ERICAN NATIONAL STANDARD

American National Standard

ANSI C18.3M, Part 2-1999

American National Standard

For Portable Primary Cells and Batteries— Safety Standard

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
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C18.3M, Part 2-1999
Revision of
ANSI C18.3M-1991

American National Standard

For Portable Lithium Primary Cells and Batteries— Safety Standard

Secretariat:

National Electrical Manufacturers Association

Approved March 23, 1999

American National Standards Institute

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Foreword (This foreword is not part of American National Standard C18.3M, Part 2-1999.)

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, 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.

In 1996, the C18 Committee began preparing what is, in effect, the first edition of this specification on safety requirements under the sponsorship of the National Electrical Manufacturers Association (NEMA).

This edition was created in an effort to harmonize with the International Electrotechnical Commission (IEC) Publication 86-4: *Product Safety Standard for Primary Lithium Batteries*. At the time of publication, this is one of two standards intended to address the safety of primary battery systems.

Suggestions for improvement of this standard will be welcome. They should be sent to the National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 1847, Rosslyn, VA 22209.

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:

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American National Standard

for Portable Lithium Primary Cells and Batteries—Safety Requirements

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 may be particularly true for coin-type batteries. 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 tests and requirements for portable primary lithium cells and batteries to ensure their safe operation under normal use and reasonably foreseeable misuse.

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 C18.3M, Part 1-1999, *Portable Lithium Primary Cells and Batteries-General and Specifications*

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 battery, in which the overall height is less than the diameter.

4.3 battery, cylindrical: A battery with cylindrical geometry, where the overall height is equal to or greater than the diameter.

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

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

4.6 battery, portable: A battery that is easily carried.

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

4.8 explosion: A failure that occurs when a cell or battery violently opens and major components are forcibly expelled.

4.9 fire: Combustion of cell/battery components with emission of flame.

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

4.11 hazard: A potential source of harm.

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

4.13 leakage: The escape of electrolyte from a cell or battery.

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

4.15 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.

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

4.17 safety: Freedom from unacceptable risk of harm.

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

4.19 venting: The release of excessive internal pressure from a battery in a manner intended by design to preclude explosion.

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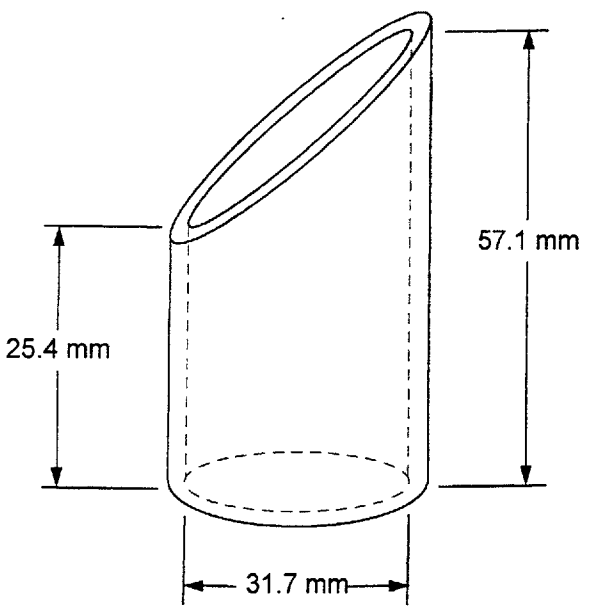


Figure 1 – Small cell or battery gauge (inner dimensions)

5 Requirements for safety

5.1 Design

5.1.1 General

Batteries shall be so designed that they do not present a safety hazard under conditions of normal (intended) use. When discharged on an application test in accordance with ANSI C18.3M, 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 Insulation resistance

The insulation resistance between externally exposed metal surfaces of the battery excluding electrical contact surfaces and the positive terminal shall be not less than 5 MΩ at 500 ± 20 V(dc).

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 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.

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5.1.4 Temperature/current management

The design of the batteries shall be such that:

- Abnormal temperature rise due to external conditions are prevented through the use of thermal limitation features which are an integral part of the battery and may allow re-use of the battery if the feature is resettable;
- 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 Attitude (orientation)

Batteries shall be so designed that they may be used in any attitude.

5.1.6 Multi-cell molded plastic battery enclosure

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

5.2 Intended use requirements

Cells and batteries shall not present a hazard when subjected to tests which simulate conditions that they are likely to encounter during intended use.

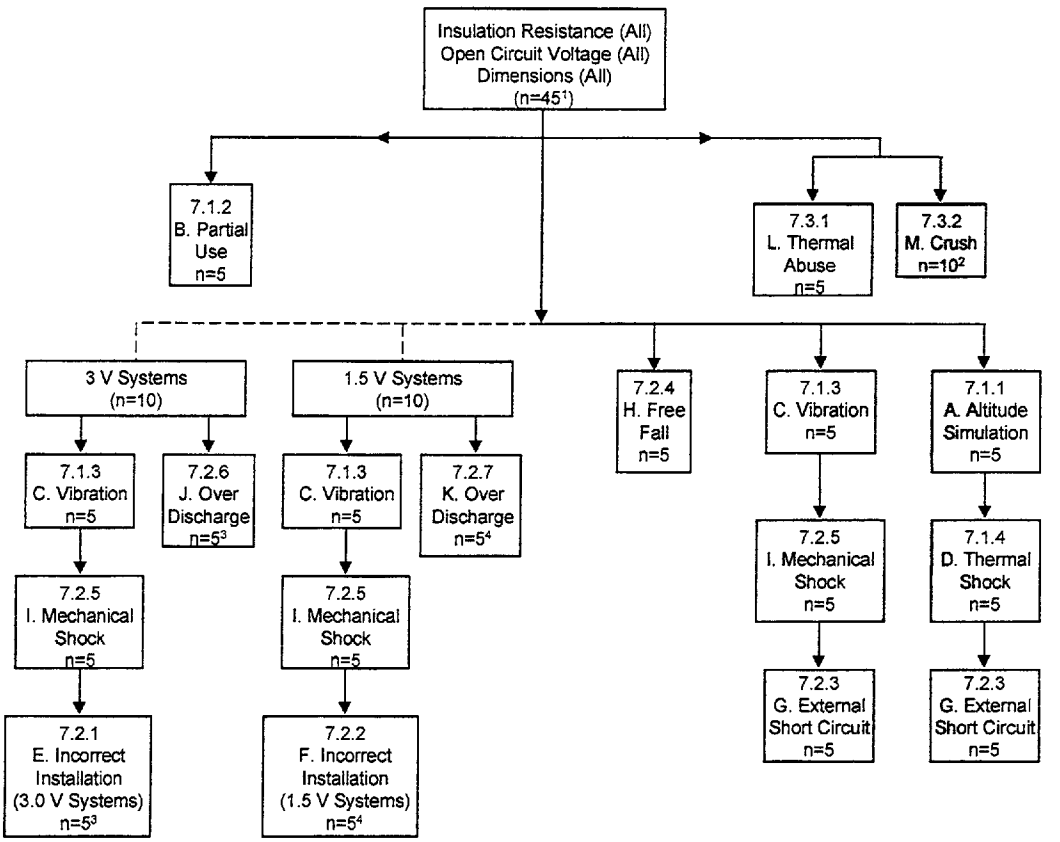
5.3 Reasonably foreseeable misuse requirements

Cells and batteries shall meet the requirements when subjected to the tests which simulate conditions that they are likely to encounter during reasonably foreseeable misuse.

6 Sequence of testing and sample size for type approval

See Figure 2 for the sequence of testing and recommended sample sizes (n equals the number of batteries) for the various tests for single-cell batteries, and see Figure 3 for the same information and recommendations for multi-cell batteries.

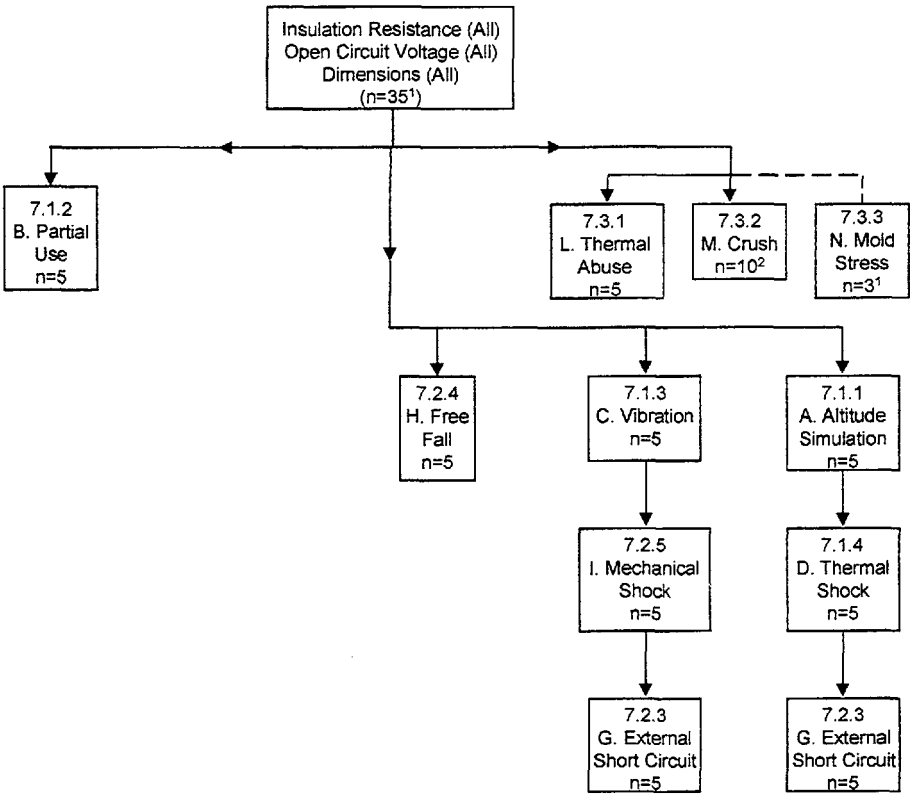
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NOTES
1 May require more batteries.
2 For coin batteries, n = 10, and for prismatic batteries, n = 20.
3 Plus 15 batteries.
4 Plus 55 batteries.

Figure 2 – Test sequence and recommended sample sizes for single-cell batteries

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NOTES
1 May require more batteries.
2 For coin batteries, n = 10, and for cylindrical batteries, n = 20.

Figure 3 – Test sequence and recommended sample sizes for multi-cell batteries

7 Testing and compliance (verification)

Warning: These tests call for the use of procedures which may result in injury if adequate precautions are not taken. It has been assumed in drafting these tests that their execution is undertaken by appropriately qualified and experienced technicians using adequate protection.

Table 2 at the end of this section summarizes required tests.

For purposes of complying with transportation requirements, those tests denoted with "transport" in parentheses may be used.

7.1 Intended use simulation tests

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

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7.1.1 Test A: Altitude simulation (transport)

Purpose

To simulate high altitude flight.

General

Undischarged batteries shall be tested.

Sample size: $n = 5$.

Test procedure

Batteries shall be stored for at least six hours at an absolute pressure of 11.6 kPa or less at a temperature of 21 ± 5°C.

Requirements

No distortion beyond dimensions given on the relevant specification sheet in ANSI C18.3M, Part 1; no leakage; no fire; and no explosion.

7.1.2 Test B: Partial use

Purpose

To determine the effects of partial use of batteries.

General

Undischarged batteries shall be tested.

Sample size: $n = 5$.

Test procedure

Step 1: Discharge batteries in accordance with any one of the discharge tests specified in ANSI C18.3M, Part 1 for that battery.

Step 2: The batteries shall then be stored at 45 ± 2°C for 30 days. As an option, in order to reduce storage time, samples may be stored at 55 ± 2°C for 15 days or 75 ± 2°C for four days.

Requirements

No distortion beyond dimensions given on the relevant specification sheet in ANSI C18.3M, Part 1; no leakage; no fire; and no explosion.

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7.1.3 Test C: Vibration (transport)

Purpose

To simulate conditions normally encountered during regular shipment (i.e., transport by common carrier truck).

General

Undischarged batteries shall be tested at 21 ± 5°C under the following conditions: (a) a simple harmonic motion shall be applied to the battery having an amplitude of 0.76 mm, with a total maximum excursion of 1.52 mm; (b) the frequency shall be varied at the rate of 1 Hertz per minute between the limits of 10 and 55 Hertz; (c) the entire range of frequencies (10 to 55 Hertz) and return (55 to 10 Hertz) shall be traversed in 90 ± 5 minutes for each mounting position (direction of vibration); (d) the vibration shall be applied in each of three mutually perpendicular directions.

Sample size: $n = 5$.

Test procedure

Step 1: Verify that the open circuit voltage of each battery to be tested meets or exceeds the nominal voltage given on the relevant specification sheet in ANSI C18.3M, Part 1.
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 the three mutually perpendicular directions.
Step 5: Rest the batteries for one hour prior to examination according to the requirements.

Requirements

No distortion (beyond dimensions given on the relevant specification sheet in ANSI C18.3M, Part 1); no leakage; no fire; and no explosion.

7.1.4 Test D: Thermal shock

Purpose

To determine the effects of the cell integrity from exposure to high and low temperature extremes.

General

Undischarged batteries shall be used for this test.

Sample size: $n = 5$.

Test procedure

Step 1: Store cells and batteries for at least 48 hours at a temperature of 75 ± 2°C.
Step 2: Follow immediately by storing for at least six hours at a temperature of -20 ± 2°C.
Step 3: Follow immediately by storing for at least 24 hours at 21 ± 5°C.

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The maximum time between storage at 75°C and -20°C shall be 10 minutes. Separate chambers may be used to perform this procedure.

Requirements

No leakage; no fire; and no explosion.

7.2 Reasonably foreseeable misuse tests

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

7.2.1 Test E: Incorrect installation (3-Volt electrochemical systems)

Purpose

To simulate incorrect installation of a battery when used in a series application.

General

Undischarged single cell batteries shall be used for this test. They shall first be exposed to vibration in accordance with 7.1.3 and meet the requirements for that test, and then be exposed to mechanical shock in accordance with 7.2.5 and meet the requirements of that test. The initial closed circuit voltage (10-30 second test) of the battery shall then be checked under a rating or application condition in accordance with ANSI C18.3M, Part 1 and must be within 10% of the typical initial closed circuit voltage for that type of battery.

Sample size: $n = 5$ test samples. If any of the original samples selected for this test fail to meet the conditions specified in General above, new samples shall be selected from the same lot, brand, type, and origin so that a total of five [5] test samples, meeting the conditions specified in General above, are available.

An additional 15 undischarged batteries of the same brand, type, and origin as the test sample batteries are required for this test. These batteries shall be checked prior to use by an initial closed circuit voltage (10-30 seconds test) under a rating or application condition in accordance with ANSI C18.3M, Part 1 and must be within 10% of the initial closed circuit voltage for that type battery.

Test procedure

Step 1: Place 3 undischarged batteries in a series with a resistive load (R1) and with one test sample battery reversed (C1) according to Figure 4. The resistive load (R1) shall be such that the average current draw is the same as the maximum discharge current specified by the manufacturer. The maximum discharge current specified by the manufacturer shall be such that any protective device used in the battery will not activate during the course of the test.

Step 2: Close the circuit and continue the test until the voltage of the series string reaches 10% of its original open circuit voltage or until 24 hours has elapsed, whichever is longer.

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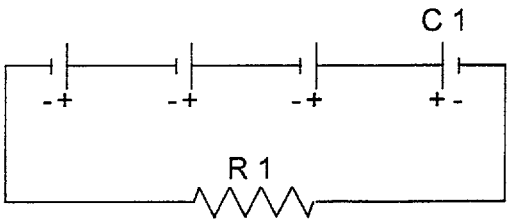


Figure 4 – Test E schematic

Requirements

No fire and no explosion.

7.2.2 Test F: Incorrect installation (1.5-Volt electrochemical systems)

Purpose

To simulate incorrect installation of a battery when used in a series application.

General

Undischarged single cell batteries shall be used for this test. They shall first be exposed to vibration in accordance with 7.1.3 and meet the requirements for that test, and then be exposed to mechanical shock in accordance with 7.2.5 and meet the requirements of that test. The initial closed circuit voltage (10-30 second test) of the battery shall then be checked under a rating or application condition in accordance with ANSI C18.3M, Part 1 and must be within 10% of the typical initial closed circuit voltage for that type of battery.

Sample size: $n = 5$ test samples. If any of the original samples selected for this test fail to meet the conditions specified in General above, new samples shall be selected from the same lot, brand, type, and origin so that a total of five [5] test samples, meeting the conditions specified in General above, are available.

An additional 55 undischarged batteries of the same brand, type, and origin as the test sample batteries are required for this test. These batteries shall be checked prior to use by an initial closed circuit voltage (10-30 seconds test) under a rating or application condition in accordance with ANSI C18.3M, Part 1 and must be within 10% of the initial closed circuit voltage for that type battery.

Test procedure

Step 1: Place the 11 undischarged batteries in a series with a resistive load (R1) and with one test sample battery reversed (C1) according to Figure 5. The resistive load (R1) shall be such that the average current draw is the same as the maximum discharge current specified by the manufacturer. The maximum discharge current specified by the manufacturer shall be such that any protective device used in the battery will not activate during the course of the test.

Step 2: Close the circuit and continue the test until the voltage of the series string reaches 10% of its original open circuit voltage or until 24 hours has elapsed, whichever is longer.

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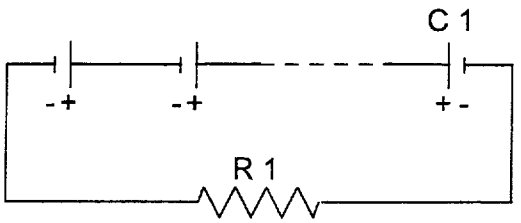


Figure 5 – Test F schematic

Requirements

No fire and no explosion.

7.2.3 Test G: External short-circuit

Purpose

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

General

This test shall be conducted on undischarged single cell batteries at a test temperature of 55 ± 2°C at two test conditions.

Test Condition 1

The test batteries shall first be exposed to vibration in accordance with 7.1.3 and meet the requirements of that test, and then be exposed to mechanical shock in accordance with 7.2.5 and meet the requirements for that test. The initial closed circuit voltage (10-30 second test) of the battery shall then be checked under a rating or application condition in accordance with ANSI C18.3M, Part 1 and must be within 10% of the typical initial closed circuit voltage for that type of battery.

Sample size n = 5 test samples. If any of the original samples selected for this test fail to meet the conditions specified in General above, new samples shall be selected from the same lot, brand, type, and origin so that a total of five [5] test samples, meeting the conditions specified in General above, are available.

Test Condition 2

The test batteries shall first be exposed to altitude simulation in accordance with 7.1.1 and meet the requirements for that test, and then be exposed to thermal shock in accordance with 7.1.4 and meet the requirements for that test. The initial closed circuit voltage (10-30 second test) of the battery shall then be checked under a rating application condition in accordance with ANSI C18.3M, Part 1 and must be within 10% of the typical initial closed circuit voltage for that type of battery.

Sample size n = 5 test samples. If any of the original samples selected for this test fail to meet the conditions specified in General above, new samples shall be selected from the same lot, brand, type, and origin so that a total of five [5] test samples, meeting the conditions specified in General above, are available.

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Test procedure

Step 1: Stabilize the ambient test and battery case temperatures at 55°C.
Step 2: Connect the positive and negative terminals of each battery, to be tested, by a wire or other means to create a short circuit of the battery. The interconnecting circuitry shall not exceed 0.05 Ω.
Step 3: Continue the test for at least one hour after the battery case temperature returns to 55°C.

Requirements

No leakage; no fire; and no explosion. The temperature of the exterior battery casing shall not exceed 150°C.

7.2.4 Test H: Free fall (user drop)

Purpose

To simulate the conditions of an inadvertent drop.

General

Undischarged batteries shall be tested at 21 ± 5°C.

Sample size: $n = 5$.

Test procedure

Test surface: Concrete.
Height of drop: 1 meter.
Number of drops: One time initially oriented in each of three mutually perpendicular faces (three total).
Rest the battery for one hour after dropping before requirement examination.

Requirements

No fire and no explosion.

7.2.5 Test I: Mechanical shock (transport)

Purpose

To simulate crash conditions or rough handling during transportation.

General

Undischarged batteries shall be tested at 21 ± 5°C under the requirements in Table 1.

Sample size: $n = 5$.

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Table 1 – Shock pulse

Acceleration		
Minimum Average Acceleration. First 3 msec.	**Peak Acceleration**	**Waveform**
75 G_n	125-175 G_n	Half Sine

Test procedure

Step 1: Verify that the open circuit voltage of the battery to be tested meets or exceeds the nominal voltage given in the relevant specification sheet of ANSI C18.3M, Part 1.

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

Step 3: One shock shall be applied in each of the three mutually perpendicular directions unless the sample has only two axes of symmetry, in which case only two directions shall be tested. For each shock, accelerate the battery so that the minimum average acceleration is 75 G during the initial 3 msec, and the peak acceleration is between 125 and 175 G.

Step 4: Observe the battery for at least one hour after the third, or final, shock.

Requirements

No leakage; no fire; and no explosion.

7.2.6 Test J: Overdischarge (3-Volt electrochemical systems)

Purpose

To simulate placing a discharged battery in a circuit with undischarged batteries (i.e., mixing new and used batteries).

General

Discharged single cell batteries shall be used for this test.

Sample size: $n = 5$ test samples.

An additional 15 undischarged batteries of the same brand, type, and origin as the test sample batteries are required for this test. These batteries shall be checked prior to use by an initial closed circuit voltage (10-30 seconds test) under a rating or application condition in accordance with ANSI C18.3M, Part 1 and must be within 10% of the initial closed circuit voltage for that type battery.

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Test procedure

Step 1: Discharge one test sample battery (C1) under a rating or an applications condition to the specified end voltage in accordance with ANSI C18.3M, Part 1.

Step 2: Connect the undischarged batteries and the discharged test sample battery in series with a resistive load (R1) as shown in Figure 5. The resistive load (R1) shall be such that the average current draw is the same as the maximum discharge current specified by the manufacturer. The maximum discharge current specified by the manufacturer shall be such that any protective device used in the battery will not activate during the course of the test.

Step 3: Maintain the circuit until the voltage of the series string reaches 10% of its original open circuit voltage or until 24 hours elapses, whichever is longer.

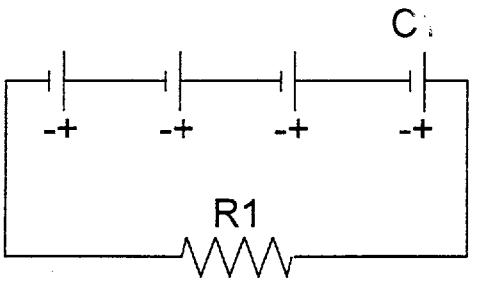


Figure 6 – Test J schematic

Requirements

No fire and no explosion.

7.2.7 Test K: Overdischarge (1.5-Volt electrochemical systems)

Purpose

To simulate placing a discharged battery in a circuit with undischarged batteries (i.e., mixing new and used batteries).

General

Discharged single cell batteries shall be used for this test.

Sample size: $n = 5$ test samples.

An additional 55 undischarged batteries of the same brand, type, and origin as the test sample batteries are required for this test. These batteries shall be checked prior to use by an initial closed circuit voltage (10-30 seconds test) under a rating or application condition in accordance with ANSI C18.3M, Part 1 and must be within 10% of the initial closed circuit voltage for that type battery.

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Test procedure

Step 1: Discharge one test sample battery (C1) under a rating or an application condition to the specified end voltage in accordance with ANSI C18.3, Part 1.

Step 2: Connect the undischarged batteries and the discharged battery in series with a resistive load (R1) as shown in Figure 6. The resistive load (R1) shall be such that the average current draw is the same as the maximum discharge current specified by the manufacturer. The maximum discharge current specified by the manufacturer shall be such that any protective device used in the battery will not activate during the course of the test.

Step 3: Maintain the circuit until the voltage of the series string reaches 10% of its original open circuit voltage or until 24 hours elapses, whichever is longer.

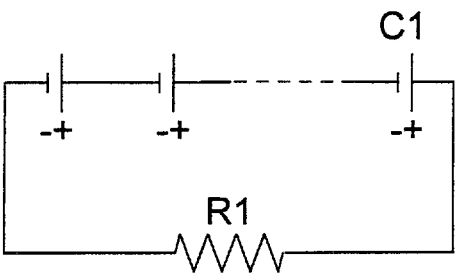


Figure 7 – Test K schematic

Requirements

No fire and no explosion.

7.3 Design consideration tests

7.3.1 Test K: Thermal abuse

Purpose

To simulate the condition of exposing a cell or battery to an extremely high temperature.

General

Undischarged batteries shall be used for this test.

Sample size: $n = 5$.

Test procedures

Step 1: Heat the batteries in a gravity or circulating-air convection oven at a rate of 5 ± 2°C per minute to a temperature of 150 ± 2°C.

Step 2: The batteries shall remain at 150 ± 2°C for 10 minutes before the test is discontinued.

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Requirements

No fire and no explosion.

7.3.2 Test M: Crush

Purpose

To simulate batteries exposed to forces encountered during household waste disposal (i.e., trash compacting).

General

This test shall be performed separately on five undischarged batteries, and five batteries which have been discharged to 50% depth of discharge under an application condition or rating test in accordance with the relevant specification sheet in ANSI C18.3M, 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.

Coin cell or battery: These batteries shall be crushed with the flat surface parallel with the flat surfaces of the crushing apparatus.

Sample size: $n = 10$ for cylindrical and coin batteries and $n = 20$ for prismatics.

Test procedure

Step 1: Position the battery between the two flat surfaces of the crushing apparatus.
Step 2: Apply a crushing force until a pressure of 17.2 MPa is reached on the hydraulic ram, resulting in an applied force of approximately 13 kN.
Step 3: Once maximum pressure has been reached, it shall be released.

Requirements

No fire and no explosion.

7.3.3 Test N: Mold stress

Purpose

To determine the effects of an elevated temperature environment on a molded battery enclosure.

General

Undischarged batteries shall be used for this test.

Sample size: $n = 3$.

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Test procedure

Step 1: Place the batteries in a full draft circulating-air oven maintained at a uniform temperature of 70 ± 2°C.
Step 2: The batteries shall remain in the oven for seven hours.
Step 3: Remove the batteries from the oven and allow them to return to room temperature before examination.

Requirements

No distortion beyond dimensions specified for the battery. No evidence of mechanical damage (exposure of internal components or leakage of electrolyte).

8 Information for safety

8.1 Batteries should be used in a manner consistent with manufacturer's recommendations and guidelines. When used correctly, primary lithium cells and batteries provide a safe and dependable source of portable power. However, if they are misused or abused, this may result in leakage or in extreme cases, fire or explosion.

8.2 Always take care to correctly insert batteries observing the (+) and (-) polarity marks on the battery and the device for which it is intended. Proper polarity must be observed to avoid charging or damage to either equipment or batteries.

8.3 Always replace the whole set of batteries at one time, taking care not to mix old and new ones, or batteries of different types, capacities, or manufacturers.

8.4 Store unused batteries in their original packaging and away from metal objects which may short-circuit them. In addition, batteries should be stored in a cool, dry place.

8.5 Primary batteries should not be charged. Charging a battery may result in leakage, fire, or explosion.

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

8.7 Never short-circuit batteries as this may lead to high temperatures, leakage, fire, or explosion.

8.8 Batteries should not be disassembled, crushed, punctured, or otherwise mutilated. Such abuses may result in leakage, fire, or explosion.

8.9 Soldering directly to the battery surface should be avoided to prevent possible internal damage, leakage, or cell rupture. Soldering should be done only with the advice of the manufacturer.

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Table 2 – Testing and requirements

System Letter	Positive Electrode	Electrolyte	Negative Electrode	Nominal Voltage per cell (V)	Shape	Applicable Tests													
						A	B	C	D	E	F	G	H	I	J	K	L	M	N
B	Carbon monofluoride	Organic	Lithium	3.0	R	X	X	X	X	X	NA	X	X	X	X	NA	X	X	X
					C	X	X	X	X	X	NA	X	X	X	NA	NA	X	X	NA
					P	X	X	X	X	NA	NA	X	X	X	NA	NA	X	NA	X
C	Manganese dioxide	Organic	Lithium	3.0	R	X	X	X	X	X	NA	X	X	X	X	NA	X	X	X
					C	X	X	X	X	X	NA	X	X	X	NA	NA	X	X	NA
					P	X	X	X	X	NA	NA	X	X	X	NA	NA	X	NA	X
E	Thionyl chloride ($SOCl_2$)	Organic	Lithium	3.6	R	Not standardized—to be determined													
					C														
					P														
F	Iron disulfide (FeS_2)	Organic	Lithium	1.5	R	X	X	X	X	NA	X	X	X	X	NA	X	X	X	X
					C	Not standardized—to be determined													
					P														
G	Copper (II) oxide (CuO)	Organic	Lithium	1.5	R														
					C														
					P														

R = Round single cell battery P = Multi-cell battery
C = Coin single cell battery NA = Not applicable

Applicable test references:

A—Altitude simulation [7.1.1]
B—Partial use [7.1.2]
C—Vibration [7.1.3]
D—Thermal shock [7.1.4]
E—Incorrect installation (3-Volt systems) [7.2.1]
F—Incorrect installation (1.5-Volt systems) [7.2.2]
G—External short-circuit [7.2.3]
H—Free fall [7.2.4]
I—Mechanical shock [7.2.5]
J—Overdischarge (3-Volt systems) [7.2.6]
K—Overdischarge (1.5-Volt systems) [7.2.7]
L—Thermal abuse [7.3.1]
M—Crush [7.3.2]
N—Mold stress [7.3.3]

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8.10 Keep cells and batteries out of reach of children, especially those batteries fitting within the limits of the truncated cylinder or swallowable object measuring device, as defined in Figure 1.

8.11 Seek medical advice immediately if a cell or battery has been swallowed. Contact the National Capitol Poison Control Center at 202-625-3333 (collect).

8.12 In the event that the electrolyte comes into contact with the skin or eyes, immediately flush with fresh water and seek medical advice.

8.13 During normal use, a lithium battery or cell should not be exposed to water. Lithium metal in contact with water may produce fire and/or hydrogen gas.

8.14 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.

8.15 When incorporating a primary lithium battery into a memory back-up circuit, protective measures should be used to prevent the main power source from charging the battery. One method that has been shown to be effective is illustrated in Figure 8.

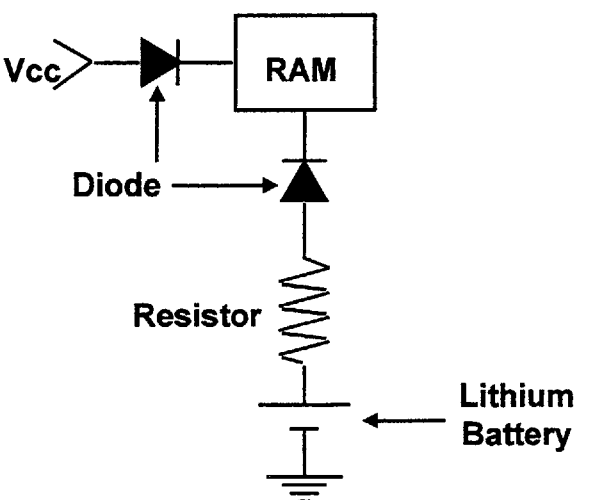


Figure 8 – Typical memory back-up circuit

8.16 Connecting cells/batteries in parallel could result in charging one of the cells and cause leakage and potential cell rupture. Diode protection may be required depending upon the cell type. Device designers should contact the manufacturer for guidance.

9 Instructions for use

9.1 Always select the correct size and type of battery most suitable for the intended use. Information provided with the appliance to assist correct battery selection should be retained for reference.

9.2 Replace all batteries of a set at the same time.

9.3 Clean the battery and appliance contacts prior to battery installation.

9.4 Ensure that the batteries are installed correctly with regard to polarity (+ and -).

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9.5 Remove batteries from equipment which is being stored or will not be used for an extended period of time.

9.6 Remove spent batteries promptly.

10 Marking

10.1 General

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

a) Battery system
b) Designation
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 trade mark of the manufacturer or supplier
g) Warnings or cautionary notes, where applicable
h) Caution for ingestion (small batteries only)

10.2 Small Size Batteries

When this sub-clause is invoked on the individual specification sheet, items b) and c) shall be marked on the battery. Items a), d), e), f), g), and h) may be given on the immediate packing instead of on the battery.

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Annex A
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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 Avoid electrical tapping.

A.4 Do not encapsulate or modify batteries.

A.5 Battery compartments should be designed such that their dimensions will accommodate batteries manufactured in accordance with ANSI C18.3M, 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 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, installed in reverse, are unable to make contact.

A.9 Battery compartments should be designed such that insulation from the electrical circuit is maintained and positioned so as to minimize possible damage and/or risk of injury.

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

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Annex B
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Guidelines for packaging, transportation, and disposal

B.1 United States packaging and transportation

Procedures for the transportation of lithium 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.

- Paragraph 175.185(b) of CFR49 permits the shipment of solid cathode lithium cells, containing no more than one gram of lithium, and lithium batteries containing no more than two grams of lithium. Shipment is permitted in all modes of transportation, provided the cells and batteries are packed in strong outside packages (except when installed in electronic devices), and separated to prevent short circuit.

- Paragraph 173.185(c) lists the procedures for transporting and shipping larger cells (containing not more than 5 grams of lithium) and larger batteries (containing not more than 25 grams of lithium). Testing in accordance with UN Recommendations on the Transport of Dangerous Goods, Tests and Criteria is required prior to the initial transport.

- Other details for transporting and shipping lithium cells are provided in CFR49, paragraph 173.185(d) to (j).

B.2 International packaging and transportation

Procedures for international air transportation of lithium 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 cells and batteries are similar, but not necessarily identical, to those specified by the U.S. Department of Transportation. Regulations for the shipment of certain lithium cells and batteries are given in Special Provision A45 of the ICAO Instructions. This Special Provision permits the shipment, in all modes of transportation, of lithium cells and batteries, as stated in paragraph A. Regulations for the shipment of larger cells and batteries are covered in Special Provision A45 and Packaging Instruction 903 of the ICAO Instructions. The International Air Transport Association (IATA) also has published regulations for the shipment of lithium batteries in their publication "Dangerous Goods Regulation." These regulations are similar to those published by ICAO.

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

B.3 Disposal procedures for lithium 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 also may 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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Appendix C
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