ANSI C18.2M, Part 2-2007

American National Standard

for Portable Rechargeable Cells and Batteries—

Safety Standard

ANSI C18.2M, Part 2-2007
Revision of
ANSI C18.2M, Part 2-1999

American National Standard

For Portable Rechargeable Cells and Batteries— Safety Standard

Secretariat:

National Electrical Manufacturers Association

May 31, 2007

American National Standards Institute, Inc.

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Published by

National Electrical Manufacturers Association (NEMA)
1300 North 17th Street, Rosslyn, VA 22209

Printed in the United States of America

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Foreword (This foreword is not part of American National Standard C18.2M, Part 2-2007.)

In 1912, a committee of the American Electrochemical Society recommended standard methods to be used in testing dry cells. Their recommendations were followed five years later when the National Bureau of Standards prepared specifications that included cell sizes, arrangement of cells within batteries, service tests, and required performance.

The need for continued revision to the specification led to the authorization, by the American Engineering Standards committee, of a permanent sectional committee on dry cells, now portable cells. This Committee, C18, representing battery users, manufacturers, government agencies, and other interested parties have remained active since that time.

In April 1996, the then ANSI Accredited Standards Committee C18 on Specifications for Dry Cells and Batteries established a new general format for the publication of its standards, dividing the standard into two parts. Part 1 of this American National Standard for Portable Rechargeable Cells and Batteries contains two basic sections. The first section has general requirements and information, such as the scope, applicable definitions, general descriptions of battery dimensions, terminal requirements, marking requirements, general design conditions, test conditions, etc. Section 2 of Part 1 is comprised of specification sheets for various types of cells and batteries. This Part 2 of the standard, a separate document, contains safety requirements.

The ANSI Committee C18 on Portable Cells and Batteries completed what is in effect the first edition of this specification on safety requirements in 1999 under the sponsorship of the National Electrical Manufacturers Association (NEMA). This latest edition was issued to update the safety tests and keep them current with the best possible practices. In particular, this latest edition considers and takes into account the *United Nations Recommendations on the Transport of Dangerous Goods*. These *Model Regulations*, adopted in December 2000, include lithium battery test recommendations in the *Manual of Tests and Criteria*. Additional consideration was also given to *IEC 62281, Ed.1: Safety of primary and secondary lithium cells and batteries during transport*. The purpose of these considerations was to harmonize test procedures, where appropriate, and prevent the proliferation of unnecessary or redundant tests. The latest edition also separates lithium batteries from nickel-based batteries and eliminates lead acid batteries to better reflect the realities of the current market. In doing so, the Committee recognized that there are some different and unique requirements for rechargeable lithium batteries.

Suggestions for improvement of this standard are welcome. They should be sent to the National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 1752, Rosslyn, VA 22209, Attention: Secretary, ANSI ASC C18.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Dry Cells and Batteries, C18. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the C18 committee had the following members:

Michael H. Babiak, Chairperson
James C. DeJager, ViceChairperson
Paul Orr, Secretary

Organization Represented:	*Name of Representative:*
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Bureau Veritas, Consumer Products Services	Thomas M. Heckmann
Consultant	David Linden

Consultant	Albert Himy
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International Imaging Industry Association	James Peyton
Intertek Testing Services	Terence J. O'Beirne
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Moltech Power Systems	Ramesh V. Shah
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The members of Subcommittee C18-5 on Safety Standards who contributed to the development of this standard are:

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James Gucinski
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Albert Himy
Paul Krehl
David Linden
Andrew Markow
Charlie Monahan
Terence O'Beirne
Steven Wicelinski
C. Richard Walk

American National Standard For Portable Rechargeable Cells and Batteries—Safety Standard

1 Introduction

The concept of safety is closely related to safeguarding the integrity of people and property. This standard defines performance requirements for portable, rechargeable cells and batteries to ensure their safe operation under normal use and reasonably foreseeable misuse.

Safety is a balance between freedom from risk of harm and other demands to be met by the product. There can be no absolute safety. Even at the highest level of safety, the product can only be relatively safe. In this respect, decision-making is based on risk evaluation and safety judgment.

As safety requirements will pose different challenges, it is impossible to provide a set of precise provisions and recommendations that will apply in every case. However, this standard, when followed on a judicious "use when applicable" basis, will provide reasonably consistent standards for safety.

2 Scope

This American National Standard specifies performance requirements for standardized portable lithium-ion, nickel cadmium, and nickel metal hydride rechargeable cells and batteries to ensure their safe operation under normal use and reasonably foreseeable misuse, and includes information relevant to hazard avoidance.

It is understood that consideration of this American National Standard might also be given to measuring and/or ensuring the safety of non-standardized secondary batteries. In either case, no claim or warranty is made that compliance or non-compliance with this American National Standard will fulfill or not fulfill any of the user's particular purposes or needs.

3 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI C18.2M, Part 1-2003, *Portable Rechargeable Cells and Batteries-General and Specifications*

IEC 60068-2-32, *Environmental Testing, Part 2: Free fall*

4 Definitions

For the purposes of this American National Standard, the following definitions apply.

4.1 **battery:** One or more cells, including case, terminals, and markings.

4.2 **battery, button (coin):** Small round battery, in which the overall height is less than the diameter.

4.3 battery, portable: A battery that is easily hand carried.

4.4 battery, primary: A battery that is not designed to be charged.

4.5 battery, prismatic: A battery with non-round geometry.

4.6 battery, secondary (rechargeable): A battery that is designed to be recharged electrically.

4.7 battery, round: Cylindrical battery, the overall height of which is greater than or equal to its diameter.

4.8 capacity: Quantity of electricity, usually expressed in Ampere-hours (Ah), which a battery can deliver under specified discharge conditions.

4.9 capacity retention: The capability of a battery to retain capacity on open circuit under specified conditions.

4.10 cell: Basic functional unit providing a source of electrical energy by direct conversion of chemical energy. The cell consists of an assembly of electrodes, separators, electrolyte, container, and terminals.

4.11 cell, cycled: Cell cycled to full depth of discharge for 25% of the manufacturer's claimed cycle life or when cell reaches 80% of initial capacity, whichever comes first.

4.12 cell, cylindrical: A cell in the shape of a cylinder, the overall height of which is greater than its diameter.

4.13 cell, fresh: Cell manufactured or received (by user) no more than 30 days and subjected to less than 10 cycles prior to being selected as a test sample.

4.14 cell, rechargeable (secondary): A cell that is designed to be recharged electrically.

4.15 discharge: An operation during which a battery delivers power (current and voltage) to an external circuit by the conversion of chemical energy into electrical energy.

4.16 effective internal resistance (R_e): The apparent opposition to current flow within a cell or battery that manifests itself as a drop in voltage proportional to the discharge current; its value depends on battery design, state of charge, temperature, and age.

4.17 explosion/disassembly: A vent or rupture where solid matter from any part of a cell or battery penetrates a wire mesh screen (annealed aluminum wire with a diameter of 0.25 mm and grid density of 6 to 7 wires per cm) placed 25 cm away from the cell or battery.

4.18 fire: Combustion of cell battery components with the emission of flame.

4.19 harm: Physical injury and/or damage to health or property.

4.20 hazard: A potential source of harm.

4.21 intended use: The use of a product, process, or service in accordance with specifications, information, and instructions provided by the supplier.

4.22 leakage: The unplanned escape of electrolyte or other material from a cell or battery.

4.23 nominal voltage: A suitable approximate value of voltage used to identify the voltage of a cell, battery, or electrochemical system.

4.24 polarity: The electrical convention used to describe the direction in which current flows on discharge.

4.25 rated: Declared value for a specific property or operating condition.

4.26 reasonably foreseeable misuse: The use of a product, process, or service under conditions or for purposes not intended by the supplier, but which may happen as a result of common human behavior.

4.27 risk: The probable rate of occurrence of a hazard causing harm and the degree of severity.

4.28 rupture: A rupture is a mechanical failure of a cell container or battery case, resulting in an expulsion of gas or spillage of liquids but not ejection of solid materials.

4.29 safety: Freedom from unacceptable risk of harm.

4.30 small cell or battery: A cell or battery fitting within the limits of the truncated cylinder as defined in Figure 1.

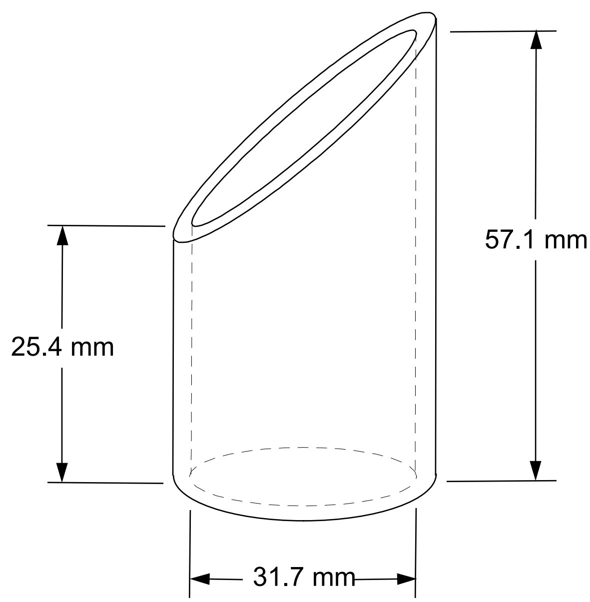


Figure 1 – Small cell or battery gauge (inner dimensions)

4.31 venting: Release of excessive internal pressure from a cell /battery in a manner intended by design to preclude explosion.

4.32 voltage, end-of-discharge (EODV): The specified closed circuit voltage of a cell or battery when the discharge is terminated.

4.33 voltage, open circuit (OCV): The voltage of a battery when no external current is flowing.

5 Requirements for safety

5.1 Design

5.1.1 General

Cells and batteries shall be so designed that they do not present a safety hazard under conditions of normal (intended) use. When discharged on a performance test in accordance with ANSI C18.2M, Part 1, there shall be no evidence of leakage, venting, fire, or explosion.

Compliance is verified by performing the tests required in this document and meeting the stated requirements.

5.1.2 Venting

All cells shall incorporate a pressure relief mechanism or shall be so constructed that they will relieve excessive internal pressure at a value and rate which will preclude explosion or self-ignition. If encapsulation is necessary to support cells within an outer case, the type of encapsulate and the method of encapsulation shall not cause the battery to overheat during normal operation nor inhibit pressure relief.

The battery case material and/or its final assembly shall be so designed that, in the event of one or more cells venting, the battery case does not present a hazard in its own right.

5.1.3 Temperature/current/voltage management

The design of the batteries shall be such that:

a) For lithium-ion and multi-cell nickel batteries, conditions of abnormal temperature rise shall be prevented through the use of thermal limitation features. These features may allow re-use of the battery after activation.

b) For lithium-ion rechargeable systems, conditions of rapid internal temperature rise shall be controlled by the immediate and irreversible shutdown of the battery, thus precluding further use.

c) Protection shall be provided to limit the current and voltage, as appropriate, during charge and discharge to design levels.

5.1.4 Terminals

The size and shape of the terminal contacts shall be such that they accommodate the maximum anticipated current requirements. The external terminal contact surfaces shall be formed from conductive materials which demonstrate good mechanical strength and corrosion resistance. The arrangements of terminal contacts shall be such that inadvertent shorting is minimized.

5.1.5 Assembly of cells

Cells used in the assembly of batteries shall be of the same chemistry, size, design, and closely matched capacities, from the same source of manufacture, and have approximately the same age.

5.1.6 Electronics

The design of lithium-ion battery electronics shall be such that all necessary charge and discharge control features are accommodated. In the event the electronics fail, the battery shall shut down.

5.2 Requirements

Batteries shall meet the requirements of all appropriate tests specified in Table 2 or Table 3.

6 Lithium-ion systems

6.1 Sampling plan, sample size and test sequence

Figure 2 lists the minimum requirements for sample size for the various tests for single-cell and multi-cell lithium-ion batteries and the sequence for conducting these tests.

Component cells, required as the test samples for specified tests, shall be selected from batteries that have met the pretest requirements.

Section 6.4.1.3 provides the procedures for samples that are to be cycled and/or tested in a fully charged, fully discharged, or partially discharged condition.

Figure 2 – Sampling for type approval – lithium-ion systems

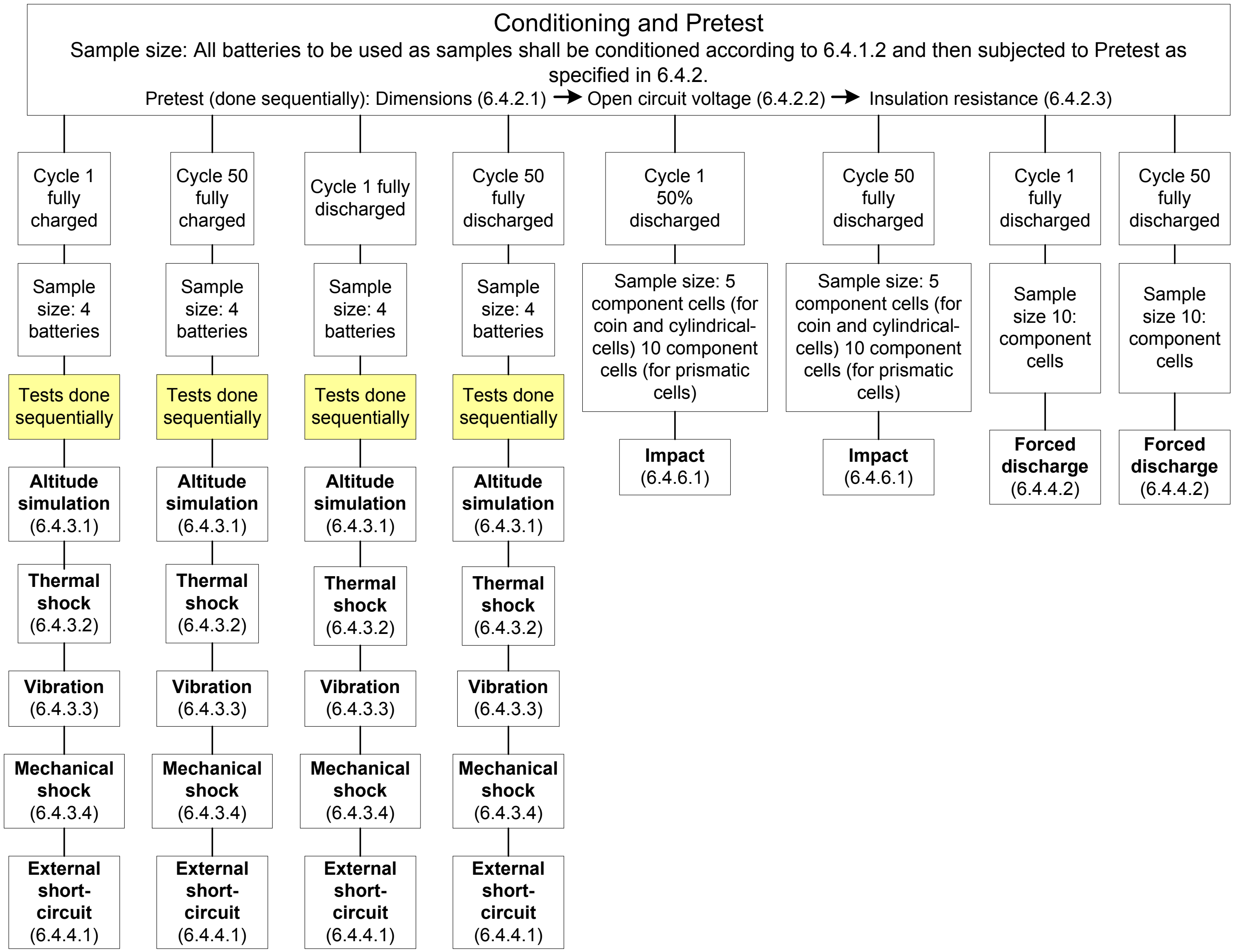
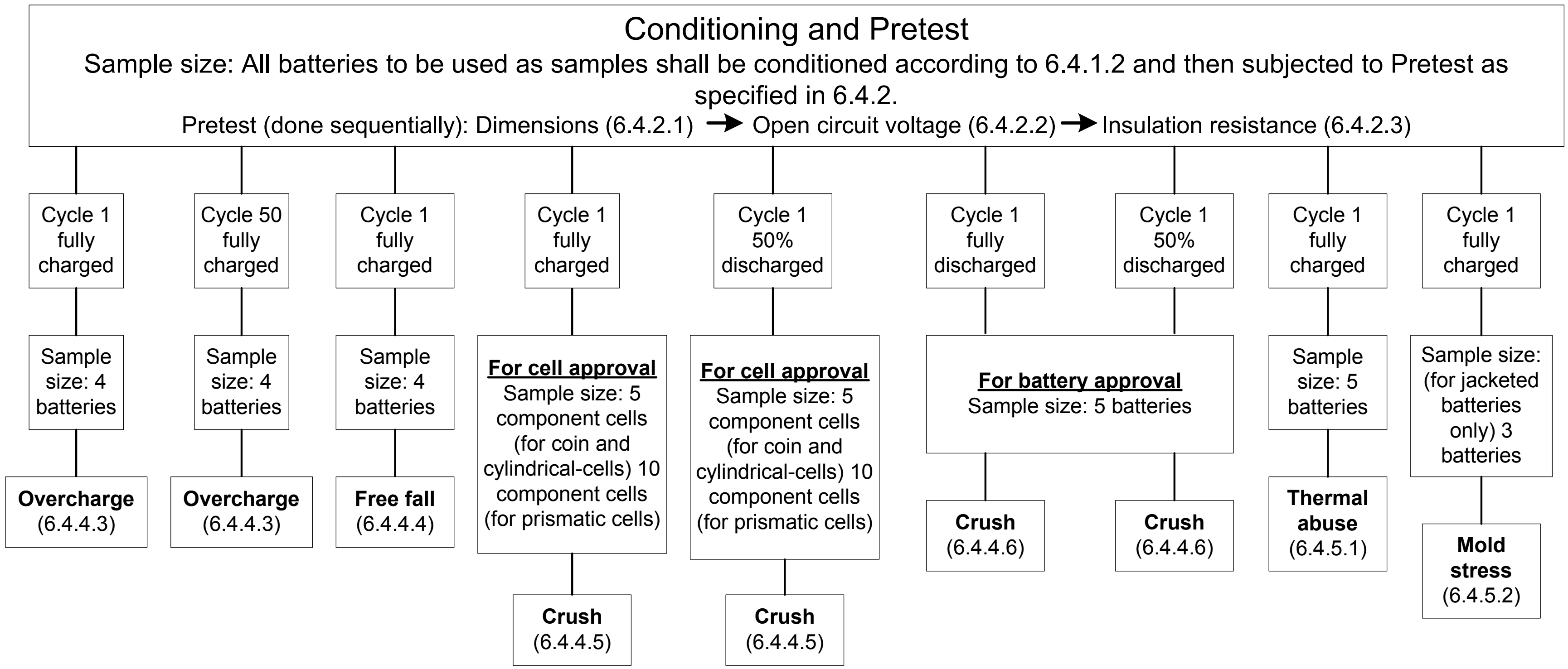


Figure continued on page 7.

Figure 2 – Sampling for type approval – lithium-ion systems (continued)

Figure continued from page 6.



6.2 Acceptance criteria

6.2.1 Excessive temperature rise

An excessive temperature rise is considered to have occurred during a test if the external case temperature of the test cell or battery rises above 170°C.

6.2.2 Leakage

Leakage is considered to have occurred during a test if electrolyte or other material escapes from the test cell or battery in a matter not intended by design.

6.2.3 Mass loss

Mass loss means a loss of mass that exceeds the values in table 1 below.
In order to quantify mass loss, Δ*m/m,* the following equation is provided.

$$\Delta m / m = \frac{m_1 - m_2}{m_1} \times 100\%$$

where,
m_1 is the mass before the first test in a series.
m_2 is the mass after the last test in a series or after any individual test.

Table 1 – Maximum mass loss

Mass of battery ***m***	**Maximum mass loss** **Δ *m/ m*** **%**
m ≤ 1 g	0.5
1 g < m ≤ 5 g	0.2
m > 5 g	0.1

6.2.4 Venting

Venting is considered to have occurred during a test if gas has escaped from a cell or battery through a feature designed for this purpose, in order to relieve excessive internal pressure. This gas may include entrapped materials.

6.2.5 Fire

A fire is considered to have occurred if, during a test, flames are emitted from the test cell or battery.

6.2.6 Rupture

A rupture is considered to have occurred if, during a test, a cell container or battery case has mechanically failed, resulting in expulsion of gas or spillage of liquids but not ejection of solid materials.

6.2.7 Explosion/disassembly

A vent or rupture where solid matter from any part of a cell or battery penetrates a wire mesh screen (annealed aluminum wire with a diameter of 0.25 mm and grid density of 6 to 7 wires per cm) placed 25 cm away from the cell or battery.

6.2.8 Open circuit voltage

The open circuit voltage of the sample after testing shall not be less than 90% of its open circuit voltage immediately prior to the test. This requirement is not applicable to samples that were tested in the fully discharged condition.

6.3 Overview of tests and acceptance criteria (Table 2)

Table 2 contains an overview of the tests and the acceptance criteria for each of the tests.

Table 2 - Acceptance criteria - lithium-ion systems

Test category	Designation (test)	Requirements
Intended use tests	Altitude (6.4.3.1)*	NL, NF, NE, NR, NV, NM, NO
	Thermal shock (6.4.3.2)*	NL, NF, NE, NR, NV, NM, NO
	Vibration (6.4.3.3)*	NL, NF, NE, NR, NV, NM, NO
	Mechanical shock (6.4.3.4)*	NL, NF, NE, NR, NV, NM, NO
Reasonably foreseeable misuse tests	External short-circuit (6.4. 4.1)*	NT, NF, NE, NR
	Forced discharge (6.4.4.2)	NF, NE
	Overcharge (6.4.4.3)	NF, NE
	Free fall (6.4.4.4)	See 6.4.4.4
	Crush (1) (6.4.4.5)	NF, NE
	Crush (2) (6.4.4.6)	NF, NE
Design consideration tests	Thermal abuse (6.4.5.1)	NE, NF
	Mold stress (6.4.5.2)	See 6.4.5.2
Other Tests	Impact (6.4.6.1)	NT, NF, NE

Key:

NE: No explosion/disassembly
NF: No fire
NL: No leakage
NM: No mass loss (cumulative)
NR: No rupture
NT: No excessive temperature rise
NV: No venting
NO: No low open circuit voltage

See 6.2 for a detailed description of the acceptance criteria
*These five tests are to be conducted in sequence using the same sample

6.4 Test procedures and compliance (verification)

Warning: These tests call for the use of procedures that may result in injury if adequate precautions are not taken. It has been assumed in the drafting of these tests that appropriately qualified and experienced technicians will conduct them using adequate protection.

For purposes of complying with transportation requirements consult shipper, federal, and international regulations, as applicable.

6.4.1 General

6.4.1.1 Test temperature

All tests shall be conducted at a test temperature of 20 ± 5° C, unless otherwise specified.

6.4.1.2 Conditioning samples

All samples shall be charged and discharged in accordance with the appropriate sections of ANSI C18.2M, Part 1 to assure that they meet the rated capacity. Samples not meeting the rated capacity shall be replaced with new samples that meet the requirement. At the completion of the conditioning procedure, samples are in a fully discharged condition.

6.4.1.3 Cycling, charging and discharging samples

6.4.1.3.1 Testing at the first cycle

Samples that are to be tested at the first cycle shall be tested.

6.4.1.3.2 Testing at the fiftieth cycle

Samples that are to be tested at the fiftieth cycle shall be cycled for 50 cycles in accordance with the charge/discharge procedures specified in ANSI C18.2M, Part 1.

6.4.1.3.3 Charging

Samples that are to be tested in a fully charged condition shall be charged as specified in ANSI C18.2M, Part 1 or as specified by the manufacturer.

6.4.1.3.4 Fully discharged

Samples that are to be tested in a fully discharged condition shall be discharged at a constant current value of $0.2C_5$ amperes to the specified end of discharge voltage (EODV).

6.4.1.3.5 Fifty percent (50%) discharged

Samples that are to be tested in a 50% discharged condition shall be discharged at a constant current value of $0.2C_5$ amperes until 50 percent of the rated capacity has been removed

6.4.2 Pretest requirements (dimensions, voltage, and insulation resistance)

All samples shall be pretested in a fully charged condition, following conditioning, in accordance with 6.4.1.2. All samples shall meet the pretest requirements. Samples not meeting the pretest requirements shall be replaced with new samples that meet the requirements. (Samples not meeting the pretest requirements should be checked for quality concerns.)

6.4.2.1 Dimensions

The dimensions shall meet the dimensions specified in the relevant specification sheet in ANSI C18.2M, Part 1 or manufacturer's specifications.

6.4.2.2 Open circuit voltage

The open circuit voltage shall meet the requirements on the relevant specification sheet in ANSI C18.2M, Part 1 or manufacturer's specifications.

6.4.2.3 Insulation resistance test

Purpose

To measure the insulation resistance, when applicable, between externally exposed surfaces of the battery and the positive terminal, excluding measurement between the positive and negative terminals.

Test procedure

Insulation resistance measurements shall be made using a megohm-meter or other suitable instrument.

The direct potential applied to the sample shall be 500 ± 20 V.

Step 1: Measure insulation resistance between mutually insulated points.

Step 2: Insulation resistance measurements shall be made immediately after a 2-minute period of uninterrupted test voltage application. However, if the instrument reading indicates that an insulation resistance meets the required limit, and is steady or increasing, the test may be terminated before the end of the specified period.

Step 3: Examine samples to determine if they meet the specified requirements.

Requirements

a) The insulation resistance shall not be less than 5 MΩ.
b) The measurement error at the insulation-resistance value required shall not exceed ±10 percent.

6.4.3 Intended use simulation tests

Tests described in this subsection are intended to simulate conditions that a battery is likely to encounter during intended use.

6.4.3.1 Test A: Altitude simulation

Purpose

To simulate and determine the effect of transportation on a battery under low pressure conditions in an aircraft cargo hold.

Test procedure

This test shall be conducted on fully charged and fully discharged samples, on both the first and fiftieth cycle, as shown in Figure 2. The samples should be cycled, charged and discharged as required and as specified in 6.4.1.3.

Sample size: see Figure 2 (note sequential testing)

Step 1: Samples shall be stored for no less than six hours at an absolute pressure of 11.6 kPa or less.

Step 2: Examine samples to determine if they meet the specified requirements.

Requirements

a) No leakage.
b) No fire.
c) No explosion/disassembly.
d) No rupture.
e) No venting.
f) No mass loss as per 6.2.3.
g) The open circuit voltage of the sample after testing shall meet the requirements of 6.2.8.

6.4.3.2 Test B: Thermal shock

Purpose

To simulate and determine the effect of exposure to high and low temperature extremes on the integrity of a battery.

Test procedure

This test shall be conducted on fully charged and fully discharged samples, on both the first and fiftieth cycle, as shown in Figure 2. The samples should be cycled, charged and discharged as required and as specified in 6.4.1.3.

Sample size: see Figure 2 (note sequential testing)

Step 1: Store samples for at least 6 hours at a temperature of 75 ± 2° C.

Step 2: Then immediately store samples for at least 6 hours at a temperature of –40 ± 2° C.

Step 3: Steps 1 and 2 are to be repeated 10 times.

The maximum time between storage at 75 ± 2° C and –40 ± 2° C shall be thirty (30) minutes.

For large batteries, the duration of the exposure to the test temperature extremes should be at least 12 hours.

Separate chambers may be used to perform this procedure.

Step 4: After Step 3 is completed, immediately store samples for at least 24 hours at ambient temperature 20 ± 5° C.

Step 5: Examine samples to determine if they meet the specified requirements.

Requirements

a) No leakage.
b) No fire.
c) No explosion/disassembly.
d) No rupture.
e) No venting.
f) No mass loss as per 6.2.3.
g) The open circuit voltage of the sample after testing shall meet the requirements of 6.2.8.

6.4.3.3 Test C: Vibration

Purpose

To simulate and determine the effect of vibration during normal transport

Test procedure

This test shall be conducted on fully charged and fully discharged samples, on both the first and fiftieth cycle, as shown in Figure 2. The samples should be cycled, charged and discharged as required and as specified in 6.4.1.3.

Sample size: see Figure 2 (note sequential testing)

The vibration shall be applied in each of three mutually perpendicular directions, unless the sample only has two axes of symmetry, in which case only two directions shall be tested.

The logarithmic frequency sweep is as follows: From 7 Hz a peak acceleration of 1 g_n is maintained until 18 Hz is reached. The amplitude is then maintained at 0.8 mm (1.6 mm total excursion) and the frequency increased until a peak acceleration of 8 g_n occurs (approximately 50 Hz). A peak acceleration of 8 g_n is then maintained until the frequency is increased to 200 Hz.

Step 1: Firmly secure samples to the platform of the vibration machine without distorting the samples in any manner as to transmit the vibration.

Step 2: Vibrate the samples according to a sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours for each of the three mutually perpendicular mounting positions of the sample. One direction of vibration shall be perpendicular to the terminal face.

Step 3: Examine the samples to determine if they meet the specified requirements.

Requirements

a) No leakage.
b) No fire.
c) No explosion/disassembly.
d) No rupture.
e) No venting.
f) No mass loss as per 6.2.3.
g) The open circuit voltage of the sample after testing shall meet the requirements of 6.2.8.

6.4.3.4 Test D: Mechanical Shock –

Purpose

To simulate and determine the effects on batteries of infrequent, non-repetitive shocks encountered during handling/transportation

Test Procedure

This test shall be conducted on fully charged and fully discharged samples, on both the first and fiftieth cycle, as shown in Figure 2. The samples should be cycled, charged and discharged as required and as specified in 6.4.1.3.

Sample size: see Figure 2 (note sequential testing)

A shock shall be applied to the sample in each of three mutually perpendicular directions, unless the sample has only two axes of symmetry, in which case, only two directions shall be tested.

Step 1: Secure each sample to the testing machine by means of a rigid mount that will support all mounting surfaces of each sample.

Step 2: Each sample shall be subjected to a half-sine shock of peak acceleration of 150 g_n and pulse duration of 6 milliseconds. (See below for large samples.) Each sample shall be subjected to three shocks in the positive direction followed by three shocks in the negative direction of three mutually perpendicular mounting positions of the sample for a total of 18 shocks (12 shocks in the case of samples with only two axes of symmetry).

Large samples shall be subjected to a half-sine shock of peak acceleration of 50 g_n and pulse duration of 11 milliseconds. Each sample shall be subjected to three shocks in the positive direction followed by three shocks in the negative direction of three mutually perpendicular mounting positions of the sample for a total of 18 shocks (12 shocks in the case of samples with only two axes of symmetry).

Step 3: Examine samples to determine if they meet the specified requirements.

Requirements

a) No leakage.
b) No fire.
c) No explosion/disassembly.
d) No rupture.
e) No venting.
f) No mass loss as per 6.2.3.
g) The open circuit voltage of the sample after testing shall meet the requirements of 6.2.8.

6.4.4 Reasonably foreseeable misuse tests

Tests described in this subsection are intended to simulate conditions that the battery is likely to encounter during reasonably foreseeable misuse.

6.4.4.1 Test E: External short-circuit

Purpose

To simulate and determine the effect of an accidental or abusive short-circuit of the positive (+) and negative (-) terminals.

Test procedure

This test shall be conducted on fully charged and fully discharged samples, on both the first and fiftieth cycle, as shown in Figure 2. The samples should be cycled, charged and discharged as required and as specified in 6.4.1.3.

Sample size: see Figure 2 (note sequential testing)

The test shall be conducted at a test temperature of 55 ± 2° C.

Step 1: Connect the positive and negative terminals of each sample by a wire or other means to create a short circuit of the sample as shown in Figure 3 with the switch S1 open.

The resistance of the interconnecting circuitry of Figure 3 shall not exceed 0.1 Ω.

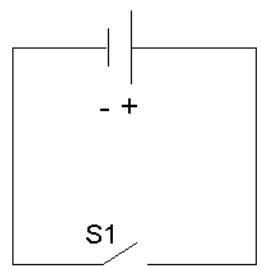


Figure 3 – Test E schematic

Step 2: Place the batteries in an environment of 55 ± 2° C.

Step 3: After the sample battery case temperature has stabilized at 55 ± 2° C, close the switch S1.

Step 4: Check the temperature of the external battery casing continuously.

Step 5: Continue the test for at least one hour after the battery case temperature returns to 55 ± 2° C.

Step 6: After the samples have been observed for an additional six hours, determine if they meet the specified requirements.

Requirements

a) The temperature of the exterior battery casing shall not exceed 170° C.
b) No fire.
c) No explosion/disassembly.
d) No rupture.

6.4.4.2 Test F: Forced discharge

Purpose

To simulate and determine the effect on component cells from fully discharged batteries to withstand a forced discharge condition.

Test procedure

This test shall be conducted on fully discharged samples (component cells) on both the first and fiftieth cycle, as shown in Figure 2. The samples should be cycled and discharged, as required, and as specified in 6.4.1.3.

Sample size: see Figure 2

Each cell shall be forced discharged at ambient temperature by connecting it in series with a 12 VDC power supply at an initial current equal to the maximum continuous discharge current specified by the manufacturer.

The specified discharge current is to be obtained by connecting a resistive load of the appropriate size and rating in series with the test cell and the D.C. power supply. Each cell shall be forced discharged for a time interval (in hours) equal to its rated capacity divided by the initial test current (in amperes) The test cells shall be observed for 7 days after the forced discharge condition has been discontinued.

Requirements

a) No fire within seven days of test.
b) No explosion/disassembly within seven days of test.

6.4.4.3 Test G: Overcharge

Purpose

To determine the ability of a rechargeable battery to withstand an overcharge condition.

Test procedure

This test shall be conducted at ambient temperature on fully charged samples, on both the first and fiftieth cycle, as shown in Figure 2. The samples should be cycled and charged, as required, and as specified in 6.4.1.3.

Sample size: see Figure 2

Each sample shall be charged at twice the recommended maximum continuous charge current for a period of 24 hours. The minimum voltage of the test shall be as follows:

a) When the recommended charge voltage is not more than 18 volts, the minimum voltage of the test shall be the lesser of two times the maximum charge voltage or 22 volts.
b) When the recommended charge voltage is more than 18 volts, the minimum voltage of the test shall be 1.2 times the maximum charge voltage

Requirements

a) No fire within seven days of test.
b) No explosion/disassembly within seven days of test.

6.4.4.4 Test H: Free fall

Purpose

To simulate and determine the effect of an inadvertent drop.

Test procedure

This test shall be conducted on fully charged samples on the first cycle.

The sample shall be charged as specified in 6.4.1.3

Sample size: See Figure 2

Step 1: Drop each sample, one at a time, oriented in each of three mutually perpendicular planes (three drops for each sample) from a height of 1 meter onto a concrete surface. However, in the case of cylindrical batteries, the sample shall be dropped twice, one time in each of two mutually perpendicular planes.

Step 2: Rest the sample for one hour after the final drop.

Step 3: Examine the sample to determine if it meets the specified requirements.

Requirements

a) The integrity of protective devices shall be maintained.
b) The outer enclosure shall not crack to the extent that any protective devices are exposed.
c) No visible leakage.
d) No fire.
e) No explosion/disassembly.

6.4.4.5 Test I: Crush—cells (test #1)

Purpose

To simulate and determine the effect of forces encountered during household waste disposal (i.e., trash compacting).

Test procedure

This test shall be conducted on fully charged and 50% discharged samples (component cells) on the first cycle. The sample shall be charged and 50% discharged as specified in 6.4.1.3

Sample size: See Figure 2

Step 1: Position a sample between two flat surfaces of the crushing apparatus.

Cylindrical (round) and prismatic cells: These batteries shall be crushed with their longitudinal axis parallel to the flat surfaces of the crushing apparatus.

Coin cells: These samples shall be crushed with the flat surface parallel with the flat surfaces of the crushing apparatus.

Step 2: Apply a crushing force, using a hydraulic ram with a 32 mm diameter piston, until a pressure of 17.2 MPa is reached on the hydraulic ram, resulting in an applied force of approximately 13 kN.

Each sample shall be subjected to a crushing force in only one direction. However, for prismatic cells, a second sample shall be rotated 90° about its longitudinal axis from the side that was crushed on the first sample, so that both the wide and narrow sides of prismatic samples will be subjected to the crushing force. Separate samples are to be used for each test.

Step 3: Release the pressure once the maximum is reached.

Step 4: Examine the samples to determine if they meet the specified requirements

Requirements

a) No fire.
b) No explosion/disassembly.

6.4.4.6 Test I: Crush—batteries (test #2)

Purpose

To simulate and determine the effect of a moderate crushing force on a battery.

Test procedure

This test shall be conducted on 50% discharged samples on the first cycle. The sample shall be charged as specified in 6.4.1.3

Sample size: See Figure 2

Step 1: Position a battery between two parallel flat maple (or equivalent) blocks, 17.7 mm or thicker.

Step 2: Gradually increase the force by applying a weight of 114 ± 2 kg across the total test surface of the battery and hold for one minute.

Step 3: Examine the samples to determine if they meet the specified requirements.

Requirements

a) No fire.
b) No explosion/disassembly.

6.4.5 Design consideration tests

Tests in this subsection are designed to describe battery design considerations.

6.4.5.1 Test J: Thermal abuse

Purpose

To simulate and determine the effect on batteries of extremely high temperature.

Test procedure

This test shall be conducted on fully charged samples on the first cycle. The sample shall be charged as specified in 6.4.1.3

Sample size: See Figure 2

Step 1: Place the sample in a gravity circulating-air convection oven (or equivalent) and raise the oven temperature at a rate of 5 ± 2° C per minute to 130 ± 2° C.

Step 2: The oven shall be maintained at a temperature of 130 ± 2° C for 10 minutes before the test is discontinued.

Step 3: Examine the samples to determine if they meet the specified requirements.

Requirements

a) No fire.
b) No explosion/disassembly.

6.4.5.2 Test K: Mold stress

Purpose

To simulate and determine the effect of an elevated temperature environment on a molded battery.

Test procedure

This test shall be conducted on fully charged samples on the first cycle. The sample shall be charged as specified in 6.4.1.3

Sample size: See Figure 2

Step 1: Place the samples in a full draft circulating-air oven maintained at a temperature of 70 ± 2° C.

Step 2: The samples shall remain in the oven for 7 hours.

Step 3: Remove the samples from the oven and allow them to return to ambient temperature (20 ± 5° C).

Step 4: Examine the samples to determine if they meet the specified requirements.

Requirement

No evidence of mechanical damage (no exposure of internal components or leakage of electrolyte).

6.4.6 Other tests

6.4.6.1 Test L: Impact Test

Purpose

This test is intended to simulate an internal short-circuit and/or an impact.

NOTE—During previous discussions on safety tests for batteries, ANSI has evaluated the impact test. Within the context of intended use and reasonable foreseeable misuse, this test was found to be inappropriate to simulate an internal short-circuit condition. While agreeing to the need for an internal short-circuit test, ANSI reserves the right to further investigate a more appropriate test.

Test procedure

This test shall be conducted on 50% discharged and fully discharged samples (component cells) on the first and fiftieth cycle, as shown in Figure 2. The samples should be cycled and discharged, as required, and as specified in 6.4.1.3.

Sample size: See Figure 2

Step 1: The sample is placed on a flat surface and a 15.8 mm diameter bar is placed across the center of the sample.

Step 2: A 9.1 kg mass is dropped from a height of 61 ± 2.5 cm onto the intersecting point of the bar and sample.

Both cylindrical and prismatic cells are to be impacted with its longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the 15.8 mm diameter curved surface lying across the center of the test sample. Additionally, a prismatic cell is to be rotated 90 degrees around its longitudinal axis so that both the wide and narrow sides will be subjected to the impact. Each sample is to be subjected to only a single impact. Separate samples are to be used for each impact.

A coin or button cell is to be impacted with the flat surface of the sample parallel to the flat surface and the 15.8 mm diameter curved surface lying across its center.

Step 3: Examine the sample to determine if it meets the specified requirements.

Requirements

a) The external surface temperature shall not exceed 170 °C.
b) No fire within six hours of the test.
c) No explosion/disassembly within six hours of the test.

7 Nickel systems

7.1 Sampling for type approval

Figure 4 lists the minimum required sample sizes and various tests that are to be conducted on the cells and batteries for each nickel system.

Figure 4 – Sampling for type approval – nickel systems

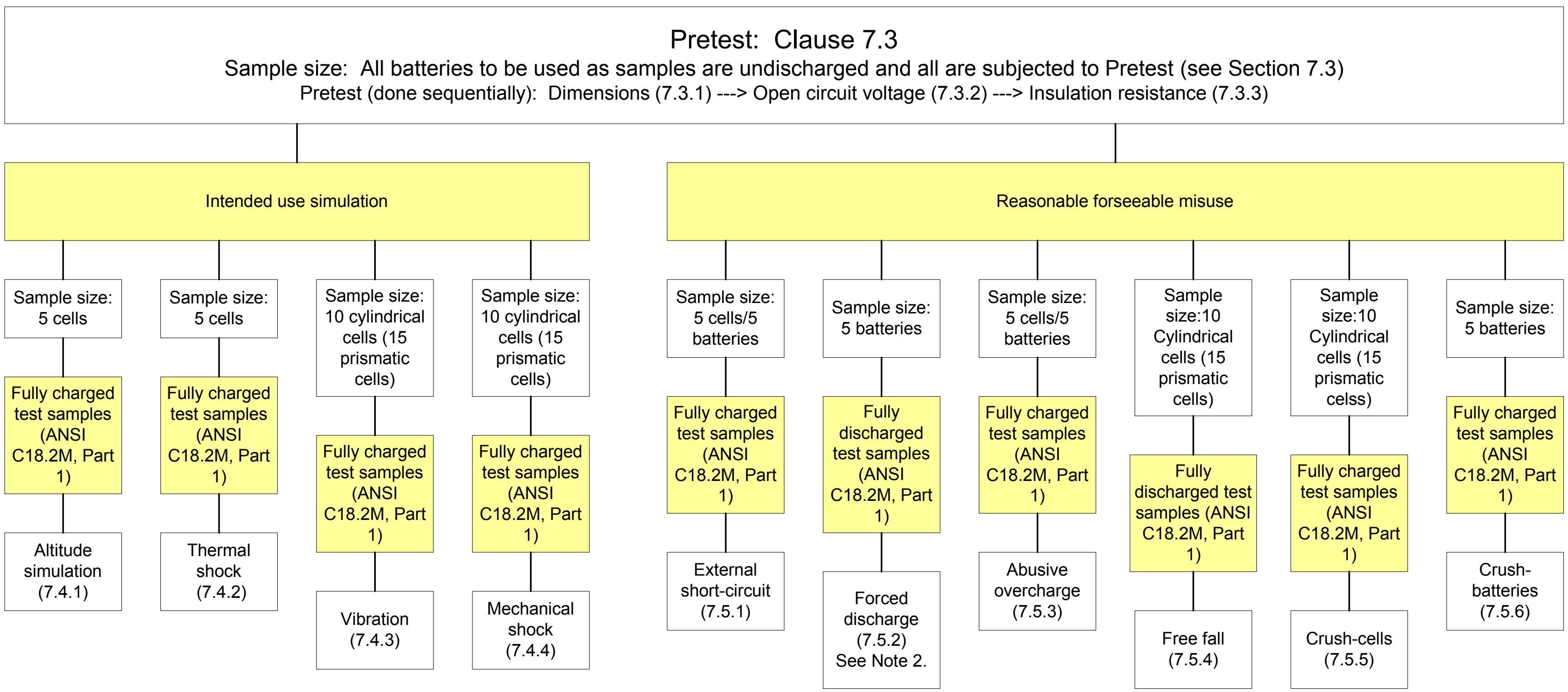


Figure continued on page 23.

NOTES:

1. Use cells for cell acceptance and batteries for battery acceptance.
2. Plus 35 batteries.
3. When cells are not available, batteries must be tested.

Figure 4 – Sampling for type approval – nickel systems (continued)

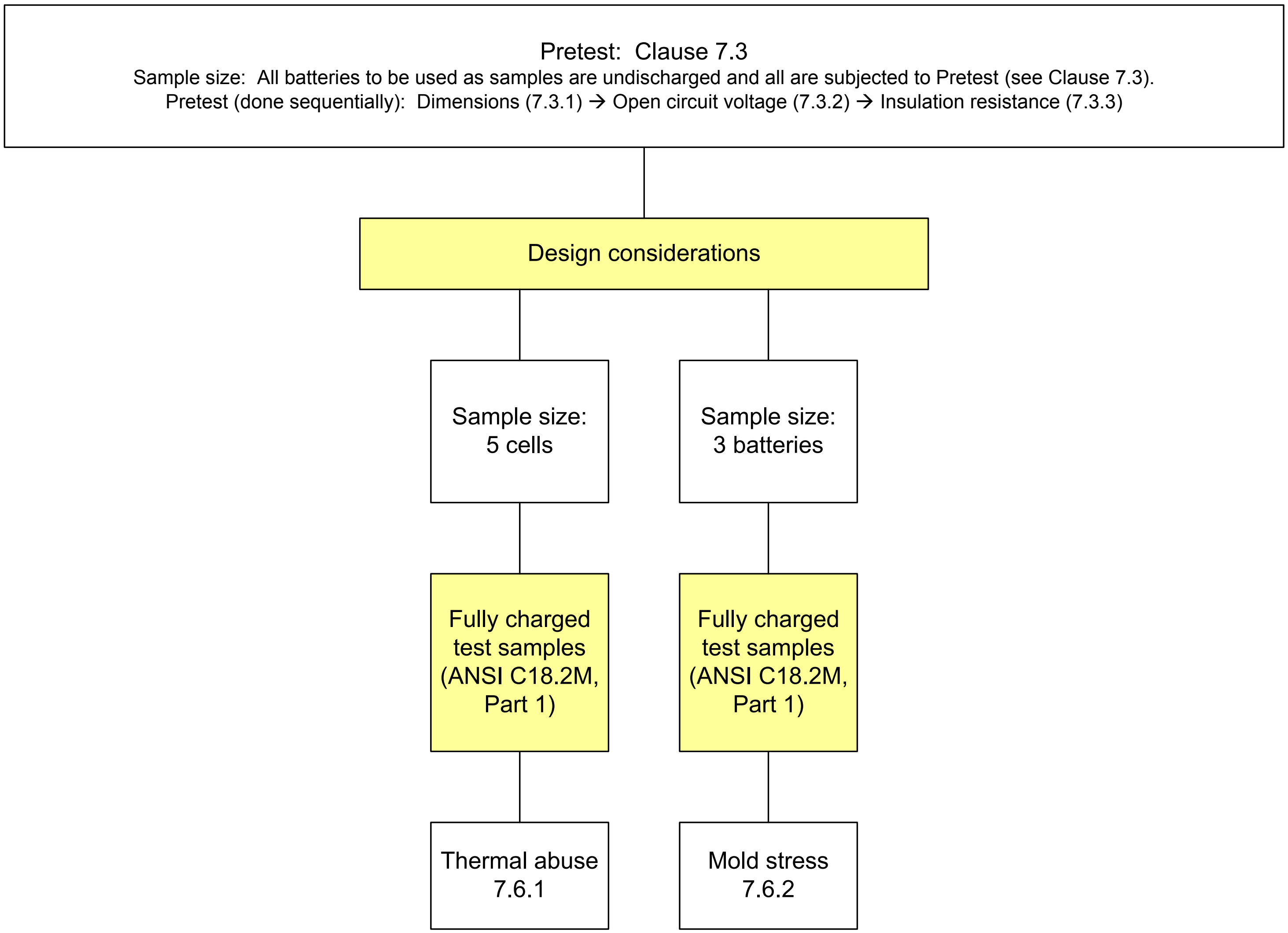


Figure continued from page 22.

Table 3 – Acceptance criteria – nickel systems

Test category	Designation (test)	Requirements
Intended use tests	Altitude (7.4.1)	NL, NF, NE
	Thermal shock (7.4.2)	NL, NF, NE
	Vibration (7.4.3)	NL, NF, NE
	Mechanical shock (7.4.4)	NL, NF, NE
Reasonably foreseeable misuse tests	External short-circuit (7.5.1)	NF, NE
	Forced discharge (7.5.2)	NF, NE
	Abusive overcharge (7.5.3)	NF, NE
	Free fall (7.5.4)	NL, NF, NE
	Crush (1) (7.5.5)	NF, NE
	Crush (2) (7.5.6)	NF, NE
Design consideration tests	Thermal abuse (7.6.1)	NF, NE
	Mold stress (7.6.2)	See 7.6.2

Key:

NE: No explosion/disassembly
NF: No fire
NL: No leakage

See 6.2 for a detailed description of the acceptance criteria

7.2 Test procedures and compliance (verification)

Component cells, required as the test samples for specified tests, shall be selected from batteries that have met the pretest requirements described in section 7.3.

7.2.1 General

7.2.1.1 Test temperature

All tests shall be conducted at a test temperature of 20 ± 5° C, unless otherwise specified.

7.3 Pretest requirements (dimensions, voltage, and insulation resistance)

7.3.1 Dimensions

The dimensions shall meet the dimensions specified in the relevant specification sheet in ANSI C18.2M, Part 1.

7.3.2 Open circuit voltage

The open circuit voltage shall meet the requirements on the relevant specification sheet in ANSI C18.2M, Part 1.

7.3.3 Insulation resistance test

Purpose

To measure the insulation resistance between externally exposed surfaces of the battery and the positive terminal, excluding measurement between the positive and negative terminals.

Test procedure

Insulation resistance measurements shall be made using a megohm-meter or other suitable instrument.

The direct potential applied to the sample shall be 500 ± 20 V.

Sample size: *n = all*

Step 1: Measure insulation resistance between mutually insulated points.

Step 2: Insulation resistance measurements shall be made immediately after a 2-minute period of uninterrupted test voltage application. However, if the instrument reading indicates that an insulation resistance meets the required limit, and is steady or increasing, the test may be terminated before the end of the specified period.

Step 3: Examine samples to determine if they meet the specified requirements.

Requirements

a) The insulation resistance shall not be less than 5 MΩ.
b) The measurement error at the insulation-resistance value required shall not exceed ±10 percent.

7.4 Intended use simulation

Tests described in this subsection are intended to simulate conditions that a battery is likely to encounter during intended use.

7.4.1 Test A: Altitude simulation

Purpose

To simulate and determine the effect of transportation on a battery in an aircraft cargo hold.

Test procedure

This test shall be conducted on fully charged samples according to a charge procedure described in ANSI C18.2M, Part 1 and under low-pressure conditions.

Sample size: n = 5.

Step 1: Verify that each sample meets the requirements of 7.2.

Step 2: Samples shall be stored for no less than six hours at an absolute pressure of 11.6 kPa or less.

Step 3: Examine samples to determine if they meet the specified requirements.

Requirements

a) No visible leakage.
b) No fire.
c) No explosion/disassembly.

7.4.2 Test B: Thermal shock

Purpose

To simulate and determine the effect of exposure to high and low temperature extremes on the integrity of a battery.

Test procedure

This test shall be conducted with fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1.

The maximum time between storage at 75 ± 2° C and –20 ± 2° C shall be ten (10) minutes.

Separate chambers may be used to perform this procedure.

Sample size: n = 5.

Step 1: Verify that each sample meets requirements of 7.2.

Step 2: Store samples for at least 48 hours at a temperature of 75 ± 2° C.

Step 3: Then immediately store samples for at least 6 hours at a temperature of –20 ± 2° C.

Step 4: Then immediately store samples for at least 24 hours at ambient temperature (20 ± 5° C).

Step 5: Examine samples to determine if they meet the specified requirements.

Requirements

a) No leakage.
b) No fire.
c) No explosion/disassembly.

7.4.3 Test C: Vibration

Purpose

To simulate and determine the effect of normal transport vibration encountered during regular shipment (i.e., transport by a common carrier truck)

Test procedure

This test shall be conducted with fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1. Samples shall be vibration tested according to the sequence given in Table 4.

Sample size: n = 5.

The vibration shall be applied in each of three mutually perpendicular directions, unless the sample only has two axes of symmetry, in which case only two directions shall be tested.

A simple harmonic motion, or vibration, shall be applied to the battery having an amplitude of 0.8 mm, with a total maximum excursion of 1.6 mm. The frequency shall be varied at the rate of 1 Hz per minute between the limits of 10 and 55 Hz. The entire range of frequencies (10 to 55 Hz) and return (55 to 10 Hz) shall be traversed in 90 ± 5 minutes for each mounting position (direction of vibration).

Step 1: Verify that each sample meets the requirements of 7.3.

Step 2: Apply the vibration in the first of three mutually perpendicular directions.

Step 3: Apply the vibration in the second of three mutually perpendicular directions.

Step 4: Apply the vibration in the third of three mutually perpendicular directions.

Step 5: Rest the sample for one hour.

Step 6: Examine samples to determine if they meet the specified requirements.

Table 4 – Vibration test sequence

Step	Storage time	Vibration time	Visual Examination
1	---	---	Pretest
2	---	90 ± 5 min	---
3	---	90 ± 5 min	---
4	---	90 ± 5 min	---
5	1 h	---	---
6	---	---	Post-test

Requirements

a) No leakage.
b) No fire.
c) No explosion/disassembly.

7.4.4 Test D: Mechanical shock

Purpose

To simulate and determine the effects of infrequent, non-repetitive shocks encountered during handling/transport.

This test shall be conducted with fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1 and according to the conditions of Table 5.

A shock shall be applied to the sample in each of three mutually perpendicular directions, unless the sample has only two axes of symmetry, in which case, only two directions shall be tested.

Sample size: n = 5.

Table 5 – Shock pulse

Acceleration		Waveform
Minimum average acceleration (first 3 msec)	Peak acceleration	
75 g_n	125 -175 g_n	Half sine

Test procedure

Step 1: Verify that each sample meets the requirements of 7.3.

Step 2: Secure each sample to the testing apparatus by means of a rigid mount that will support all mounting surfaces.

Step 3: Each shock shall consist of the sample being accelerated in such a manner that the minimum average acceleration is 75 g_n during the initial 3 msec, and the peak acceleration is between 125 and 175 g_n.

Step 4: Apply the shock in the first of three mutually perpendicular directions.

Step 5: Apply the shock in the second of three mutually perpendicular directions.

Step 6: Apply the shock in the third of three mutually perpendicular directions.

Step 7: Rest the sample for at least one hour.

Step 8: Examine samples to determine if they meet the specified requirements.

Requirements

a) No leakage.
b) No fire.
c) No explosion/disassembly.

7.5 Reasonable foreseeable misuse

Tests described in this subsection are intended to simulate conditions that the battery is likely to encounter during reasonably foreseeable misuse.

7.5.1 Test E: External short-circuit

Purpose

To simulate and determine the effect of an accidental or abusive short-circuit of the positive (+) and negative (-) terminals.

Test procedure

This test shall be conducted with fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1.

Sample size: n = 5.

Step 1: Verify that each sample meets requirements of 7.3.

Step 2: Connect the positive and negative terminals of each sample by a wire or other means to create a short circuit of the sample as shown in Figure 5 with the switch S1 open. The resistance of the interconnecting circuitry of Figure 5 shall not exceed 0.1 Ω.

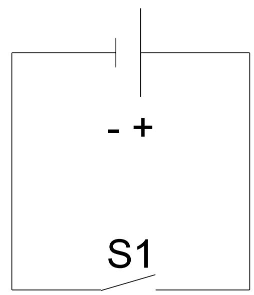


Figure 5 – Circuit for external short-circuit test

Step 3: Place the samples in an environment of 20 ± 2° C.

Step 4: After the sample battery case temperature has stabilized at 20 ± 2° C, close the switch S1.

Step 5: Check the temperature of the external battery casing continuously.

Step 6: Continue the test for at least twenty-four hours or until the case temperature declines by 20 percent of the temperature rise.

Step 7: Examine samples to determine if they meet the specified requirements.

Requirements

a) No fire.
b) No explosion/disassembly.

7.5.2 Test F: Forced discharge

Purpose

To simulate and determine the effect on a cell of a multi-cell installation where the state of charge for the individual cells is not balanced or on a battery where it is installed backward in a charger.

Test procedure

This test shall be conducted with seven fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1 connected in series with a discharged sample.

Sample size: *n = 5*.

Step 1: Verify that each sample meets the requirements of 7.3.

Step 2: Connect the discharged sample cell in series with seven charged cells.

Step 3: The resultant assembly shall be discharged using a resistance that simulates the intended application, but at a level at which the protective device will not activate during the course of the test. The resistance value shall be recommended by the manufacturer.

Step 4: Continue the test until a failure occurs or the outer case temperature declines by 20 percent of the temperature rise.

Step 5: Examine the samples to determine if they meet the specified requirements.

Requirements

a) No fire.
b) No explosion/disassembly.

7.5.3 Test G: Abusive overcharge

Purpose

To simulate and determine the effects on a battery being charged at a higher rate and for a longer period of time than specified by the manufacturer.

Test procedure

This test shall be performed on fully discharged samples.

Sample size: *n = 5*.

Test procedure

Step 1: Verify that each sample meets the requirements of 7.3.

Step 2: A thermocouple shall be attached to each sample.

Step 3: Subject each sample to a high-rate charge 2.5 times the recommended charging current for a time that produces 250 percent charge input (250% rated capacity).

Step 4: The samples shall remain on test for either (a) 250% input, (b) until the temperature of the outer casing reaches a steady state, or (c) until the temperature begins to decline.

Step 5: Examine the samples to determine if they meet the specified requirements.

Requirements

a) No fire.
b) No explosion/disassembly.

7.5.4 Test H: Free fall (user drop)

Purpose

To simulate and determine the effect of an inadvertent drop.

Test procedure

This test shall be conducted with fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1.

Sample size: n = 5.

Step 1: Verify that each sample meets the requirements of 7.3.

Step 2: Drop each battery, one battery at a time, oriented in each of three mutually perpendicular planes (three drops for each battery) from a height of 1 meter onto a concrete surface. However, in the case of cylindrical batteries, the sample battery shall be dropped twice, one time in each of two mutually perpendicular planes.

Step 3: Rest the sample for one hour after the final drop.

Step 4: Examine the sample to determine if it meets the specified requirements.

Requirements

a) The integrity of protective devices shall be maintained and verified by appropriate functional tests.
b) The outer enclosure shall not crack to the extent that any protective devices are exposed.
c) No visible leakage.
d) No fire.
e) No explosion/disassembly.

7.5.5 Test I: Crush—cells (test #1)

Purpose

To simulate and determine the effect of forces encountered during household waste disposal (i.e., trash compacting).

Test procedure

This test shall be performed separately on five fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1 and five samples that have been discharged to 50 percent depth of discharge under an application condition or rating test in accordance with the relevant specification sheet in ANSI C18.2M, Part 1.

Hydraulic ram: The force for the crushing shall be applied by a hydraulic ram with a 32 mm diameter piston.

Cylindrical (round) and prismatic batteries: These batteries shall be crushed with their longitudinal axis parallel to the flat surfaces of the crushing apparatus.

Each sample battery shall be subjected to a crushing force in only one direction. However, for prismatic batteries, a second battery shall be rotated 90° about its longitudinal axis from the side that was crushed on the first battery, so that both the wide and narrow sides of prismatic batteries will be subjected to the crushing force. Separate samples are to be used for each test.

Sample size: *n = 5*.

Step 1: Verify that each sample meets the requirements of 7.3.

Step 2: For those samples to be discharged 50 percent, discharge them in accordance with any one of the discharge tests given in ANSI C18.2M, Part 1 until 50 percent of the minimum average duration capacity has been removed.

Step 3: Position a sample between two flat surfaces of the crushing apparatus.

Step 4: Apply a crushing force until a pressure of 17.2 MPa is reached on the hydraulic arm, resulting in an applied force of approximately 13 kN.

Step 5: Release maximum pressure once it has been reached.

Step 6: Examine the samples to determine if they meet the specified requirements.

Requirements

a) No fire.
b) No explosion/disassembly.

7.5.6 Test I: Crush—batteries (test #2)

Purpose

To simulate and determine the effect of a moderate crushing force on a battery.

Test procedure

This test shall be conducted with fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1.

Sample size: $n = 5$.

Step 1: Verify that each sample meets the requirements of 7.3.

Step 2: Position a battery between two parallel flat maple (or equivalent) blocks, 17.7 mm or thicker.

Step 3: Gradually increase the force by applying a weight of 114 ± 2 kg across the total test surface of the battery and hold for one minute.

Step 4: Examine the samples to determine if they meet the specified requirements.

Requirements

a) The integrity of the protective devices shall be maintained and verified by appropriate functional tests.
b) The outer enclosure shall not crack to the extent that any protective devices are exposed.
c) No fire.
d) No explosion/disassembly.

7.6 Design considerations

Tests in this subsection are intended to evaluate battery design considerations.

7.6.1 Test J: Thermal abuse

Purpose

To simulate and determine the effect on batteries of extremely high temperature.

Test procedure

This test shall be conducted with fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1.

Sample size: *n = 5*.

Step 1: Verify that each sample meets the requirements of 7.3.

Step 2: Place the sample in a gravity circulating-air convection oven (or equivalent) and raise the oven temperature at a rate of 5 ± 2° C per minute to 130 ± 2° C.

Step 3: The oven shall be maintained at a temperature of 130 ± 2° C for 10 minutes before the test is discontinued.

Step 4: Examine the samples to determine if they meet the specified requirements.

Requirements

a) No fire.
b) No explosion/disassembly.

7.6.2 Test K: Mold stress

Purpose

To simulate and determine the effect of an elevated temperature environment on a molded battery.

Test procedure

This test shall be conducted with fully charged samples according to a charge procedure described in the relevant specification sheet in ANSI C18.2M, Part 1.

Sample size: *n = 3*.

Step 1: Verify that each sample meets the requirements of 7.2.

Step 2: Place the samples in a full gravity circulating-air convection oven (or equivalent) maintained at a temperature of 70 ± 2° C.

Step 3: The samples shall remain in the oven for 7 hours.

Step 4: Remove samples from the oven and allow them to return to ambient temperature (20 ± 5° C).

Step 5: Examine the samples to determine if they meet the specified requirements.

Requirement

No evidence of mechanical damage (no exposure of internal components or leakage of electrolyte).

8 Information for safety

8.1 General

When used correctly, rechargeable cells and batteries provide a safe and dependable source of portable power. However, if they are misused or abused, this may result in leakage, burns, fire, or explosion/disassembly.

8.2 Specific

8.2.1

Cells or batteries should not be disassembled, crushed, punctured, opened, or otherwise mutilated.

8.2.2

Always take care to correctly insert cells and batteries observing the positive (+) and negative (-) polarity marks on the product and the device for which it is intended.

8.2.3

Do not short circuit the cells or batteries. Store cells and batteries in their original packaging and away from metal objects which may short-circuit them.

8.2.4

Batteries should not be heated or exposed to temperatures exceeding the manufacturer's recommended maximum temperature. Such thermal exposure may lead to leakage, fire, or explosion/disassembly.

8.2.5

Use only the charger recommended for the cell or battery, or the one that was provided with the original equipment.

8.2.6

Do not drop or subject the cell or battery to strong mechanical shock.

8.2.7

Use the cell or battery with equipment that specifies its use.

8.2.8

Keep cells and batteries out of reach of children.

8.2.9

Seek medical advice immediately if a cell or battery has been swallowed.

8.2.10

In the event that the electrolyte comes into contact with the skin or eyes, immediately flush with fresh water for at least 15 minutes and seek medical advice.

8.2.11

Do not mix cells or batteries of different sizes, brands, capacities, or chemistries.

8.2.12

Consult the cell manufacturer for the maximum number of cells to be assembled in a battery.

8.2.13

Batteries should not be placed into a fire except under conditions of controlled incineration. Failure to observe this precaution may result in an explosion/disassembly.

9 Instructions for use

9.1

Purchase the correct size and grade of cell or battery most suitable for the intended use.

9.2

Keep cells or batteries clean and dry both during use and storage. Wipe metal terminals with a soft, dry cloth if they become dirty.

9.3

Charge cells or batteries before use. Refer to the manufacturer's instructions or device manual for proper charging instructions.

9.4

On first use, or after prolonged periods of storage, it may be necessary to charge and discharge the cell or battery two or three times before obtaining maximum performance.

9.5

It is best to charge the cell or battery at temperatures between 15° C and 30° C unless otherwise specified by the manufacturer.

9.6

If so instructed, remove the cell or battery from the charger when not in use.

9.7

Retain original product literature for future reference.

9.8

Only use the cell or battery in the application for which it was intended.

10 Marking

10.1 General

At least the following items shall be marked on the battery or package:

a) Battery system
b) Designation (ANSI, IEC or common)
c) Polarity of terminal (when applicable)
d) Nominal voltage
e) Year and month or week of manufacture, which may be in code, or the expiration date
f) Name or trademark of the manufacturer or supplier
g) Country of origin
h) Caution for ingestion (small batteries only)
i) Warnings or cautionary notes, where applicable

10.2 Small size batteries

When this sub-section is invoked on the individual specification sheet in ANSI C18.2M, Part 1, Section 2.2, Items (b) and (c) shall be marked on the battery. Items (a), (d), (e), (f), (g), (h), and (i) may be given on the immediate packing instead of on the battery.

NOTE—Batteries that are considered “small” are so noted on the individual battery specification sheets in ANSI C18.2M, Part 1, Section 2.2.

Annex A
(informative)

Guidance for device designers

A.1 Follow the manufacturer's advice on the proper use of the batteries.

A.2 Designing circuits, which use batteries in parallel, should only be done with the advice of the manufacturer.

A.3 Do not discharge a battery through two separate circuits requiring different voltages through electrical tapping.

A.4 Do not encapsulate without consulting the manufacturer.

A.5 Battery compartments should be designed such that their dimensions will accommodate batteries manufactured in accordance with ANSI C18.2M, Part 1. Battery compartments should not be designed around a single manufacturer's dimensions as this may result in fit problems with another manufacturer's product.

A.6 Battery compartments should be designed such that contact designs and materials ensure that effective electrical connections are made and maintained.

A.7 Battery compartments should be designed such that the battery compartment closure is mechanically retained or secured in such a way as to prevent easy access by children.

A.8 Battery compartments should be designed such that batteries, if installed in reverse, are unable to make electrical contact.

A.9 Battery compartments should be electrically and physically isolated from the electrical circuit, and from any heat-generating source, and positioned so as to minimize possible damage, and/or risk of injury.

A.10 Battery compartments should be designed such that correct orientation marking of the batteries is visible and permanent.

A.11 Do not modify batteries.

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Annex B
(informative)

Guidelines for packaging, transportation, and disposal

B.1 United States packaging and transportation

Procedures for the transportation of lithium-ion cells and batteries are specified by the Department of Transportation in the Code of Federal Regulations, CFR49 "Transportation." These procedures are based on the weight of lithium contained in the cell and battery.

B.2 International packaging and transportation

Procedures for international air transportation of lithium-ion cells and batteries outside of the United States are specified by the International Civil Aviation Organization (ICAO), Montreal, Quebec, in the publication "Technical Instructions for the Safe Transport of Dangerous Goods by Air." The ICAO procedures for air shipment of lithium-ion cells and batteries are similar, but not necessarily identical, to those specified by the U.S. Department of Transportation. The International Air Transport Association (IATA) also has published regulations for the shipment of lithium-ion batteries in their publication "Dangerous Goods Regulation." These regulations are similar to those published by ICAO. The International Maritime Organization (IMO) procedures for maritime shipment of lithium-ion cells and batteries are similar, but not necessarily identical, to those specified by the U.S. Department of Transportation.

NOTE—The U.S. Department of Transportation, ICAO, IATA, and IMO regulations for transportation of lithium-ion batteries are revised periodically and should be contacted for the latest information.

B.3 Disposal procedures for lithium-ion batteries

The disposal of waste products in the United States is regulated by the U.S. Environmental Protection Agency. The EPA Regulations are listed in the "Code of Federal Regulations," CFR40, entitled "Protection of Environment." Individual states and local communities may also establish regulations covering the disposal of waste products. These may be more stringent than the federal regulations and may cover the disposal of household waste, which is not included in the federal regulation. Thus, state and local agencies should be contacted for their disposal guidelines.

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Annex C
(informative)

Bibliography

All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

1. *United Nations Recommendation on the Transport of Dangerous Goods: Manual of Tests and Criteria*, New York and Geneva.

2. UL 1642, *Standard for Lithium Batteries.* Underwriters Laboratories Inc., Northbrook, Illinois, United States of America.

3. IEC 60068-2: *Basic Environmental Testing Procedures.*

4. IEC TR62188, Ed. 1: *Technical report – Secondary cells and batteries containing alkaline and other non-acid electrolytes – design and manufacturing recommendations for portable batteries made from sealed secondary cells.*

5. ANSI/IEEE 286, *Metric Practices.*

6. ISO/IEC GUIDE 51: *Guidelines for the Inclusion of Safety Aspects in Standards*.

7. ICAO Doc. 9284-AN/905: *Technical Instructions for the safe transport of Dangerous Goods by Air.*

8. IMO: *International Maritime Dangerous Goods Code.*

9. IATA: *International Air Transportation Association.*

10. IEC 60950 Annex J: *Information technology equipment – Safety – Part 1: General requirements.*

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