ANSI C18.3M, Part 2-2019

American National Standard for Portable Lithium Primary Cells and Batteries—Safety Standard

Secretariat:

National Electrical Manufacturers Association

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American National Standards Institute

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Foreword (This foreword is not part of American National Standard ANSI C18.3M, Part 2-2019)

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, and government agencies, has 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 Lithium Primary 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, and test conditions. Section 2 of Part 1 is composed 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). The purpose of the first edition was to harmonize with the International Electrotechnical Commission (IEC) Publication 60086-4: *Product Safety Standard for Primary Lithium Batteries*. This second edition was undertaken to update the safety tests and keep them current with the best possible practices.

This latest edition continues to consider and take into account the *United Nations Recommendations on the Transport of Dangerous Goods*. The document also contains new marking and packaging requirements to address accidental Lithium coin cell ingestion.

Suggestions for the improvement of this Standard are welcome. They should be sent to the National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 900, Rosslyn, VA 22209, Attention: Secretary ANSI ASC C18.

This Standard was processed and approved for submittal to ANSI by the Accredited Standards Committee C18 on Portable Cells and Batteries. 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:

Steven Wicelinski, Chairperson
Marcus Boolish, Vice-Chairperson
Khaled Masri, Secretary

Name of Representative(s):		Organization Represented:	Voting Status
Heather	Peterson	Batteries Plus Bulbs	Voting
Jason	Fladhammer	Batteries Plus Bulbs	Alt. Voting
David	Grandin	Bureau Veritas Consumer Product Services	Voting
Robert	Coughlin	Consumer Product Integrity Consulting, LLC	Voting

Jody	Leber	CSA Group	Voting
Steven	Wicelinski	Duracell, Inc.	Voting
Christopher	Brown	Duracell, Inc.	Alt. Voting
Marcus	Boolish	Energizer Brands, LLC	Voting
Carin	Stuart	Energizer Brands, LLC	Alt. Voting
Douglas	Golde	Fisher-Price	Voting
Thomas	O'Hara	Intertek	Voting
Rich	Byczek	Intertek	Alt. Voting
Cary	Costello	Kimberly-Clark Corporation	Voting
Jeff	Becker	Micropower Battery Co.	Voting
Charles	Monahan	Panasonic Corporation of North America	Voting
Rodney	Grimes	SGS	Voting
John	Hadley	Spectrum Brands, Inc.	Voting
Andy	Roszkowski	Spectrum Brands, Inc.	Alt. Voting
Laurie	Florence	UL LLC	Voting
Jeff	Ortega	ZPower, LLC	Voting
Tim	Powers	ZPower, LLC	Alt. Voting

The Members of Subcommittee C18-6 on Safety Standards who contributed to the development of this Standard are:

Carin Stuart, Chairperson
Tom O'Hara, Vice-chairperson
Khaled Masri, Secretary

Name		**Organization**
Yasuo	Akai	FDK CORPORATION
Larry	Albert	Stanley Black & Decker
Akinrori	Awano	Battery Association of Japan
Jeff	Becker	Micropower Battery Co.
Zekarias	Bekele	CSA Group
Marcus	Boolish	Energizer Brands, LLC
Christopher	Brown	Duracell, Inc.
Rich	Byczek	Intertek
Denis	Carpenter	Spectrum Brands, Inc.
Cary	Costello	Kimberly-Clark Corporation
Robert	Coughlin	Consumer Product Integrity Consulting, LLC
Raju	Desai	Apple Inc.
Sharon	Ensminger	Sy Kessler Sales, Inc.
Melissa	Fensterstock	Landsdowne Labs
Jacquline	Ferrante	U. S. Consumer Product Safety Commission
Jeff	Fischer	Spectrum Brands, Inc.
Jason	Fladhammer	Batteries Plus Bulbs
Laurie	Florence	UL LLC

Akio	Furukawa	Panasonic Automotive & Industrial Systems Company
Douglas	Golde	Fisher-Price
David	Grandin	Bureau Veritas Consumer Product Services
Rodney	Grimes	SGS North America
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Ray	Iveson	Duracell, Inc.
Judith	Jeevarajan	Underwriters Laboratories Inc.
Henry	Kessler	Sy Kessler Sales, Inc.
Roland	Klinger	RENATA
Jody	Leber	CSA Group
Douglas	Lee	U. S. Consumer Product Safety Commission
Khaled	Masri	NEMA
Charles	Monahan	Panasonic Corporation of North America
Thomas	O'Hara	Intertek
Jeff	Ortega	ZPower, LLC
Heather	Peterson	Batteries Plus Bulbs
Tim	Powers	ZPower, LLC
Andy	Roszkowski	Spectrum Brands, Inc.
John	Rotondo	Duracell, Inc.
Hirotaka	Shima	Hitachi Maxell, Ltd.
Carin	Stuart	Energizer Brands, LLC
Yoshiki	Terao	Panasonic
Hirohito	Teraoka	FDK CORPORATION
Kelly	Tsudama	Google
Steven	Wicelinski	Duracell, Inc.

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1 Introduction

The concept of safety is closely related to safeguarding the integrity of people and property. This Standard defines tests and requirements for primary lithium 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 will pose different problems, it is impossible to provide a set of precise provisions and recommendations that will apply in every case. This Standard, when following a judicious "use when applicable" basis, will provide reasonably consistent Standards for safety.

2 Scope

This American National Standard specifies tests and requirements for portable primary lithium cells and batteries, both the chemical systems and the types covered in ANSI C18.3M, Part 1, to ensure their safe operation under normal use and reasonably foreseeable misuse. For reference, the chemical systems standardized in ANSI C18.3M, Part 1 are:

Lithium carbon monofluoride
Lithium manganese dioxide
Lithium iron disulfide

3 Normative References

The following Standard contains provisions that, through reference in this text, constitute provisions of this American National Standard. 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 edition of the Standard indicated below.

ANSI C18.3M, Part 1 *American National Standard for Portable Lithium Primary Cells and Batteries—General and Specifications*

ANSI C18.4M *American National Standard for Portable Cells and Batteries—Environmental*

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 marking.

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

Note: The term "battery, button" is defined in ANSI C18.1M Part 1 as a small round non-lithium battery, in which the overall height is less than the diameter.

4.3 **cylindrical (cell or battery):** round cell or battery in which the overall height is equal to or greater than the diameter

4.4 **battery, portable:** A battery that is easily hand-carried.

4.5 **battery, primary lithium:** A battery that has metallic lithium or lithium alloy as its anode, and that is not designed to be charged.

4.6 **battery, prismatic:** A battery with non-round geometry.

4.7 **cell, primary:** A source of electrical energy that is obtained by the direct conversion of chemical energy, and that is not designed to be charged by any other electrical source.

4.8 **explosion/disassembly:** An explosion is considered to have occurred if a cell container or battery case open violently, and solid components are forcibly expelled.

4.9 **fire:** Combustion of cell or battery components with the emission of flame.

4.10 **fully discharged:** A primary cell or battery which has been electrically discharged to remove 100% of its rated capacity.

4.11 **harm:** Physical injury or damage to health or property.

4.12 **hazard:** A potential source of harm.

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

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

4.15 **nominal voltage:** Suitable approximate value used to designate or identify the voltage of a cell, battery, or electrochemical system.

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

4.17 **rated capacity:** The capacity, in ampere-hours, of a cell or battery as measured by subjecting it to a load, temperature, and voltage cut-off point specified by the manufacturer.

4.18 **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.

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

4.20 **rupture:** A rupture is considered to have occurred if a cell container or battery case has mechanically failed, resulting in the expulsion of gas or spillage of liquids but not forcible ejection of solid materials

4.21 **safety:** Freedom from unacceptable risk of harm.

4.22 **small cell or battery:** A cell or battery fitting within the limits of the ingestion gauge as defined in Figure 1.

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

4.24 **voltage, closed-circuit (CCV):** The voltage of a battery when an external current is flowing.

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

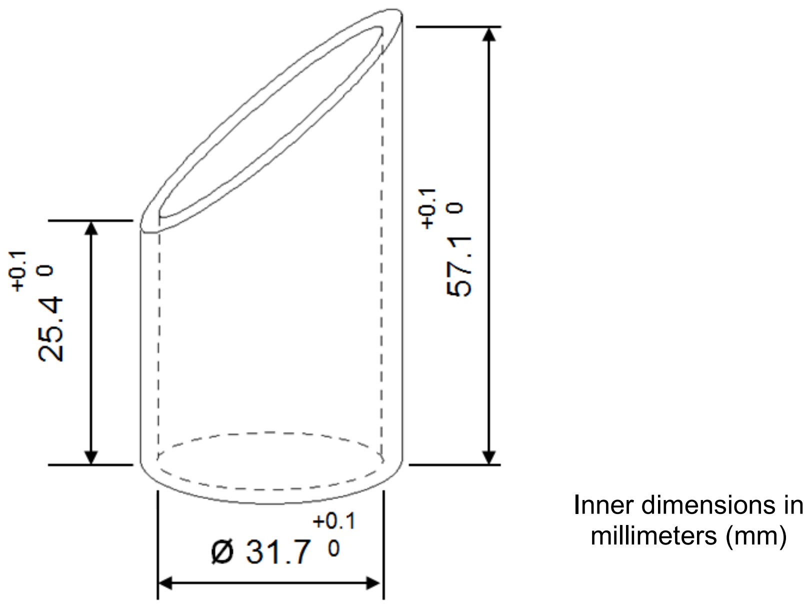


Figure 1
Ingestion Gauge

5 Requirements for Safety

5.1 Design

5.1.1 General

If discharged on an application test(s) in accordance with ANSI C18.3M, Part 1, there shall be no evidence of leakage, venting, fire, or explosion.

Batteries shall be so designed that they do not present a safety hazard under conditions of normal (intended) use. Compliance is verified by performing all of the tests required in this document and by meeting the stated requirements.

5.1.2 Battery Case

The casing of a battery shall be of a material and form that satisfies the Mold Stress Test given in 7.5.2.

5.1.3 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 that will preclude explosion or self-ignition. If encapsulation is necessary to support cells within an outer case, the type of encapsulant and the method of encapsulation should not cause the battery to overheat during normal operation nor inhibit pressure relief.

The battery case material and its final assembly should 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.

5.1.4 Temperature/Current Management

The design of cylindrical and prismatic batteries shall be such that:

a. Abnormal temperature rise due to external conditions is prevented through the use of thermal limitation features that are an integral part of the battery and may allow re-use of the battery if the feature is resettable;

b. Rapid internal temperature rise conditions shall be controlled by the immediate and irreversible shut down of the battery, thus precluding further use.

5.1.5 Multi-Cell Molded Plastic Battery Enclosure

For multi-cell batteries with plastic over-cases, the over-case should be so designed that it cannot be opened without mechanical assistance.

5.1.6 Quality Assurance Plan

The manufacturer should prepare and implement a quality plan that defines procedures for the inspection of materials, components, cells, and batteries and which covers the whole process of producing each type of cell or battery. Manufacturers should understand their process capabilities and should institute the necessary process controls as they relate to product safety.

6 Type Approval

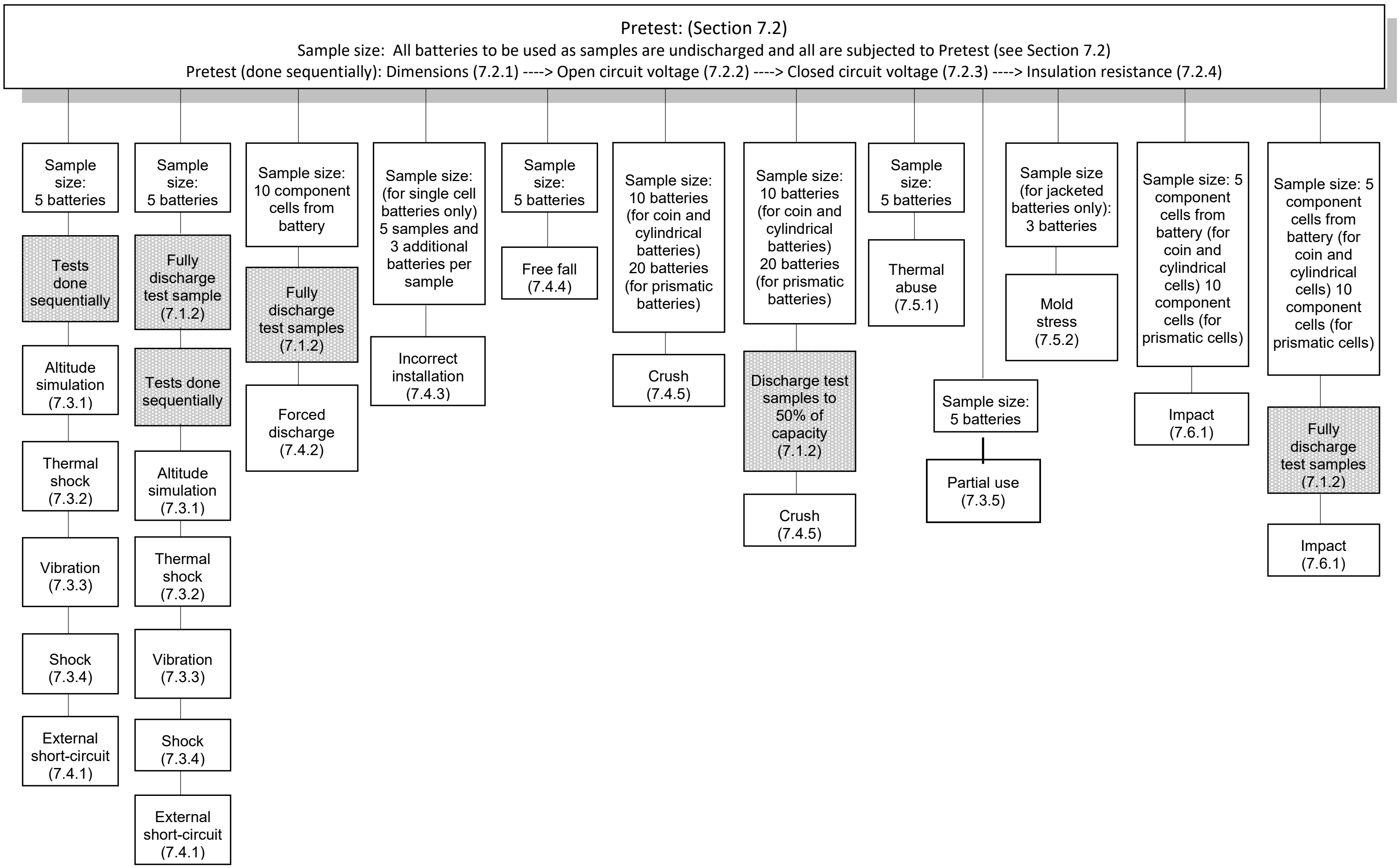
6.1 Sample Plan, Sample Size, and Test Sequence

Figure 2 lists the minimum requirements for sample size for the various tests for single-cell and multi-cell 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 pre-test requirements.

Samples that are to be subsequently tested in a fully discharged or partially discharged condition shall be discharged after the pretest, as specified in Section 7.1.2.

Figure 2
Sample Size for Single-Cell and Multi-Cell Batteries



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, $\Delta m/m$, 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*** *(g)*	**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 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

Test Category	Test	Requirements
Intended Use	A: Altitude simulation (7.3.1)*	NE, NF, NL, NM, NO, NR, NV
	B: Thermal shock (7.3.2)*	NE, NF, NL, NM, NO, NR, NV
	C: Vibration (7.3.3)*	NE, NF, NL, NM, NO, NR, NV
	D: Shock (7.3.4)*	NE, NF, NL, NM, NO, NR, NV
	E: Partial use (7.3.5)	NE, NF, NL
Reasonably Foreseeable Misuse	F: External short-circuit (7.4.1)*	NE, NF, NR, NT
	G: Forced discharge (7.4.2)	NE, NF
	H: Incorrect installation (7.4.3)	NE, NF
	I: Freefall (7.4.4)	NE, NF, NL, NR
	J: Crush (7.4.5)	NE, NF
Design Consideration	K: Thermal abuse (7.5.1)	NE, NF
	L: Mold stress (7.5.2)	See 7.5.2
Other	M: Impact (7.6.1)	NE, NF, NT

Requirements Key

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

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

7 Test Procedures and Compliance (Verification)

⚠	**<u>Warning</u>: 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.	

Tables 3 and 4 at the end of this section summarize the required tests.

7.1 General

7.1.1 Test Temperature

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

7.1.2 Discharging Samples

For those samples that must be fully discharged, discharge them in accordance with clause 4.10.

For those samples to be discharged 50 percent, discharge them in accordance with any one of the discharge tests given in ANSI C18.3M, Part 1 until 50 percent of the rated capacity has been removed. Component cells selected from multi-cell batteries shall be discharged at the same rate that they would have been discharged in a battery.

7.2 Pretest Conditions

All samples shall be pretested in an undischarged condition, and all samples shall meet the pre-test requirements. Samples not meeting the pre-test requirements shall be replaced with new samples that meet the requirements. Samples not meeting the pre test requirements should be checked for quality concerns.

7.2.1 Dimensions

The dimensions shall meet the dimensions specified in the relevant specification sheet in ANSI C18.3M, Part 1.

7.2.2 Open Circuit Voltage

The open-circuit voltage shall meet the requirements on the relevant specification sheet in ANSI C18.3M, Part 1.

7.2.3 Closed Circuit Voltage

The initial closed-circuit voltage (within five seconds) of the battery shall be checked under a rating or application test specified in the relevant specification sheet in ANSI C18.3M, Part 1. This voltage shall be typical for that battery.

7.2.4 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 megohmmeter or other suitable instrument.

The direct potential applied to the sample shall be 500 (−0/+100) V.

Step 1: Measure insulation resistance between mutually insulated points.

Step 2: Insulation resistance measurements shall be made immediately after a period of uninterrupted test voltage application.

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 of the insulation-resistance value required shall not exceed ±10 percent.

7.3 Intended Use Simulation Tests

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

7.3.1 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 undischarged and fully discharged batteries under low-pressure conditions.

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 explosion/disassembly (4.8)
b. No fire (4.9)
c. No leakage (6.2.2).