AMERICAN NATIONAL STANDARD



ANSI C18.2M, Part 2-1999

American National Standard

For Portable Rechargeable Cells and Batteries— Safety Standard

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
1300 NORTH 17TH STREET, SUITE 1847, ROSSLYN, VA 22209
(703) 841-3200 FAX: (703) 841-3300

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ANSI C18.2M, Part 2-1999
Revision of
ANSI C18.2M-1997

American National Standard

For Portable Rechargeable Cells and Batteries—Safety Standard

Secretariat:

National Electrical Manufacturers Association

Approved January 7, 1999

American National Standards Institute, Inc.

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Foreword (This foreword is not part of American National Standard C18.2M, 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 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 began preparing what is in effect the first edition of this specification on safety requirements in 1996 under the sponsorship of the National Electrical Manufacturers Association (NEMA).

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

Terrence N. Telzrow, Chairperson
Michael H. Babiak, Vice Chairperson
Ronald R. Runkles, Secretary

Organization Represented:	*Name of Representative:*
Consultant	David Linden
Consultant, U.S. Navy	Albert Himy

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Duracell	S. Keel Kelly Steven Wicelinski (Alt.)
Eastman Kodak Company	James C. DeJager Henry J. Heirigs (Alt.)
Energizer	Terrence N. Telzrow Michael H. Babiak (Alt.) Nate M. Banes (Alt.) Ramesh V. Shah (Alt.)
Koehler-Bright Star, Inc.	Harley B. Kaplan Paul Kish (Alt.)
Photographic & Imaging Association	John Gignac
Rayovac Corp.	David L. Wilberg Mel Hammer (Alt.)
U.S. Navy, Crane Division, Naval Surface Warfare Center	James Gucinski John Inman (Alt.)
Wilson Greatbatch Limited	William D. Clark Paul W. Krehl (Alt.)

The members of Subcommittee C18-5 on Safety Standards who contributed to the development of this standard are:

S. Keel Kelly, Chairperson
Ramesh V. Shah, Vice Chairperson
Ronald R. Runkles, Secretary

Joseph Allen
Michael Babiak
Nate Banes
James DeJager
Norm England
James Gucinski
Mel Hammer
Albert Himy
John Inman
Keel Kelly
Paul Krehl
David Linden
Ramesh Shah
Terrence Telzrow
Steven Wicelinski
David Wilberg

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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 portable, rechargeable cells and batteries to ensure their safe operation under normal use and reasonably foreseeable misuse, and includes information relevant to hazard avoidance.

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 1-1999, *Portable Rechargeable Cells and Batteries-General and Specifications*

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

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

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

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

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

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

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 manufacturers 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.

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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; it's value depends on battery design, state of charge, temperature, and age.

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

4.18 fire: Combustion of cell/battery components with 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 escape of electrolyte 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, induced by the design of the product in combination with, or 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 of the harm.

4.28 safety: Freedom from unacceptable risk of harm.

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

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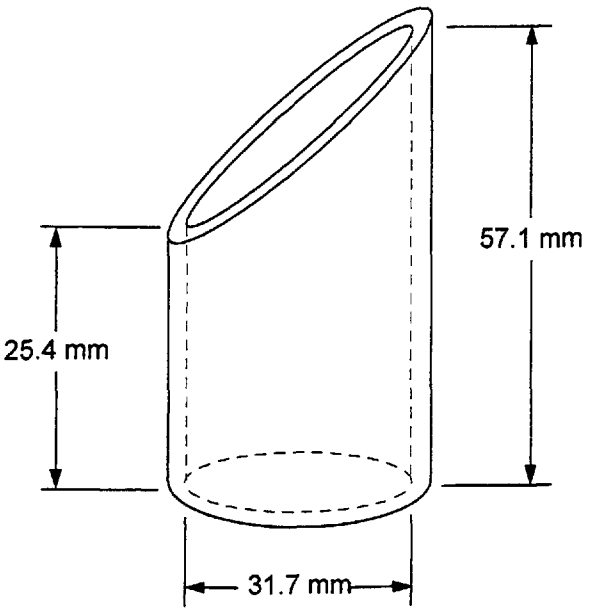


Figure 1 – Small cell or battery gauge (inner dimensions)

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

4.31 voltage, end-of-discharge (EODV): The specified voltage of a cell or battery, when supplying power, at which the discharge is terminated.

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 test required in this document and meeting the stated requirements.

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5.1.2 Insulation and wiring

The insulation 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.

5.1.4 Temperature/current/voltage management

The design of the batteries shall be such that:

a) Abnormal temperature rise conditions are prevented through the use of thermal limitation features which are an integral part of the battery. These features may allow re-use of the battery after activation.

b) For lithium rechargeable systems, rapid internal temperature rise conditions shall be controlled by the immediate and irreversible shut down 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.

5.1.5 Terminals

Terminals shall be clearly marked on the external surface of the battery. 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.

5.1.6 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.

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5.1.7 Electronics

The design of 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 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 not present a hazard when subjected to tests which simulate conditions that they are likely to encounter during reasonably foreseeable misuse.

5.4 Quality

The manufacturer shall prepare a quality plan defining the procedures for the inspection of materials, components, cells, and batteries during the course of manufacture.

6 Sampling for type approval

Table 1 lists the sample sizes and various tests that are to be conducted on the cells and batteries of each electrochemical system.

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Table 1 – Sampling for type approval

	Ni Systems		Lithium Ion			Pb Acid	
	Cells	Batteries	Fresh Cells	Cycled Cells	Batteries	Cells	Batteries
Intended Use							
Vibration	5	-	5	5	5	5	5
Mechanical shock	5	-	5	5	5	5	5
Altitude simulation	-	-	5	5	-	5	-
Thermal shock	5	-	5	5	-	5	-
Misuse							
Free fall	-	3	-	-	3	-	3
Ext. short	5	5	5	5	5	5	5
Crush #1	5	-	5	5	-	5	-
Crush #2	-	5	-	-	5	-	5
Abusive Overcharge	5	5	5	5	5	-	5
Design							
Mold stress	-	3	-	-	3	3	3
Thermal abuse	5	-	5	5	-	5	-
Forced Discharge	5	--	5	5	--	-	--

NOTE—When cells are not available, batteries must be tested.

7 Testing and compliance (verification)

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

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 the drafting of these tests that their execution is undertaken by appropriately qualified and experienced technicians using adequate protection.

7.1 Intended use simulation

7.1.1 Vibration (transport)

Purpose

To simulate conditions normally encountered during regular shipment/ transportation.

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General

Fully charged samples shall be vibration tested at 21 ± 5°C under the following test conditions and the sequence in Table 2. Sample size: n = 5.

Test procedure

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. The frequency shall be varied at the rate of 1 Hertz per minute between the limits of 10 and 55 Hertz. 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).

Step 1: Verify that the measured open circuit voltage is typical of the charged product being tested.

Step 2-4: Apply the vibration specified (above) in the sequence provided in Table 2.

Step 5: Rest battery for one hour.

Requirement: No leakage; no explosion; and no fire.

TABLE 2 – Vibration test sequence

Step	Storage Time	Battery Orientation	Vibration Time	Visual Examination
1	—	—	—	Pre-test
2	—	See note.	90±5 min	—
3	—	See note.	90±5 min	—
4	—	See note.	90±5 min	—
5	1 hr	—	—	Post-test

NOTE—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.

7.1.2 Mechanical shock (transport)

Purpose

To simulate conditions of infrequent, non-repetitive shocks encountered during handling/transportation.

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General

Fully charged samples shall be tested at 21 ± 5°C. Sample size: n = 5.

Test procedure

The sample shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of the sample. 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, the sample is to be accelerated in such a manner that during the initial 3 msec, the minimum average acceleration is 75 G. The peak acceleration shall be between 125 and 175 G.

Requirement: No leakage; no explosion; and no fire.

7.1.3 Altitude simulation (transport)

Purpose

To simulate transportation in an aircraft cargo hold.

General

Fully charged samples shall be tested under low pressure conditions at 21 ± 5°C. Sample size: n = 5.

Test procedure

Samples shall be stored for at least six hours at an absolute pressure of 11.6 ± 0.2 kPa.

Requirement: No leakage; no explosion; and no fire.

7.1.4 Thermal shock

Purpose

To determine the effects on the cell integrity of repeated exposure to high and low temperatures.

General

Fully charged samples shall be temperature cycled according to the following procedure. Sample size: n = 5.

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Test procedure

Step 1: Store cells and batteries for at least 48 hours at a temperature of 75°C.

Step 2: Follow immediately by storing for at least six hours at a temperature of -20°C.

Step 3: Follow immediately by storing for at least 24 hours at room temperature.

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

Requirement: No leakage; no explosion; and no fire.

7.2 Reasonable foreseeable misuse

7.2.1 Free fall

Purpose

To simulate the condition of an inadvertent drop of a battery.

General

Fully charged samples shall be tested at 21 ± 5°C. Sample size: n = 3.

Test procedure

Each sample shall be tested in accordance with IEC 68-2-32 at 21 ± 5°C under the following conditions:

Test Surface:	Concrete
Height of Drop:	1 meter
Number of Drops:	Three

Rest sample for one hour after the final drop prior to requirement examination.

Requirement: No leakage; no explosion; and no fire. The integrity of protective devices shall be maintained. The outer enclosure shall not crack to the extent that any protective devices are exposed.

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7.2.2 External short circuit

Purpose

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

General

Fully charged samples shall be stabilized at each of two test temperatures, 21 ± 5°C and at 55 ± 2°C, and short-circuit tested. Sample size: n = 5 per temperature.

Test procedure

Each test sample shall be short-circuited by remotely connecting the positive and negative terminals of the cell or battery. The total external resistance shall be less than 100 mΩ. The sample shall remain on test for 24 hours or until the case temperature declines by 20% of the temperature rise.

Requirement: No explosion and no fire.

7.2.3 Crush (test #1)–cells

Purpose

To simulate the condition of disposal in a waste compactor.

General

Fully charged samples shall be crush tested at 21° ± 5°C. Sample size: n = 5.

Test procedure

Fully charged samples are to be crushed with a force of approximately 13 kN between two flat surfaces covering the total surface of the sample. Once maximum pressure has been reached, it is to be released.

A cylindrical or prismatic cell is to be crushed with its longitudinal axis parallel to the flat surface of the crushing apparatus. A prismatic cell is also to be rotated 90 degrees around its longitudinal axis so that both the wide and narrow sides will be subjected to the crushing force. Each sample cell is to be subjected to a crushing force in only one direction. Separate samples are to be used for each test.

Requirement: No explosion and no fire.

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7.2.4 Crush (test #2)

Purpose

To simulate the condition of a moderate crushing force on a battery.

General

Fully charged test samples shall be exposed to a moderate crushing force at 21 ± 5°C. Apply a weight of 114 ± 2 kg across the total test surface of the battery. Sample size: n = 5.

Test procedure

Place the battery between two parallel flat maple (or equivalent) blocks, 12.7 mm or thicker. Gradually increase the force and hold at the above stated value for one minute.

Requirement: No fire and no explosion. The integrity of protective devices shall be maintained. The outer enclosure shall not crack to the extent that any protective devices are exposed.

7.2.5 Abusive overcharge

Purpose

To simulate a cell or battery under charge, either (1) in a charger that was not designed for that battery, or (2) where a fault has occurred in the charger and it is not limiting the charge current as intended.

General

Samples which have been stored for at least 7 days since being charged (partial or fully) shall be tested at 21 ± 5°C. Sample size: n = 5.

Test procedure

Samples are subjected to a constant charging current of 2.0 times the recommended charging current or maximum of 2.0 times C_5 rate. A thermocouple is to be attached to each test sample. The sample shall remain on test for either one hour, until the temperature of the outer casing reaches a steady state, or until the temperature begins to decline.

Requirement: No explosion and no fire.

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7.3 Design considerations

7.3.1 Mold stress

Purpose

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

General

Fully charged batteries are to be exposed to a moderately high temperature to evaluate enclosure integrity. Sample size: n = 3.

Test procedure

The sample shall be placed in a full draft circulating-air oven maintained at a uniform temperature of 70 ± 2°C. The samples are to remain in the oven for 7 hours, after which they are to be removed and allowed to return to room temperature for examination.

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

7.3.2 Thermal abuse

Purpose

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

General

Fully charged samples shall be evaluated under thermal abuse conditions at 130 ± 2°C. Sample size: n = 5.

Test procedure

The sample shall be placed in a gravity or circulating-air convention oven. Raise the oven temperature at a rate of 5 ± 2°C per minute to a temperature of 130 ± 2°C. The battery shall remain at this temperature for 30 minutes before the test is discontinued.

Requirement: No explosion and no fire.

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7.3.3 Forced discharge

Purpose

To simulate either (1) a cell in a multicell installation where the state of charge for the individual cells is not balanced, or (2) a battery that is installed backwards in a charger.

General

The number of charged cells to be connected in series with the discharged cell is seven. Five samples are to be tested at 21 ± 5°C.

Test procedure

Once the discharged cell is connected in series with seven charged cells, the resultant assembly is discharged using a resistance that simulates the intended application (the resistance value is to be recommended by the manufacturer). The test shall continue until a failure occurs or the outer case temperature declines by 20% of the temperature rise.

Requirement: No explosion and no fire.

8 Information For Safety

8.1 General

When used correctly, secondary 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.

8.2 Specific

8.2.1 Cells or batteries shall not be disassembled, opened, or shredded.

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

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

8.2.4 Never subject cells or batteries to heat or dispose of in a fire.

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

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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. Contact the National Capitol Poison Control Center at 202-625-3333 (Collect).

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

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

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

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.

9.6 Remove the cell or battery from the charger or alternating current adapter 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.

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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
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) 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 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), and (h) 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 2.2.

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