STD.NEMA C18.1M PART 2-ENGL 1999 ■ 6470247 0518612 264 ■

ERICAN NATIONAL STANDARD

American National Standard

ANSI C18.1M, Part 2-1999

American National Standard

For
Portable Primary Cells
and Batteries with
Aqueous Electrolyte—
Safety Standard

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ANSI ®
C18.1M, Part 2-1999
Revision of
ANSI C18.1M-1994

American National Standard For Portable Primary Cells and Batteries With Aqueous Electrolyte— Safety Standard

National Electrical Manufacturers Association

Approved March 11, 1999

American National Standards Institute

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Published by

National Electrical Manufacturers Association
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Foreword (This Foreword is not part of American National Standard C18.1M, 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 (currently the National Institute of Standards and Testing) 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. This Committee, C18, representing battery users, manufacturers, and government agencies, has remained active since that time. Committee C18 prepared ANSI Standard C18.1M-1994 upon which this document is based under the sponsorship of the National Electrical Manufacturers Association (NEMA).

This revision has been created in parallel with the International Electrotechnical Commission (IEC) project to develop a product safety standard for primary batteries with aqueous electrolyte (future IEC Publication 60086-5).

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:

Terrence Telzrow, Chairman
Michael Babiak, Vice-Chairman
Ronald Runkles, Secretary

Organization Represented	*Name of Representative*
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Consultant, U.S. Navy	Albert Himy
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Ramesh Shah, Vice-chair
Ronald Runkles, Secretary

Michael Babiak
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Terrence Telzrow
Steven Wicelinski
David Wilberg

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American National Standard For Portable Primary Cells and Batteries With Aqueous Electrolyte—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 primary batteries with aqueous electrolyte 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 button 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 performance requirements for portable primary batteries with aqueous electrolyte and zinc anode (non-lithium) 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 C18.1M, Part 1-1999, *For Portable Primary Cells and Batteries with Aqueous Electrolyte—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, button: Small round battery, where the overall height is less than the diameter.

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

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

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

4.6 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.

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

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

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

4.10 hazard: A potential source of harm.

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

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

4.13 nominal voltage: A suitable approximate value used for the designation or identification of the voltage of a cell or battery.

4.14 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.

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

4.16 safety: Freedom from unacceptable risk of harm.

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

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

4.19 voltage, closed circuit (CCV): The voltage of a battery when external current is flowing.

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

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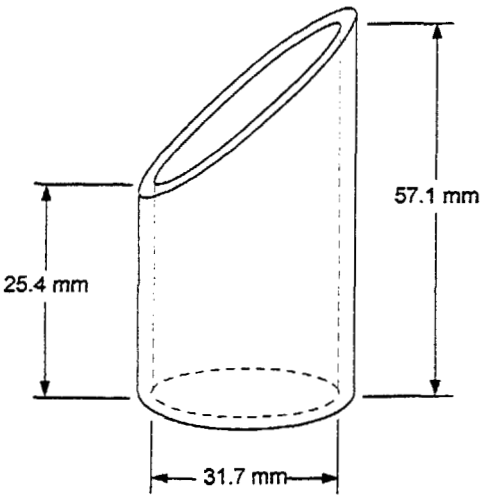


Figure 1 – Small cell or battery gauge (inner dimensions)

5 Requirements for safety

5.1 Design

5.1.1 General

Cells and batteries shall be so designed and constructed that they are safe under conditions of normal (intended) use. When discharged on an application test in accordance with ANSI C18.1M, Part 1, there shall be no evidence of leakage, venting, fire, or explosion.

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

5.1.2 Battery case

The casing of a battery shall be of a material and form which satisfies the mold stress test given in 7.3.3.

5.1.3 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).

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5.1.4 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 encapsulant 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.

5.1.5 Attitude (orientation)

Batteries shall be so designed that, when used in any attitude, they do not leak, vent, catch fire, or explode.

5.1.6 Multi-cell molded plastic battery enclosure

For multi-cell batteries with plastic over-cases, the over-case shall be so designed such 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 not present hazards as stated when subjected to the tests in 7.2 of this document.

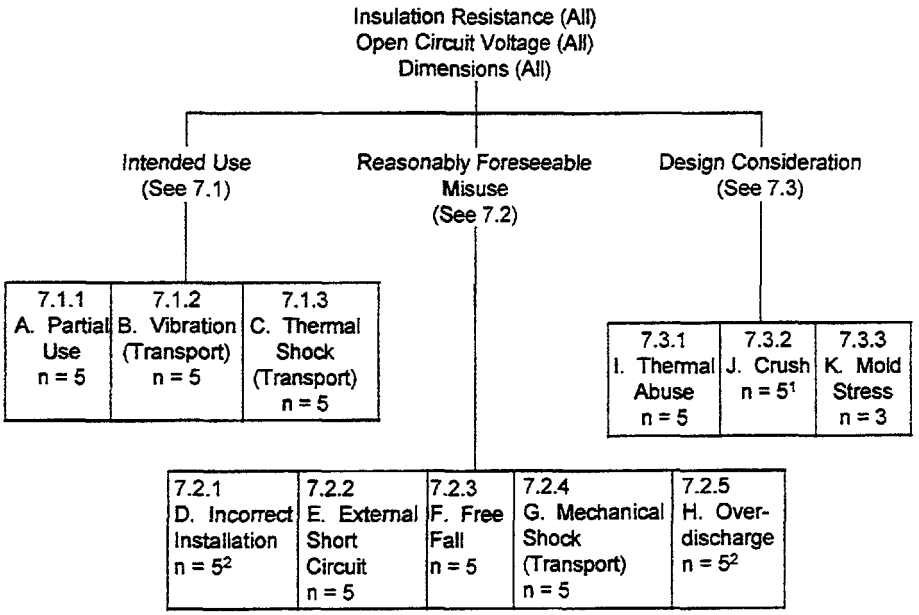
5.4 Quality assurance plan

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

See Figure 2 for the recommended sample sizes (n equals the number of batteries) for the various tests given in this standard.

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NOTES
1. Ten samples are required for prismatic batteries.
2. Plus 15.

Figure 2 – Tests and recommended sample sizes

7 Testing and compliance (verification)

Table 3 at the end of this section summarizes required tests.

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 tests

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

7.1.1 Test A: Partial Use

Purpose

To determine the effects of partial use of batteries.

General

Undischarged batteries shall be tested.

Sample size: *n* = 5.

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Test procedure

Step 1: Discharge batteries in accordance with one of the discharge tests given in ANSI C18.1M, Part 1 until 50% of the minimum average duration capacity has been removed.

Step 2: The batteries shall then be stored at 45° ± 2° C for 30 days.

Requirements

- No leakage;
- No fire; and
- No explosion.

7.1.2 Test B: Vibration (transport)

Purpose

To simulate conditions normally encountered during regular shipment.

General

Undischarged batteries shall be vibration tested at 21° ± 5° C under the test conditions and the sequence in Table 1.

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

Step 2-4: Apply the vibration specified (above) in the sequence provided in Table 1.

Step 5: Rest batteries for one hour prior to examination according to the requirements.

Table 1 – 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.

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Requirements

- No leakage;
- No fire; and
- No explosion.

7.1.3 Test C: Thermal shock (transport)

Purpose

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

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° C.

Step 2: Follow immediately by storing for at least 6 hours at a temperature of -20° C.

Step 3: Follow immediately by storing for at least 24 hours at 21° ± 5° C.

The maximum time between storage at 75° ± 2° C and -20° ± 2° 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 D: Incorrect installation

Purpose

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

General

Five undischarged single-cell test sample batteries of the same brand, type, and origin shall be used.

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The initial closed circuit voltage (10-30 second test) of the battery shall be checked under a rating or an applications condition in accordance with ANSI C18.1M, Part 1 prior to the use of the battery as a test sample. If this initial closed circuit voltage is 10 percent or more below the typical initial closed voltage for that type of battery, the battery cannot be used for this test.

Sample size: $n = 5$ test samples.

NOTE—An additional 15 undischarged batteries similarly meeting the above stated CCV requirement of the same brand, type, and origin as the test sample batteries are required for this test.

Test procedure

Step 1: Place three undischarged and unconditioned batteries in a series with one test sample battery reversed (C1) according to Figure 3.

Step 2: Complete the circuit via the switch (S1) until vent activation or until the temperature of the reversed battery returns to ambient.

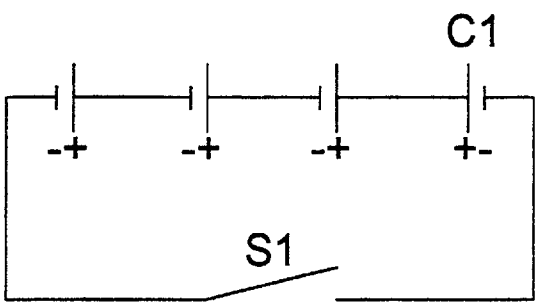


Figure 3 – Circuit for incorrect installation test

Requirements

- No fire; and
- No explosion.

7.2.2 Test E: External short circuit

Purpose

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

General

The test shall be conducted on a battery at a test temperature of 21° ± 5° C. The resistance of the inter-connecting circuitry shall not exceed 0.1Ω.

Sample size: $n = 5$.

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Test procedure

Step 1: 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 as shown in Figure 4.

Step 2: The sample shall remain on test for 24 hours or until the case temperature declines by 20 percent of the temperature rise.

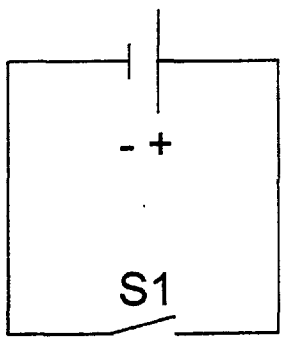


Figure 4 – Circuit for external short circuit test

Requirements

- No fire; and
- No explosion.

7.2.3 Test F: Free fall (user drop)

Purpose

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

General

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

Sample size: $n = 5$.

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Test procedure

Step 1: Drop each undischarged battery one time initially, oriented in each of three mutually perpendicular faces (three total) from a height of 1 meter, onto a concrete surface.

Step 2: Observe the battery for at least one hour after the third and final drop.

Requirements

- No fire; and
- No explosion.

7.2.4 Test G: 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 conditions in Table 2.

Sample size: $n = 5$.

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

Step 2: 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 3: Observe the battery for at least one hour after the third or final shock.

Requirements

- No leakage;
- No fire; and
- No explosion.

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7.2.5 Test H: Overdischarge

Purpose

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

General

Five discharged single-cell test sample batteries of the same brand, type, and origin shall be used.

Sample size: $n = 5$ test samples.

NOTE—An additional 15 undischarged batteries similarly meeting the above stated CCV requirement of the same brand, type, and origin as the test sample batteries are required for this test.

Test procedure

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

Step 2: Connect three undischarged batteries and the discharged test sample battery in series with a resistive load (R1) as shown in Figure 5. The value of the resistance (R1) shall correspond to the lowest test resistance specified for that battery in ANSI C18.1M, Part 1.

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

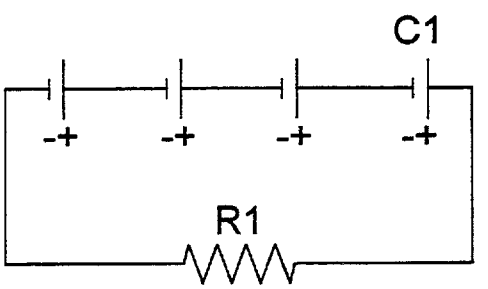


Figure 5 – Circuit for overdischarge test

Requirements

- No fire; and
- No explosion.

7.3 Design consideration tests

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

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7.3.1 Test I: 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 130 ± 2°C.

Step 2: The batteries shall remain at 130 ± 2°C for 10 minutes before the test is discontinued.

Requirements

- No fire; and
- No explosion.

7.3.2 Test J: 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 undischarged batteries at 21 ± 5°C.

Sample size: $n = 5$ (10 for prismatic).

Test procedure

Undischarged batteries 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 battery is to be crushed with its longitudinal axis parallel to the flat surface of the crushing apparatus. A prismatic battery (a separate sample) 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 battery is to be subjected to a crushing force in only one direction. Separate samples are to be used for each test.

Requirements

- No fire; and
- No explosion.

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7.3.3 Test K: 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: $n = 3$.

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 in ANSI C18.1M, Part 1;
- No evidence of mechanical damage (exposure of internal components or leakage of electrolyte).

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Table 3 – Required tests

System letter	Positive electrode	Electrolyte	Negative electrode	Nominal voltage per cell (v)		Applicable tests										
						A	B	C	D	E	F	G	H	I	J	K
C CD, CS D, F	Manganese Dioxide	Ammonium Chloride, Zinc Chloride	Zinc	1.5	R	X	X	X	X	X	X	X	X	X	X	NR
					B	Not applicable										
					P	X	X	X	NR	X	X	X	NR	X	X	X
A AC AP	Manganese Dioxide	Alkali Metal Hydroxide	Zinc	1.5	R	X	X	X	X	X	X	X	X	X	X	NR
					B	X	X	X	NR	X	X	X	NR	X	X	NR
					P	X	X	X	NR	X	X	X	NR	X	X	X
Z ZD	Oxygen (Air)	Alkali Metal Hydroxide	Zinc	1.4	R	Not applicable										
					B	NR	X	X	NR	X	X	X	NR	X	X	NR
					P	NR	X	X	NR	X	X	X	NR	X	X	X
SO SOP	Silver Oxide	Alkali Metal Hydroxide	Zinc	1.5	R	Not applicable										
					B	X	X	X	NR	X	X	X	NR	X	X	NR
					P	X	X	X	NR	X	X	X	NR	X	X	X

R = Round single cell battery
B = Button single cell battery
P = Multi-cell battery
NR = Not required

NOTE—Alkaline and silver oxide button cells or batteries under 250 mAh and zinc air button cells or batteries under 700 mAh are exempted from any testing.

Applicable test references

A—Partial use, 7.1.1
B—Vibration, 7.1.2
C—Thermal shock, 7.1.3
D—Incorrect installation, 7.2.1
E—External short circuit, 7.2.2
F—Free fall (user drop), 7.2.3
G—Mechanical shock, 7.2.4
H—Overdischarge, 7.2.5
I—Thermal abuse, 7.3.1
J—Crush, 7.3.2
K—Mold stress, 7.3.3

8 Information for safety

8.1 When used correctly, primary batteries provide a safe and dependable source of portable power. However, misuse or abuse may result in leakage, fire, or explosion.

8.2 Always take care to install your batteries correctly observing the "+" and "-" marks on the battery and the device.

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.

8.4 Store unused batteries in their original packaging and away from metal objects which may short circuit them.

8.5 Remove discharged batteries from equipment promptly to avoid possible damage from leakage.

8.6 Never dispose of batteries in fire, except under conditions of controlled incineration. (Failure to observe this precaution may result in an explosion.)

8.7 Never attempt to recharge primary batteries as this may cause leakage, fire, or explosion.

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

8.9 Never heat batteries in order to revive them.

8.10 Remember to switch off devices after use.

8.11 Never attempt to disassemble or open batteries as this can lead to electrolyte burns.

8.12 Keep batteries out of the reach of children, especially those batteries fitting within the limits of the truncated cylinder as defined in Figure 1.

8.13 Seek medical advice immediately if a battery has been swallowed.

9 Instructions for use

9.1 Always purchase the correct size and grade of battery most suitable for the intended use.

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

9.3 Clean the battery contacts and also those of the device prior to battery installation.

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

9.5 Remove batteries from equipment which is not to be used for an extended period of time.

9.6 Remove used batteries promptly.

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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—except carbon zinc
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 (when applicable)
h) Caution for ingestion (small batteries only)

10.2 Small size batteries

When this subclause is invoked on the individual specifications 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
(informative)

Guidance for device designers

A.1 Design compartments so that batteries are easily inserted and do not fall out.

A.2 Design compartments to prevent easy access to the batteries by young children.

A.3 Consider the battery dimensions and tolerance as specified in ANSI C18.1 when designing the battery compartment.

A.4 Clearly indicate the type of battery to use, the correct polarity alignment, and directions for insertion.

A.5 To overcome the problems associated with the reversed placement of a battery, consideration should be given at the design stage to ensure that batteries cannot be installed incorrectly or, if so installed, will not make electrical contact.

A.6 Some suggestions for battery compartments utilizing cylindrical cells are illustrated in Figures 6-8 below. Provision should also be made to prevent unnecessary movement of batteries within the battery compartment.

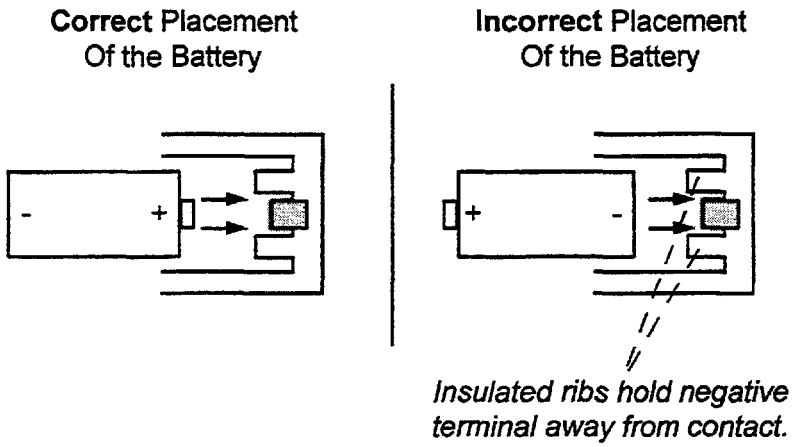


Figure 6 – Positive contact, contact recessed between ribs

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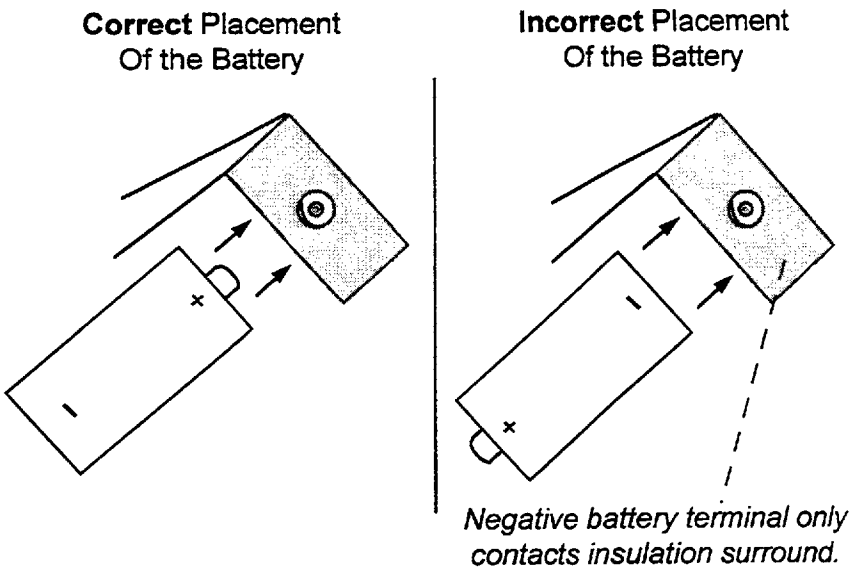


Figure 7 – Positive contact, recessed aperture

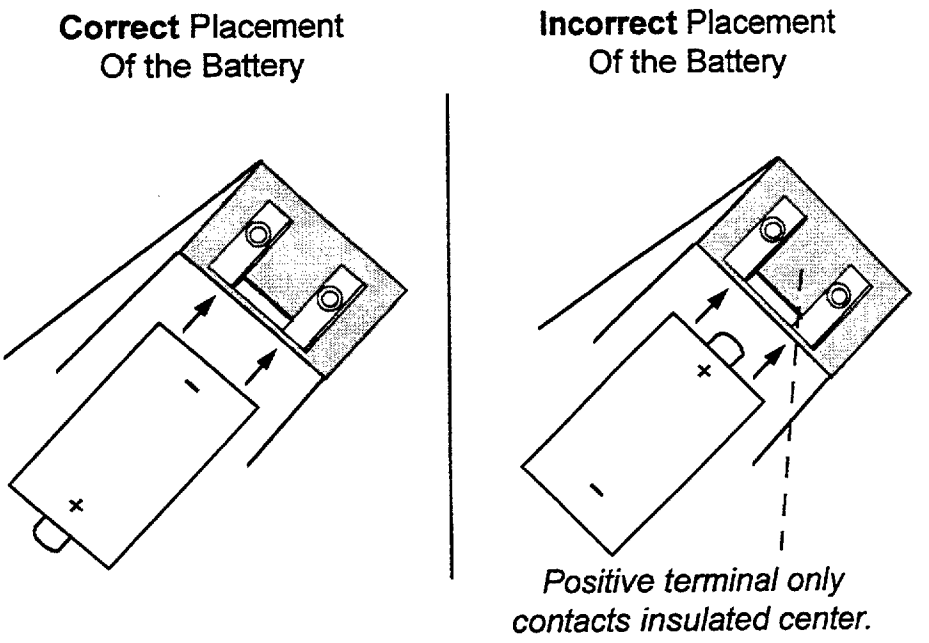


Figure 8 – Negative contact, contact is "U" shaped

A.7 Battery compartment dimensions **should not** be tied to dimensions and tolerances of a particular manufacturer, as this may create problems if replacements of different origin are installed.

A.8 For dimensional details, particularly those related to the positive and negative terminals, reference should be made to the relevant battery specification sheets contained in ANSI C18.1M, Part 1.

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A.9 Only the battery terminals should physically contact the electrical circuit.

A.10 Battery compartments should be electrically and physically isolated from the electrical circuit and positioned so as to minimize possible damage, and/or risk of injury.

A.11 Provide protective devices to ensure battery isolation from alternative power sources.

A.12 In case of using backup power source, use protective devices to ensure safety from accidental battery charging. Selection of protective devices should be performed with the recommendation of the battery manufacturer.

A.13 Positive (+) and negative (-) battery contacts should be visibly different in form to avoid confusion when inserting batteries.

A.14 Select device contact materials with the lowest electrical resistance and that are compatible with battery contacts.

A.15 Battery compartment should be designed to allow the gas generated from batteries to escape.

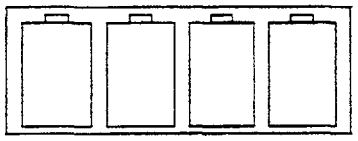
A.16 The material of battery compartment should be selected to avoid shock and environmental pollution.

A.17 Equipment designed to be powered by air-depolarized batteries should provide for adequate air access.

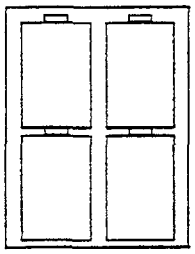
A.18 Series parallel and parallel connections are not recommended since a wrongly placed battery causes continuous discharge of the batteries.

A.19 To overcome reversed placement described above and with the end-user in mind, consideration should be given to a consistent orientation through the battery compartment arrangement as given in Figure 9(a) and (b).

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(a) 

In this arrangement, polarity protection of positive compartment contacts is necessary as shown in Figures 6 and 7.

(b) 

In this arrangement, polarity protection of positive and negative compartment contacts is necessary as shown in Figures 6 or 7 and 8.

Figure 9 – Recommended physical arrangement of a battery compartment

A.20 In waterproof and non-vented devices, it is important that hydrogen gas generated by the batteries during use is either adsorbed or allowed to escape, otherwise a spark could ignite the entrapped hydrogen/air mixture. The advice of the manufacturer should be sought at the design stage of such applications.

A.21 In order to avoid the possibility of short circuits, it is essential that no part of the equipment circuitry, (including conductive rivets or screws used to secure the battery contacts, etc.) is allowed to contact the battery case / jacket.

A.22 Recognizing that there are non-standardized batteries available, in conventional cylindrical sizes (e.g., ANSI 13, 14, 15) with voltages typically in the three volt region, equipment designers are strongly advised to select and recommend for replacement only those batteries contained in ANSI C18.1M, Part 1.

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Annex B
(informative)

Guidance for packaging, handling, and transportation

B.1 Introduction

The greatest satisfaction to the user of primary batteries results from a combination of good practices during manufacture, distribution, and use. The purpose of this code is to describe these good practices in general terms and, more specifically, to warn against procedures known from experience to be harmful. It takes the form of advice to battery manufacturers, distributors, and users, and to equipment designers.

B.2 Packing

The packing should be adequate to avoid mechanical damage during transport, handling, and stacking. The materials and pack design should be chosen so as to prevent the development of unintentional electrical conduction, corrosion of the terminals, and ingress of moisture.

B.3 Transport and handling

Shock and vibration should be kept to a minimum. For instance, boxes should not be thrown off trucks, slammed into position or piled so high as to overload battery containers below. Protection from inclement weather should be provided.

B.4 Storage and stock rotation

B.4.1 For normal storage, the temperature should be between +10°C and +25°C (+50°F and +77°F) and never exceed +30°C (+86°F). Extremes of humidity (over 95% and below 40% relative humidity) for sustained periods should be avoided since they are detrimental to both batteries and packing. Therefore, batteries should not be stored next to radiators or boilers, in box cars or direct sunlight, or next to other sources of heat.

B.4.2 Although the storage life of batteries at room temperature is good, storage is improved at lower temperatures provided that special precautions are taken. The batteries should be enclosed in special protective packing (such as sealed plastic bags or variants) which should be retained to protect them from condensation during the time they are warming to ambient temperature. Accelerated warming is harmful.

B.4.3 Batteries may be stored fitted in equipment or packages if determined suitable by the battery manufacturer.

B.4.4 The height to which batteries may be stacked is clearly dependent on the strength of the pack.

B.4.5 The above recommendations are equally valid for storage conditions during prolonged transit. Thus, batteries should be stored away from ship engines and not left for long periods in unventilated metal box cars (containers) during summer.

B.4.6 Batteries should be shipped promptly after manufacture and in rotation to distribution centers and on to the users. In order that stock rotation (first-in, first-out) can be practiced, storage areas and displays should be properly designed and packs adequately marked.

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B.5 Display at sales points

B.5.1 When batteries are unpacked, care should be taken to avoid physical damage and electrical contact. For example, they should not be jumbled together.

B.5.2 Batteries should not be displayed in windows exposed to direct sunlight.

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Annex C
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