or conductor(s) that interrupt the discharge current may operate during the above tests provided at least one of the following is fulfilled:

a) For all components that operate other than a user adjustable temperature limiter, the same test shall be repeated and passed two more times, using two additional samples;

b) For all user adjustable temperature limiters that operate, the test shall be repeated with the temperature limiter set to the most unfavorable setting and then repeated at this setting with two additional samples;

c) The appliance withstands the test with the fuse, thermal cut-out or thermal link or other portions of the electronic circuit bridged; or

d) If a certified fuse-link operated, the appliance withstands the test of Clause 11.4.1.

11.2.9 If a conductor of a printed circuit board becomes open-circuited, the appliance shall be considered to have withstood the particular test, provided all of the following conditions are met:

a) Any loosened conductor does not reduce the creepage distances or clearances between live parts and accessible conductive parts below the values specified in Creepage Distance, Clearances, and Distances Through Insulations, Clause 20; and

b) The appliance withstands the test when repeated with the open-circuited conductor bridged or, alternatively, the test may be repeated two more times, using two additional samples, providing each test opens the conductor at the same point.

11.3 Electronic circuit fault conditions

11.3.1 To determine compliance with Abnormal Operation – Electronic Circuit Evaluations, Clause 11.2 or Abnormal Operation – Safety Critical Function Circuits, Clause 11.6, the following fault conditions shall be considered and, if necessary, applied one at a time, consequential faults being taken into consideration:

a) Short-circuit of creepage distances and clearances between conductive parts of different polarity, if these distances are less than the values specified in Creepage Distance, Clearances, and Distances Through Insulations, Clause 20, unless the relevant part is adequately encapsulated;

b) Open-circuit at the terminal of any component;

c) Short-circuit of capacitors, unless they are certified EMI capacitors;

d) Short-circuit of any two terminals of an electronic component, other than a monolithic integrated circuit. This fault is not applied between the two circuits of an optocoupler;

e) Failure of triacs in the diode mode; and

f) Failure of a monolithic integrated circuit or other circuits that cannot be assessed by the fault conditions (a) to (e). In this case the possible hazardous situations of the appliance shall be assessed to ensure that safety does not rely on the correct functioning of such a component. All possible output signals shall be considered under fault conditions within the integrated circuit. Components such as thyristors and triacs are not subjected to this fault condition.

11.3.2 Positive temperature coefficient resistors (PTC's) and negative temperature coefficient resistors (NTC's) that comply with the Standard for Thermistor-Type Devices, UL 1434, or the Standard for General Requirements – Canadian Electrical Code, Part II, CSA C22.2 No. 0, or the Standard for Component Acceptance Requirements for PTC Thermistors for Overcurrent Protection in Electrical and Electronic Equipment, CSA TIL No. CA-3A, need not be open-circuited or short-circuited if they are used within their manufacturer's declared specification.

11.3.3 For simulation of the conditions, the appliance shall be operated at no-load adjusted to maximum output. Maximum output, for example, may be the highest output speed or greatest light output or highest heat level.

11.3.4 When any of the fault conditions are simulated, the duration of the test shall be conducted until failure or until one of the following conditions exist:

a) Steady conditions are established;

b) The test samples return to within 5 K of the ambient temperature;

c) A test period of 3 h has elapsed; or

d) For appliances supplied by mains or a non-isolated source, the appliance no longer draws supply mains current.

11.4 Circuit current conditions

11.4.1 If required in accordance with Clause 11.2.8(d), the following tests shall be conducted to ensure the repeatable operation of the certified fuse-link. The abnormal fault condition of Clause 11.3.1 shall be repeated but with the fuse replaced by an ammeter. If the current measured:

a) Does not exceed 2.1 times the rated current of the fuse, the circuit shall not be considered to be adequately protected and the test is carried out with the fuse short-circuited;

b) Is at least 2.75 times the rated current of the fuse, the circuits shall be considered to be adequately protected; or

c) Is between 2.1 times and 2.75 times the rated current of the fuse, the fuse is short-circuited and the test shall be carried out:

1) For the relevant period or for 30 min, whichever is the shorter, for fast acting fuses; or

2) For the relevant period or for 2 min, whichever is the shorter, for time delay fuses.

11.4.2 In case of doubt, the maximum resistance of the fuse shall be taken into account when determining the current.

11.5 Motor reversal

11.5.1 Switches or other devices for motor reversal shall withstand the stresses occurring when the sense of rotation is reversed under running conditions where such a reversal is possible in normal use without first separately stopping the appliance.

11.5.2 Compliance with Clause 11.5.1 shall be checked by operating the appliance at no-load; the device for reversing the sense of rotation being in such a position that the rotor rotates in one direction at full speed. The direction of the rotation shall then be reversed, without the device resting in an intermediate ″off″ position. This operation sequence shall be performed 25 times. After the test, the switch shall have no electrical or mechanical failure. If the switch operates properly at the end of the test, it shall be considered to have no mechanical or electrical failures.

11.6 Safety critical function circuits

11.6.1 Electronic circuits that provide a safety critical function shall be:

a) Reliable, and

b) Not susceptible to loss of safety critical function due to exposure to electromagnetic environmental stresses encountered in anticipated environments.

11.6.2 Compliance with Clause 11.6.1 shall be checked by exposing these electronic circuits to the immunity tests described in Clause 11.6.9 carried out with the appliance operated with the battery and shall not experience a loss of the safety critical function.

11.6.3 In addition, these electronic circuits shall be evaluated using the fault conditions of Clause 11.3.1 (a) – (f) and shall not result in a loss of any safety critical function or shall place and maintain the appliance into a safe state (e.g. the appliance is inoperable) while the fault condition is present. A lithium-ion charging system need not comply with Clauses 11.6.3 – 11.6.8.

11.6.4 If the circuit cannot comply with Clause 11.6.3 or if Clause 11.3.1 is not applicable to the electronic circuit by virtue of its design (e.g. single channel design), then the circuit's reliability shall be evaluated by the methods of the Standard for Safety of Machinery – Safety Related Parts of Control Systems – Part 1: General Principles for Design, ISO 13849-1, as required in Clauses 11.6.5 – 11.6.7. Required performance levels (PLr) for typical safety critical functions (SCF) are listed in Table 11.1. Software for this case shall be evaluated as required in Clause 11.6.8.

11.6.5 Unless special conditions exist, the required $MTTF_d$ for each PL level shall be as follows:

PL= a.....$MTTF_d$ = 5 years

PL= b.....$MTTF_d$ = 20 years

PL= c.....$MTTF_d$ = 50 years

Table 11.1
Required performance levels

Type and purpose of SCF	Minimum Performance Level (PL)
Prevent unwanted turn on where unexpected operation exposes users or bystanders to a substantial risk of injury as identified in the end-product standard	c*
Provide desired switch-off of the appliance if continued operation exposes the user to a substantial risk of injury as identified in the end-product standard	b*
Overspeed prevention above a particular speed for those appliances where operation above that speed would expose users or bystanders to a substantial risk of injury due to the disintegration of moving parts or accessories as indicated in the end-product standard	b*
For appliances with output speed increases that do not meet the condition above	Not a SCF
Prevent exceeding a thermal limit as defined in Heating, Clause 9	a*

Table 11.1 Continued on Next Page

Table 11.1 Continued

Type and purpose of SCF	Minimum Performance Level (PL)
Prevent reverse direction of rotation if end product standard requires a specific direction of rotation to avoid the risk of injury	b*
Prevent self-resetting as required by the end-product standard or for appliances where unexpected operation exposes users or bystanders to a substantial risk of injury as identified in the end-product standard	c*
Note – See Indent G in Table D1.1. * If the safety of the electronic control circuit has been evaluated in accordance with the functional safety requirements in the end product standard, then the safety of the electronic circuit has fulfilled the requirements of this standard.	

11.6.6 For safety critical functions not listed in Table 11.1 and provided by electronic circuits, the PL values shall be determined using the methods of Safety of Machinery – Safety Related Parts of Control Systems – Part 1: General Principles for Design, ISO 13849-1. Annex C provides guidance in applying ISO 13849-1 for SCF of products covered by this standard.

11.6.7 Any design that only alerts the user of the loss of the SCF shall not be considered sufficient to fulfill the required PL_r level, except as evidenced in a manner as described in Annex C.

11.6.8 Software used in portions of the circuit comprised of a microcontroller or in other programmable devices shall comply with the requirement for software class B in accordance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, IEC 60730-1:2010, H.11.12.3 , if the failure of these circuits would create a loss of the safety critical function. . In the case where software class B is realized by single channel with periodic self-test, an acceptable period is regarded as either after each activation of the power switch or a maximum of 5 minutes. H.11.12.3.4.1 is only applicable for SCF with a PL_r = c or higher.

Note: The allowance to use microcontrollers and other programmable logic, which are considered as "complex electronic circuits" for category 1 in Safety of Machinery – Safety Related Parts of Control Systems – Part 1: General Principles for Design, ISO 13849-1, is based upon their fulfillment of the requirements of Annex H.11.12.3 of IEC 60730-1:2010.

11.6.9 The appliance shall be subjected to electrostatic discharges in accordance with Electromagnetic compatibility (EMC) – Part 4-2: Testing and Measurement Techniques – Electrostatic Discharge Immunity Test, IEC 61000-4-2, test level 4 being applicable for air discharge and test level 3 being applicable for contact discharge. Ten discharges having a positive polarity and ten discharges having a negative polarity shall be applied.

11.7 Lithium-ion charging systems

11.7.1 This clause applies only to lithium-ion batteries. Compliance is checked by the test of Clause 11.7.2.

11.7.2 A sample containing the battery and the associated assemblies of the charging system shall be placed on a soft wood surface covered by two layers of tissue paper; the sample shall be covered by one layer of untreated 100% cotton medical gauze or cheesecloth. The battery system shall be operated as specified in Clause 7.6(a) with all of the categories of abnormal conditions listed below in (a) – (d). The cumulative stress resulting from successive tests on electronic circuits or the battery shall be avoided. Additional samples may be used as necessary.

a) Components in the charging system are faulted as described in Clause 11.7.5, one at a time, if the outcome of such a fault is uncertain based upon analysis. For each fault condition introduced, the state of the battery before charging is as follows:

1) A series configured battery shall have a deliberate imbalance. The imbalance shall be introduced into a fully discharged battery by charging one cell to approximately 50% of full charge; or

2) If the test of Normal Charging of Lithium-ion Systems, Clause 10 is conducted with an imbalance of less than 50%, a series configured battery shall have a deliberate imbalance as established in Clause 10.6; or

3) A single cell or parallel only configuration battery shall be fully discharged.

b) If the test of Normal Charging of Lithium-ion Systems, Clause 10 is conducted with an imbalance of less than 50% due to the function of circuit(s), and if a single fault of any component within that circuit(s) is shown to result in the loss of that function, then a series configured battery shall be charged with a deliberate imbalance. The imbalance shall be introduced into a fully discharged battery by charging one cell to approximately 50% of full charge.

c) For a battery with a series configuration, all cells shall be at approximately 50% charge except for one which is shorted. The battery is then charged.

d) With a fully charged battery connected to the charger, a short is introduced to the charging system across a component or between adjacent PCB tracks at a location expected to produce the most unfavorable results to evaluate the effect of back-feed from the battery. For a charger with a cord that connects to the battery, the short shall be introduced at the point likely to produce the most adverse effects. The resistance of the short shall not exceed 10 mΩ.

11.7.3 During the tests of Clause 11.7.2, each cell voltage shall be continuously monitored to determine if it has exceeded the limit condition. Venting of the cells is permitted. The test shall be continued until the sample under test experiences a failure as described in Clause 11.7.4, returns to within 5 K of the ambient temperature or, if neither of these, until at least 7 h or twice the normal charge period has elapsed, whichever is longer.

11.7.4 The tests of Clause 11.7.2 shall be considered passed if all of the following results comply:

a) There has been no explosion during the test.

b) No charring or burning of the medical gauze, cheesecloth or tissue paper has resulted. Charring is defined as a blackening of the medical gauze or cheesecloth caused by combustion. Discoloration of the medical gauze or cheesecloth caused by smoke is acceptable. Charring or igniting of the tissue paper, cheesecloth or medical gauze from the shorting means is not considered a failure.

c) The cells shall not have exceeded the upper limit charging voltage by more than 150 mV or, if they have, then the charging system shall be permanently disabled from recharging the battery. To determine if recharging is disabled, the battery shall be discharged by using the appliance tested (in the case of an integral system) or by using a new sample of the appliance (in the case of a detachable battery system) to approximately 50% charge, followed by an attempt to recharge the battery normally. There shall be no charging current after 10 min or after 25% of the nominal capacity has been delivered, whichever occurs first.

d) There shall be no evidence of damage to the cell vent to impair compliance with Clause 16.2.

11.7.5 Fault conditions for components as required by Clause 11.7.2 shall be as follows:

a) Open-circuit at the terminal of any component;

b) Short-circuit of capacitors, unless they are certified EMI capacitors;

c) Short-circuit of any two terminals of an electronic component, other than a monolithic integrated circuit. This fault is not applied between the two circuits of an optocoupler;

d) Failure of triacs in the diode mode; and

e) Failure of a monolithic integrated circuit or other circuits that cannot be assessed by the fault conditions (a) to (d). All possible output signals are considered under fault conditions within the integrated circuit. Components such as thyristors and triacs are not subjected to this fault condition.

11.8 Lithium-ion battery short circuit

11.8.1 There shall be no risk of fire or explosion when the main discharge connections of a series configured integral battery, detachable battery pack or separable battery pack are shorted under conditions of extreme imbalance. Compliance shall be checked by the tests of Clauses 11.8.2 – 11.8.5.

11.8.2 The test shall be conducted with all the cells of the battery fully charged and one cell fully discharged. A detachable battery pack or separable battery pack shall be placed on a soft wood surface covered by two layers of tissue paper; and covered by one layer of untreated 100% cotton medical gauze or cheesecloth. An appliance containing an integral battery shall be placed on a soft wood surface covered by two layers of tissue paper and covered by one layer of untreated 100% cotton medical gauze or cheesecloth.

11.8.3 The main discharge connections of the battery shall be shorted with a resistance not to exceed 10 mΩ. The test shall be conducted until the test sample experiences a failure or until the test sample returns within 5K of to room temperature. There shall be no explosion during the test. As a result of the test, there shall be no charring or burning of the gauze or tissue paper. Venting of cells is acceptable.

11.8.4 Charring is defined as a blackening of the gauze caused by combustion. Discoloration of the gauze caused by smoke is acceptable. Charring or igniting of the tissue paper or gauze from the shorting means is not considered a failure.

11.8.5 Fuses, thermal cut-outs, thermal links, temperature limiters, electronic devices or any component(s) or conductor(s) that interrupt the discharge current may operate during the above tests. If these devices are relied upon to pass the test, the test shall be repeated two more times, using two additional samples, and shall open the circuit in the same manner, unless the test is otherwise satisfactorily completed. Alternatively, the test may be repeated with the open-circuited device bridged.

11.8.6 Electronic circuits that are relied upon to pass a test shall be regarded as providing a safety critical function and comply with Abnormal Operation – Safety Critical Function Circuits, Clause 11.6 with a PL = a. If a user adjustable temperature limiter operates, the test shall be conducted with the temperature limiter set to the most unfavorable setting and then repeated at this setting with two additional samples.

11.9 Batteries other than lithium-ion – overcharging

11.9.1 Batteries comprised of cells other than the lithium-ion type shall withstand abusive overcharging without risk of fire or explosion when tested in accordance with Clause 11.9.2.

11.9.2 The battery shall be placed on a soft wood surface covered by two layers of tissue paper and the sample shall then be covered by one layer of untreated 100% cotton medical gauze or cheesecloth and charged at a rate of 10 times the C_5 rate for the battery for 1.25 h. There shall be no explosion and no charring or burning of the gauze or tissue paper during the test. Charring is defined as a blackening of the gauze caused by combustion. Discoloration of the gauze caused by smoke is acceptable. Venting of the cells is acceptable.

12 Mechanical Hazards

12.1 It shall not be possible to install a detachable or separable battery pack in reverse polarity unless it does not result in an increase in risk of fire, shock or personal injury.

12.2 Battery enclosures for vented batteries where explosive gases such as hydrogen are released to the atmosphere during normal charging or discharging shall have adequate ventilation located in areas where these gases, based upon their density, are likely to accumulate. The ventilation shall have an area of at least 0.5 mm^2/Wh of battery capacity. Batteries that cannot comply with this requirement shall be evaluated as in Clauses 12.3 and 12.4. See the example in (a) for batteries not considered to release gases.

a) Batteries comprised of sealed or valve regulated cells are not considered to release gases to the atmosphere under normal conditions.

12.3 The battery shall be charged under the most severe normal conditions for 7 h or the time to achieve 120% of full charge as stated in the instruction manual, whichever is longer. Samples of the air within the enclosure shall be made at locations of highest anticipated concentration at approximately 25%, 50%, 75% and 100% of the total time of the test by means of a probe or aspirator as part of the concentration measurement equipment. The concentration of explosive gases shall not exceed 2% by volume in air.

12.4 The test of Clause 12.3 shall be repeated under conditions of load used during the heating test.

13 Vibration for Lithium-Ion Batteries

13.1 If the end-product standard contains requirements for vibration resistance that subjects the end-product to vibration levels likely to be encountered in normal use, then the end-product containing the lithium-ion batteries shall be tested in the end product under these conditions. After this conditioning, cells shall not catch fire, explode or exhibit less than 90% of their original terminal voltage due to internal cell damage.

14 Lithium-Ion Enclosure Pressure Test

14.1 An enclosure for lithium-ion batteries shall be designed such that it will safely release gases that may be generated as a result of venting. Compliance shall be checked by the following:

a) The total area of the openings in the enclosure allowing gases to pass without obstruction shall be equal to or greater than 20 mm^2 (0.03 in^2); or

b) A total of 21 ml ±10% of air shall be delivered at an initial pressure of 2070 kPa ±10% through a 2.87 ±0.05 mm (0.11 ±0.002 in) diameter orifice to the enclosure of an appliance with integral battery or the enclosure of a detachable or separable battery pack. The pressure within the enclosure shall drop below 70 kPa in 30 s. There shall be no rupturing that would cause the enclosure to fail to comply with the requirements of this standard. An additional volume, not to exceed 3 ml, is allowed to be added to the enclosure volume as may be required for test fittings.

15 Mechanical Strength

15.1 Battery operated appliances and battery packs shall have adequate mechanical strength, and shall be so constructed that they withstand such rough handling that may be expected. Compliance shall be checked by the test of Clauses 15.2 and 15.3.

15.2 The appliance with any batteries connected shall be dropped or impacted per the conditions required in the end product standard. If no impact conditions exist in the end product standard, then the following conditions shall be employed:

a) Batteries shall be fully charged prior to the test.

b) A hand-held or body supported appliance with any detachable battery pack attached, shall withstand being dropped three times on a concrete surface from a height of 1 m (3.3 ft). For these three drops, the sample shall be tested in the three most unfavorable positions the lowest point of the appliance being 1 m (3.3 ft) above the concrete surface. For the test, the appliance shall be equipped as described in the instruction manual or intended normal use.

c) Counter or bench supported appliances with the battery pack attached shall withstand three impacts of a 50 ±2 mm (2.0 ±0.08 in) steel ball dropped with a minimum impact energy of 1.02 J (0.75 ft-lbf). The point of impact shall be varied without striking the same location more than once in an effort to produce the most adverse results.

d) Floor supported appliances with the battery pack attached shall withstand three impacts of a 50 ±2 mm (2.0 ±0.08 in) steel ball dropped with a minimum impact energy of 6.8 J (5 ft-lbf). The point of impact shall be varied without striking the same location more than once in an effort to produce the most adverse results.

15.3 All detachable battery packs or separable battery packs shall be dropped three times from a height of 1 m (3.3 ft) onto either a concrete or a hardwood surface as specified in the end product standard. The hardwood surface shall consist of a layer of nominal 25 mm (1 in) tongue-and-groove oak flooring mounted on two layers of nominal 19 mm (3/4 in) plywood. The assembly shall rest on a concrete floor, or an equivalent nonresilient floor, during the test. The sample shall be positioned to vary the point of impact. Batteries shall be fully charged prior to the test. Battery packs for end products requiring testing under special low temperature conditions and classified as in Clause 4.1 or 4.2 shall be additionally tested under the conditions of Clause 15.4 or 15.5 as applicable. See Indent H in Table D1.1.

15.4 With regards to Clause 15.3, battery packs classified as Low Temperature (LT) shall be preconditioned for at least 6 h at an ambient temperature no higher than 0°C. The battery packs shall be impacted after removal.

15.5 With regards to Clause 15.3, battery packs classified as Extra Low Temperature (ELT: *t*) shall be preconditioned for at least 6 h at an ambient temperature no higher than *t*°C. The battery packs shall be impacted after removal.

15.6 Following the tests of Clauses 15.2 and 15.3, the appliance shall comply with the applicable end product requirements with respect to exposure of moving parts capable of causing risk of injury and the appliance and battery pack shall not catch fire or explode and shall comply with:

a) The requirements of Protection Against Electric Shock, Clauses 8, and 20.3 and;

b) Either Clause 11.1.6(f) or 20.1.

15.7 After the impact testing of Clauses 15.2 and 15.3, the open circuit voltage of lithium-ion batteries, shall not be less than 90% of the voltage measured immediately prior to the test. In addition, the lithium-ion battery shall demonstrate normal discharging and recharging after the test. There shall be no damage to the cell vent that impairs compliance with Clause 16.2. There shall be no new openings that permit the test probe illustrated in Figure 8.1 applied with a force not exceeding 5 N (1.1 lbf) to access cells or uninsulated circuitry that were not accessible prior to the impact.

16 Construction

16.1 Battery operated appliances shall not readily accept general purpose batteries (either primary or rechargeable) as an energy source for their primary function.

16.2 Cell vents shall not be obstructed in such a way as to defeat their operation if venting is relied upon for compliance with this standard. Compliance shall be checked by inspection or, if in doubt, by inspecting the cells after conclusion of the abnormal tests of Clause 11.1.6 (a), (b) and (c) to ensure that cells have not vented by any means other than through the cell vent.

16.3 User accessible interfaces between elements of a lithium-ion battery system shall not employ connectors of the following types:

a) Standard mains inlet connectors, except for mains supply connections;

b) Barrel connectors with outside diameters of 6.5 mm (0.26 in) or less; or

c) Phone plugs with a diameter of 3.5 mm (0.14 in) or less.

16.4 Battery enclosures for batteries composed of vented cells shall be comprised of or coated with materials that are resistant to corrosion from the electrolyte contained within the cells.

16.5 Batteries shall be located away from the effect of a heating element or the discharge of hot air from heating appliances.

16.6 Separable battery packs may be provided with a single shoulder harness, double shoulder harness or belt harness for supporting a separable battery pack(s) on the body of the operator. A single shoulder harness or belt harness shall not be permitted for a total mass of separable battery pack(s) of 7.5 kg or more. The harness shall be adjustable to the size of the operator and its operation shall be in accordance with Clause 7.6(d). The harness need not be reusable after the release system has been activated. It is understood that the fault conditions of Clause 11 that may result in fire of the battery pack also create preceding notification behavior (e.g. such as “no operation”) of the appliance that is evident to the user.

16.7 Shoulder harnesses shall be:

a) Designed in a way for easy removal; or

b) Equipped with a quick release mechanism that ensures that the separable battery pack(s) can be removed or released quickly from the operator.

16.8 The quick release mechanism shall be positioned either at the connection between the separable battery pack(s) and harness or between the harness and operator. The quick release mechanism shall only allow separation by deliberate action of the operator. The quick release mechanism shall be designed to open while under the weight of the separable battery pack(s). It shall require the use of only one hand and have no more than two release points. An example of a release point is a buckle that requires squeezing between a thumb and finger before releasing, e.g. side release buckles.

16.9 A double shoulder harness shall be considered to be designed in a way for easy removal, if the left and right shoulder straps are not connected to each other in front of the operator's body. If the straps to connect between the left and right shoulder straps are provided, it is also considered to be designed in a way for easy removal when the straps connecting between the left and right shoulder straps can be released under the load of the battery pack by using one hand and no more than two release points. The release mechanism shall only allow separation by deliberate action of the operator.

16.10 The requirements in Clauses 16.7 – 16.9 shall be evaluated using the heaviest separable battery pack(s) identified in Clause 7.6(b).

17 Internal Wiring

17.1 Internal wiring shall comply with the applicable requirements of the end-product standard for those battery operated appliances containing hazardous voltages.

17.2 Different parts of a battery operated appliance that can move relative to each other and have wiring that carries hazardous voltage in normal use or adjustment shall comply with the requirements of the end-product standard.

17.3 Different parts of a battery operated appliance that can move relative to each other in normal use, during adjustment, operation, or during user maintenance where the wiring does not carry hazardous voltage in normal use or adjustment shall be conditioned as in a) or b) below. Following the test, the appliance and battery pack shall not catch fire or explode and shall comply with the requirements in Protection Against Electric Shock, Clause 8; Mechanical Hazards, Clause 12; and either Clause 11.3.1(a) or 20.1 and any provisions to protect against mechanical hazards in the end product standard.

a) Be conditioned as described in the end-product standard if such conditioning is provided.

b) If no flexing conditions exist in the end product standard, then the movable part is moved backwards and forwards, so that the conductor is flexed through the largest angle allowed by the construction, the rate of flexing being a minimum of 6 per minute. The number of flexings is:

1) 10,000 for conductors/connections flexed during normal use;

2) 2,000 for conductors/connections flexed during adjustments; or

3) 100 for conductors/connections flexed during user maintenance.

17.4 The requirement in Clause 17.3 does not apply to movements of parts with small amplitudes caused by vibration.

18 Components

18.1 Power switches shall comply with the requirements of Clause 18.4. Power switches that control motor loads shall additionally comply with the requirements of Clause 18.2.

18.2 Compliance for power switches that control motor loads as described in Clause 18.1 shall be checked by subjecting a switch to 50 operation cycles of making and breaking the locked output mechanism current of the fully charged battery-operated appliance. Each “on” period shall have a duration of not more than 0.5 s and each “off” period shall have a duration of at least 10 s.

18.3 After the test described in Clause 18.2, the power switch shall have no electrical or mechanical failure. If the switch operates properly in the on and off positions at the end of the test, it shall be considered to have no mechanical or electrical failures.

18.4 Compliance with Clause 18.1 for all power switches shall be checked by subjecting a switch to 6,000 cycles of operation making and breaking the current encountered in the fully charged appliance operated at no-load. The switch shall be operated at a uniform rate of 30 operations per minute. During the test, the switch shall operate correctly. After this test, the power switch shall have no electrical or mechanical failure. If the switch operates properly in the ″on″ and ″off″ positions at the end of the test, it shall be considered to have no mechanical or electrical failures.

18.5 A battery-operated appliance employing an exposed cutting device or operation that may result in a risk of serious, injury or death shall have a switch actuator that requires two separate and dissimilar actions before the appliance operates. Switch actuator arrangements that employ a press and push action shall be considered to comply with this requirement. See Indent I in Table D1.1.

18.6 Lithium ion cells employed in battery operated appliances or lithium-ion cells employed in battery packs shall comply with the Standard for 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, UL 62133 or CAN/CSA E62133.

18.7 Battery packs are not required to be tested according to the Standard for Household and Commercial Batteries, UL 2054. See Clause 1.9.

18.8 External chargers or power units shall comply with the following as applicable:

a) The Standard for Power Units Other Than Class 2, UL 1012, the Standard for Battery Chargers, CAN/CSA C22.2 No. 107.2, or the Standard for General Use Power Supplies, CSA C22.2 No. 107.1; or

b) The Standard for Class 2 Power Units, UL 1310, or the Standard for Power Supplies with Extra-low-voltage Class 2 Outputs, CAN/CSA-C22.2 No. 223; or

c) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or CAN/CSA-C22.2 No. 60950-1.

18.9 Appliances with integral batteries, where the battery is charged by a separate power unit, shall not exceed the rated output current or power of the charger or power unit when measured after 1 hour or 90% of the recommended charging time, whichever is shorter. The appliance shall be charged with an initially discharged battery and with the appliance off.

18.10 As identified in the end product standard, protection devices (e.g. overload or overtemperature protection devices) or circuits that switch off the appliance that are required to be of the non-self-resetting type shall be subject to the following allowances:

a) Resetting an overload protection device by switching the appliance off and on with the power switch is considered to be a non-self-resetting action; and

b) Electronic speed and load regulators are not considered to be overload protection devices if they do not switch off the appliance but reduce the speed of the appliance as a load is applied and increase the speed of the appliance when the load is removed.

19 Supply Connection and External Flexible Cords

Note: In this Clause, the term ″external flexible cord″ refers to cords that are located on the exterior of the end product enclosure and not to power cords intended to be connected to the mains.

19.1 Except as allowed in Clause 19.2, battery supply cord or other external flexible cord intended to be permanently attached to a battery-operated appliance shall be:

a) Provided with strain relief and tested to the cord pull requirements and any cord torque requirement related to the attachment of the cord in accordance with the requirements of the end-product standard; and

b) Subjected to any cord flexing requirements of the end-product standard.

19.2 The requirements of Clause 19.1 are not applicable if the application of stress to the terminals is not likely to increase the risk of electric shock, fire, or personal injury in accordance with the requirements of the end-product standard.

19.3 A battery supply cord or other external flexible cord intended to be attached to a separable battery pack shall be subjected to 10 pulls of three times the weight of the separable battery pack, but not less than 156 N (35 lbf) or more than 220 N (49 lbf). The pulls are applied for 1 minute each in the most unfavorable direction. After this conditioning, a torque of 0.35 Nm (0.26 lbf·ft) shall be applied as close as possible to the separable battery pack, unless the cord is on a reel. During the tests there shall be no appreciable strain imparted to the internal connections.

19.4 For a battery supply cord or other external flexible cord intended to be attached to a separable battery pack where there is flexing of the cord in normal use, the separable battery pack shall be fixed in an oscillating member of an apparatus that permits movement from – 45° to + 45° about the vertical. A mass equal to that of the battery pack, but not less than 2 kg (4.4 lb) or more than 6 kg (13.2 lb), shall be attached to the cord approximately 300 mm (11 in) from the center of rotation. The cord shall be flexed 10,000 times and the rate of flexing is 60 per min. A flexing is one movement, either backwards or forwards through 90°. After 5,000 flexings, the sample shall be turned through 90° about the center line of the cord exit. After the tests there shall be no separation of the conductor from its terminal or a breakage of more than 10% of the strands of any conductor.

20 Creepage Distances, Clearances and Distances Through Insulation

20.1 Creepage distances and clearances shall not be less than the values in millimeters shown in Table 20.1. The clearances specified do not apply to the air gap between the contacts of thermal controls, overload protection devices, switches of micro-gap construction, and the like, or to the air gap between the current-carrying members of such devices where the clearances vary with the movement of the contacts. Creepages and clearances also do not apply to the construction of battery cells or the

interconnections between cells in a battery pack. The values specified in Table 20.1 do not apply to cross-over points of motor windings. The way in which creepage distances and clearances are measured is indicated in Annex A.

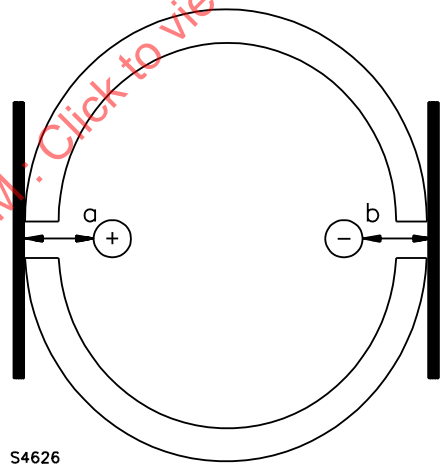
20.2 For parts of different polarity, clearance and creepage distances less than those given in Table 20.1 are acceptable if the shorting of the two parts does not result in the appliance starting. The risk of fire due to spacings below the required values is covered by the requirements of Abnormal Operation – Charging Systems, Clause 11.1.

Table 20.1
Minimum creepage distances and clearances between parts of opposite polarity

≤ 15 V				> 15 V and ≤ 32 V				> 32 V			
Creepage distance		Clearance		Creepage distance		Clearance		Creepage distance		Clearance	
in	mm	in	mm	in	mm	in	mm	in	mm	in	mm
0.03	0.8	0.03	0.8	0.06	1.5	0.06	1.5	0.08	2.0	0.06	1.5

20.3 For parts having a hazardous voltage between them, the sum total of the measured distances between each of these parts and their nearest accessible surface shall not be less than 1.5 mm (0.06 in) clearance and 2.0 mm (0.08 in) creepage. Compliance is checked by measurement. See Figure 20.1 and Clauses 20.4 – 20.7 for clarification on the measurement method. The way in which creepage distances and clearances are measured is indicated in Annex A.

Figure 20.1
Measurement of clearances



Dimension *a* = distance from positive bare conductive part to the external surface as defined by foil stretched across the openings.

Dimension *b* = distance from negative bare conductive part to the external surface as defined by foil stretched across the openings.

a + *b* is the sum total as defined in Clause 20.

20.4 Distances through slots or openings in external parts of insulating material shall be measured to the metal foil in contact with the accessible surface; the foil shall be pushed into corners and the like by means of the standard test probe of Figure 8.1, but is not pressed into openings.

20.5 The sum total of distances measured between parts operating at hazardous voltage and accessible surfaces shall be determined by measuring the distance from each part to the accessible surface. The distances shall be added together to determine the sum total. See Figure 20.1. For the purpose of this determination, one of the distances shall be 1.0 mm (0.04 in) or greater. See Annex A.

20.6 If necessary, a force shall be applied to any point on bare conductors and to the outside of metal enclosures, in an endeavour to reduce the creepage distances and clearances while taking the measurements.

20.7 Means provided for fixing the appliance to a support are considered to be accessible.

20.8 For all measurements of creepage distances and clearances, a force shall be applied by means of the test probe of Figure 8.1 and that has a value of:

a) 2 N (0.4 lbf) for bare conductors; or

b) 30 N (6.7 lbf) for enclosures.

21 Resistance to Heat and Fire

21.1 General

21.1.1 For battery operated appliances without heating elements, the risk of ignition and fire shall be met by compliance with Clause 21.1.2. For products with heating elements, the appliance, not including any detachable or separable battery, shall instead comply with the requirements of the end-product standard. Any separable or detachable battery shall comply with Clause 21.1.2.

21.1.2 Materials forming the enclosure of a battery operated appliance and a detachable or separable battery pack shall be adequately resistant to ignition and to spread of fire. Compliance shall be checked by Clauses 21.1.3 – 21.1.5.

21.1.3 Compliance with Clause 21.1.2 shall be checked by subjecting parts of non-metallic material, or representative specimens no thicker than the relevant parts, to the glow-wire test of the Standard for Fire Hazard Testing – Part 2-11: Glowing/Hot-Wire Based Test Methods – Glow-Wire Flammability Test Method for End-Products, IEC 60695-2-11, which is carried out at 550°C (1022°F) or the material has a glow wire ignition temperature of at least 575°C (1067°F) according to the Standard for Fire Hazard Testing – Part 2-13: Glowing/Hot-Wire Based Test Methods – Glow-Wire Ignition Temperature (GWIT) Test Method for Materials, IEC 60695-2-13, provided the test sample was no thicker than the relevant part.

21.1.4 The glow-wire tests in Clause 21.1.3 shall not be carried out on parts of material classified as HB by the test method described in the Standard for Fire Hazard Testing – Part 11-10: Test Flames – 50 W Horizontal and Vertical Flame Test Methods, IEC 60695-11-10:2013, provided that the test sample was no thicker than the relevant part.

21.1.5 Non-metallic parts of a detachable or separable battery pack or non-metallic parts of an appliance that contains an integral battery supporting connections that carry a current exceeding 0.2 A during charging and non-metallic parts within a distance of 3 mm (0.1 in) of such connections, shall be subjected to the glow wire test of the Standard for Fire Hazard Testing – Part 2-11: Glowing/Hot-Wire Based Test Methods – Glow-Wire Flammability Test Method for End-Products, IEC 60695-2-11, which is carried out at 850°C. However, the tests shall not be applicable to:

a) Parts supporting welded connections and parts within a distance of 3 mm (0.1 in) of these connections;

b) Parts supporting connections in low-power circuits described in Annex H of IEC 60695-2-11 and parts within a distance of 3 mm (0.1 in) of these connections;

c) Soldered connections on printed circuits boards and parts within a distance of 3 mm (0.1 in) of these connections; or

d) Connections on small components on printed circuit boards, such a diodes, transistors, resistors, inductors, integrated circuits and capacitors, and parts within a distance of 3 mm (0.1 in) of these connections.

21.1.6 Parts for which the glow-wire test cannot be carried out, such as those made of soft or foamy material, shall comply with the requirements specified in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for category HBF material, the test sample being no thicker than the relevant part.

21.1.7 Detachable or separable battery packs shall have enclosures comprised of a polymeric material with a minimum flame class in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17, or the Standard for Fire Hazard Testing – Part 11-10: Test Flames – 50 W Horizontal and Vertical Flame Test Methods, IEC 60695-11-10 of:

a) V (i.e. V-2, V-1 or V-0); or

b) HB, provided the test in Clause 11.1.6(a) is conducted, even if the battery terminals are not exposed.

21.1.8 The integrity of the enclosure of a battery operated appliance excluding a detachable or separable battery pack, the deterioration of which might cause the battery operated appliance to fail to comply with this standard, shall be evaluated by the mold-stress test or ball pressure test in accordance with the test conditions and procedures of the end product standard based on the temperatures recorded in Clause 9.2. The acceptability of the result is determined by the relevant requirements of Protection Against Electric Shock, Clause 8; Mechanical Hazards, Clause 12; and Creepage Distances, Clearances and Distances Through Insulation, Clause 20. If no requirements exist in the end product standard, then the evaluation of Clause 21.2 shall be used instead on the enclosure material of the appliance.

21.1.9 The integrity of the enclosure of a separable or detachable battery pack, the deterioration of which might cause the battery pack to fail to comply with this standard, shall be evaluated by the ball pressure test in accordance with Clause 21.2. The acceptability of the result shall be determined by the relevant requirements of Protection Against Electric Shock, Clause 8.

21.2 Ball pressure

21.2.1 To fulfill the requirements of Clause 21.1.8 and/or Clause 21.1.9, as applicable, parts of thermoplastic material provided as an enclosure shall be sufficiently resistant to heat as evaluated by Clause 21.2.2.

21.2.2 Compliance with Clause 21.2.1 shall be checked by subjecting the relevant parts to the ball pressure test in the Standard for Fire Hazard Testing – Part 10-2: Abnormal Heat – Ball Pressure Test, IEC 60695-10-2. Any soft materials (elastomers), such as soft grip coverings, shall be removed. The required thickness may be obtained by using two or more sections of the part.

21.2.3 For the appliance, excluding any separable or detachable battery pack, the test shall be made in a heating cabinet at a temperature of 55 ±2°C (131 ±3.6°F) plus the maximum temperature rise determined during the Heating test of Clause 9, but for external parts it shall be at least 75 ±2°C (167 ±3.6°F). (In Clause 9, only outside temperatures are measured. The basic temperature of 40 ±2°C (104 ±3.6°F) has been changed to 55 ±2°C (131 ±3.6°F) representing the typical difference between the inside and outside temperatures of enclosures.)

21.2.4 Separable or detachable battery packs shall be tested in a heating cabinet at a temperature of at least 75 ±2°C (167 ±3.6°F).

22 Additional Requirements for Battery Operated Appliances with a Connection to Mains or a Non-isolated Source

22.1 Appliances that are provided with a connection to the mains or a non-isolated source shall also be evaluated to requirements in the end-product standard pertaining to the risk of electric shock for those portions of the appliance exposed to these sources in addition to all requirements in this standard. See Indent J in Table D1.1.

22.2 Portions of the appliance electrically isolated from the mains or non-isolated source by a safety isolating transformer, protective impedance or other similar means shall only be evaluated to the battery operated requirements of this standard.

22.3 If isolation is obtained by means of a safety isolating transformer, it shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 or CSA C22.2 No. 66.1 and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2 or CSA C22.2 No. 66.2 or the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3 or CSA C22.2 No. 66.3 as applicable or the requirements for such transformers within the Standard for Class 2 Power Units, UL 1310, the Standard for Power Supplies with Extra-low-voltage Class 2 Outputs, CAN/CSA-C22.2 No. 223, the Standard for Power Units Other Than Class 2, UL 1012, the Standard for General Use Power Supplies, CSA C22.2 No. 107.1, Standard for Battery Chargers, CSA C22.2 No. 107.2 or the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or CAN/CSA-C22.2 No. 60950-1.

22.4 In the case of protective impedance, the current between the part and the supply source shall not exceed 2 mA for d.c., and its peak value shall not exceed 0.7 mA for a.c., and moreover:

a) For voltages having a peak value over 42.4 V up to and including 450 V, the capacitance shall not exceed 0.1 µF;

b) For voltages having a peak value over 450 V up to and including 15 kV, the discharge shall not exceed 45 µC.

22.5 Compliance with Clause 22.4 shall be checked by operating the appliance at rated voltage. Voltages and currents shall be measured between the relevant parts and each pole of the supply source. Discharges shall be measured immediately after the interruption of the supply. The quantity of electricity in the discharge shall be measured using a resistor having a nominal non-inductive resistance of 2,000 Ω. The quantity of electricity shall be calculated from the sum of all areas recorded on the voltage/time graph without taking voltage polarity into account.

22.6 Protective impedance shall consist of at least two separate components, the impedance of which is unlikely to change significantly during the lifetime of the appliance. If any one of the components is short-circuited or open-circuited, the values specified above shall not be exceeded. Resistors complying with Clause 14.1(a) of the Standard for Audio, Video, and Similar Electronic Apparatus-Safety Requirements, IEC 60065 and capacitors complying with Clause 14.2 of IEC 60065 are considered to comply with this requirement.

22.7 Optical isolators (optocouplers), used as a means of achieving electrical isolation shall have an isolation voltage rating not less than the electric strength test potential required in the end-product standard and shall comply with the Standard for Optical Isolators, UL 1577 or the Standard for Component Acceptance Service for Optocouplers and Related Devices, CSA Component Acceptance Notice No. 5A.

22.8 Electro-mechanical relays, used as a means of achieving electrical isolation shall have an isolation voltage rating not less than the working voltage employed in the end-product and shall comply with the isolation requirements for Standard for Industrial Control Equipment, UL 508 or CSA C22.2 No. 14.

22.9 Circuits connected to mains or a non-isolated source shall fulfill the insulation and spacing requirements for double insulation (Class II) between such circuits and isolated circuits.

23 Appliances Intended to be Powered or Charged by an Automotive Adapter

23.1 Appliances intended to be powered or charged by an automotive adapter shall comply with the following:

a) Be rated 12 V d.c.

b) Be provided with a plug provided with an integral fuse or other overcurrent protection device. The plug has an outer contact intended for connection to the shell of the automotive jack and an inner pin.

c) Have no internal voltage greater than 42.4 V peak with respect to either supply pole during any mode of normal operation unless, as applicable:

1) The appliance has been investigated to the end-product standard with respect to electric shock, or

2) The charger or power unit has been evaluated to the Standard for Power Units Other Than Class 2, UL 1012, or the Standard for Battery Chargers, CSA C22.2 No. 107.2, or the Standard for General Use Power Supplies, CSA C22.2 No. 107.1, with respect to electric shock.

d) Accessible metal shall either be connected to the outer contact of the plug or comply with (e).

e) Accessible surfaces not connected to the outer contact of the plug shall be checked by applying a 50 Hz or 60 Hz essentially sinusoidal potential of 750 V between accessible surfaces and the terminals of the plug for one minute without breakdown.

f) For the purpose of the heating test, these appliances shall be treated as having isolated sources.

g) For the purposes of testing, these products are treated as having separable batteries.

h) The plug and cord shall comply with the Standard for Vehicle Battery Adapters, UL 2089 (2011 edition).

23.2 With reference to Clause 23.1(h), a vehicle battery adapter shall comply with the following requirements from the Standard for Vehicle Battery Adapters, UL 2089 (2011 edition):

a) Flexible Cords;

b) Input Contacts;

c) Strain Relief test;

d) Abnormal, battery-supply cord short circuit test; and

e) Resistance to Crushing test.

24 Charging System Powered by a Universal Serial Bus (USB) Power Source(s)

24.1 The charging system intended to be connected to a Universal Serial Bus (USB) power source(s) shall be considered as powered by a limited power source as described in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or CAN/CSA-C22.2 No. 60950-1 or a Class 2 power source as described in the Standard for Class 2 Power Units, UL 1310 or the Standard for Power Supplies with Extra-low-voltage Class 2 Outputs, CAN/CSA-C22.2 No. 223 and shall comply with the following:

a) A product which is intended to be connected to USB power source(s) shall be evaluated with respect to risk of fire in accordance with Clause 21.1 unless the product is powered by a low-power circuit as determined by Annex B.

b) Cable assemblies or wiring with lengths external to the unit not exceeding 3.05 m (10 ft), coiled or uncoiled, shall be constructed of materials rated VW-1 or FT-1 or better with no additional requirements.

c) The end-product appliance shall be marked in proximity to the connection point as to the type of source (either the USB symbol ″ ″ or the abbreviation ″USB″).

d) The following statement, or equivalent, shall be permanently marked on the product or in the instruction manual: ″Use only with Listed/Certified Information Technology (Computer) Equipment″ or, ″Use only with Listed/Certified ITE Power Supply″ or ″Listed Class 2 Power Unit″, as applicable. The markings may be combined.

e) During the required tests, each USB connection shall be connected to an independent 5.25 V, 8 A capacity DC source of supply.

f) The instruction manual shall indicate the proper USB supply connection(s) and warn against using unapproved sources.

25 USB

25.1 Battery packs with a USB output for recharging or powering electronic devices shall comply with a Low-Power Circuit as determined by Annex B.

Annex A
(normative)
Measurement of Creepage Distances and Clearances

A1 Measurement of Creepage Distances and Clearances

A1.1 The methods of measuring creepage distances and clearances, which are specified in Clause 20.1, are indicated in cases 1 to 10 (see Figures A1.1 – A1.4).

A1.2 These cases do not differentiate between gaps and grooves, or between types of insulation.

A1.3 The following assumptions shall be made:

a) A groove may have parallel, converging, or diverging sides;

b) Any groove having diverging sides, a minimum width exceeding 0.25 mm, a depth exceeding 1.5 mm, and a width at the bottom equal to or greater than 0.04 in (1 mm), shall be regarded as an air gap across which no creepage path exists (case 8);

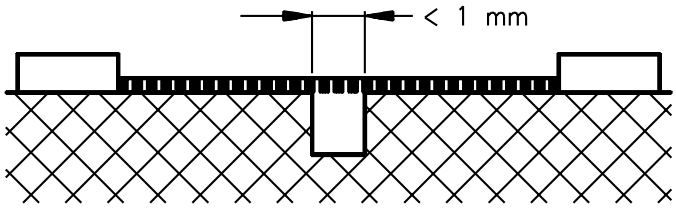
c) Any corner including an angle less than 80° shall be assumed to be bridged with an insulating link of 1 mm width 0.25 mm for dirt-free situations), moved into the most unfavorable position (case 3);

d) Where the distance over the top of a groove is 1 mm (0.25 mm for dirt-free situations) or more, no creepage distance exists across the air gap (case 2);

e) Creepage distances and clearances measured between parts moving relative to each other are measured when these parts shall be placed in their most unfavourable stationary positions; and

f) Any air gap less than 1 mm wide (0.25 mm for dirt-free situations) shall be ignored in computing the total clearance.

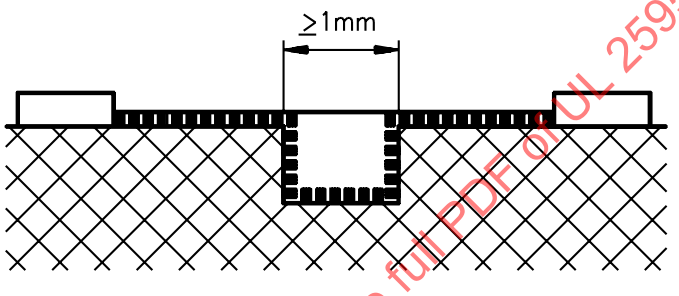
Figure A1.1
Clearance gap for parallel sided and V-shaped groove



Condition: Path under consideration includes a parallel or converging sided groove of any depth with width less than 1 mm.

Rule: Creepage distance and clearance are measured directly across the groove as shown.

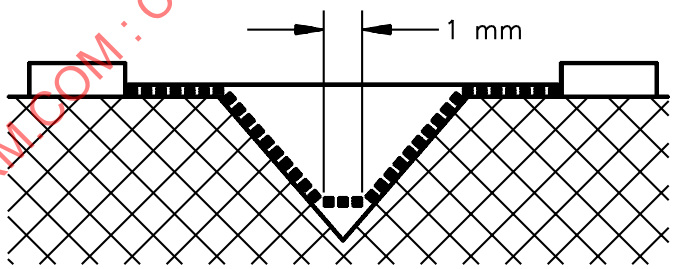
Case 1



Condition: Path under consideration includes a parallel sided groove of any depth equal to or more than 1 mm wide.

Rule: Clearance is the "line of sight" distance. Creepage path follows the cfontour of the groove.

Case 2



Condition: Path under consideration includes a V-shaped groove with internal angle of less than 80° and with a width greater than X mm.

Rule: Clearance is "line of sight" distance. Creepage path follows the contour of the groove but "short circuits" the bottom of the groove by 1 mm link (0,25 mm for dirt-free situations).

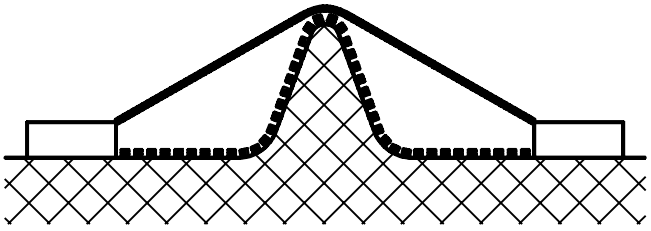
Case 3

CLEARANCE

CREEPAGE DISTANCE

S4621

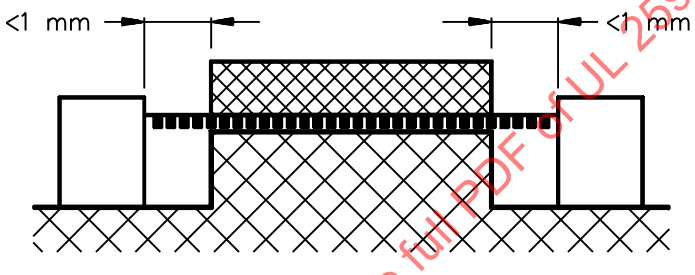
Figure A1.2
Clearance gap for rib and uncemented joint with groove



Condition: Path under consideration includes a rib.

Rule: Clearance is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib.

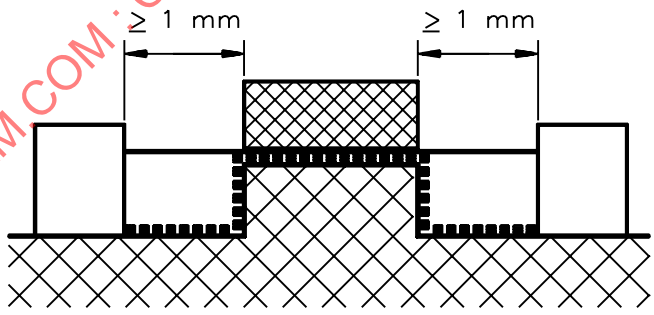
Case 4



Condition: Path under consideration includes an uncemented joint with grooves less than 1 mm wide on either side (0,25 mm for dirt-free situations).

Rule: Creepage and clearance is the "line of sight" distance shown.

Case 5



Condition: Path under consideration includes an uncemented joint with a groove equal to or more than 1 mm wide each side.

Rule: Clearance is the "line of sight" distance. Creepage path follows the contour of the groove.

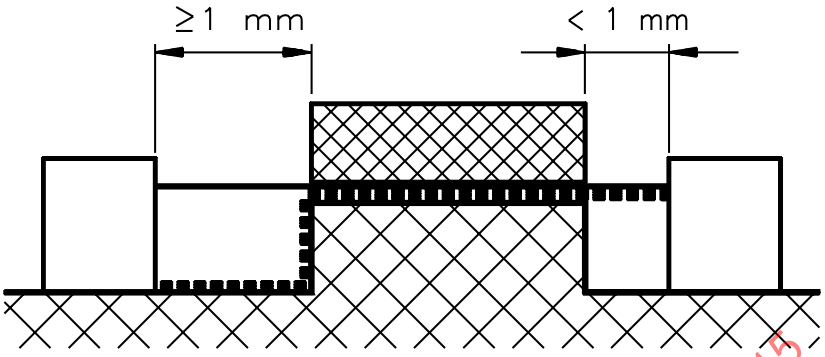
Case 6

Clearance

Creepage distance

S4622

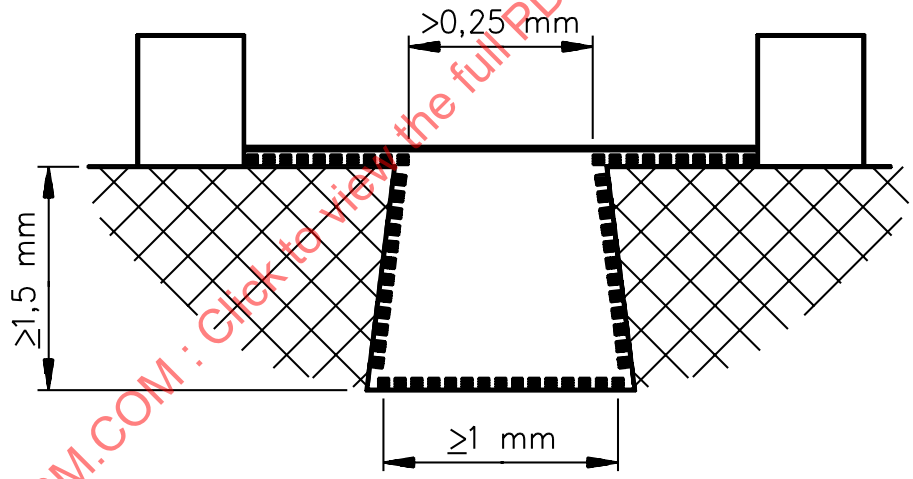
Figure A1.3
Clearance gap for uncemented joint and diverging-sided groove



Condition: Path under consideration includes an uncemented joint with a groove on one side less than 1 mm wide and a groove on the other side equal to or more than 1 mm wide.

Rule: Clearance and creepage path are as shown.

Case 7



Condition: Path under consideration includes a diverging–sided groove equal to or greater than 1,5 mm deep and greater than 0,25 mm wide at the narrowest part and equal to or greater than 1 mm at the bottom.

Rule: Clearance is the "line of sight" distance. Creepage path follows the contour of the groove.

Case 3 also applies to the internal corners if they are less than 80°.

Case 8

Clearance

Creepage distance

S4623