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AMERICAN NATIONAL STANDARD

American National Standard

ANSI C18.2M-1997

AMERICAN NATIONAL STANDARD

FOR BATTERIES— SEALED RECHARGEABLE (SECONDARY) NICKEL-CADMIUM CYLINDRICAL BARE CELLS AND JACKETED BATTERIES

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ANSI C18.2M-1997
Revision of
ANSI C18.2M-1991

AMERICAN NATIONAL STANDARD

for Batteries—

Sealed Rechargeable (Secondary) Nickel-Cadmium Cylindrical Bare Cells and Jacketed Batteries

Secretariat:

National Electrical Manufacturers Association

Approved May 28, 1997

American National Standards Institute, Inc.

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Foreword (This foreword is not part of American National Standard C18.2M-1997.)

This standard is a revision of American National Standard for Batteries - Sealed Rechargeable Nickel-Cadmium Cylindrical Bare Cells, ANSI C18.2-1991.

This revised standard includes nomenclature and dimensional specifications for nickel-cadmium jacketed batteries, as well as a revised table of dimensional designations for rechargeable single bare cells.

Suggestions for the improvement of this standard will be welcome. They should be sent to the National Electrical Manufacturers Association,1300 North 17th Street, Suite 1847, Rosslyn, VA 22209, attn.: Secretary, C18 Committee.

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee on Specifications for 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:*
Bright Star Industries, Inc.	Lee Kirwan
Consultant, Duracell Inc.	David Linden
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National Association of Photographic Manufacturers	John Gignac
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The C18.2 Subcommittee for Sealed Rechargeable Nickel-Cadmium Batteries, which developed this standard, had the following members:

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AMERICAN NATIONAL STANDARD **ANSI C18.2M-1997**

for Batteries—

Sealed Rechargeable (Secondary) Nickel-Cadmium Cylindrical Bare Cells and Jacketed Batteries

1 Scope

This standard for cylindrical bare cells and jacketed batteries includes nomenclature, definitions, theory of operation, dimensions, safety, reliability, tests, user guidelines, and performance for sealed rechargeable nickel-cadmium batteries.

The tests specified are designed to evaluate the performance of batteries as defined in this standard. The batteries listed, although not intended to be all-inclusive, do represent most of those available to the user, and therefore merit consideration in future designs of equipment.

2 Normative references

The following publication contains provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the edition indicated was 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 edition of the publication indicated below.

Battery Cross-Reference Guide. Chicago: 1990; National Electronic Distributors Association[1]

3 Definitions

In this standard the following definitions shall apply:

3.1 battery: One or more electrically connected cells assembled in a single container having terminals.

3.2 capacity: The electrical output, expressed in ampere-hours (Ah), obtained from discharging a cell at a specific current and temperature, to a specified end-of-discharge voltage. Capacity is the integral, with respect to time, of the value of current during the discharge period.

3.3 capacity, rated (C_1): The capacity that is stated by the manufacturer as the minimum to be expected in the last three of the first five successive cycles, in accordance with the conditions specified in 12.2 of this standard.

The term C_1 used throughout this standard is the manufacturer's rated capacity of the cell at a discharge rate of 1.0 C_1, amperes (1.0 C_1A).

3.4 capacity retention: The capacity remaining after a period of self discharge under open circuit conditions.

[1] Available from the National Electronic Distributors Association, 35 E. Wacker Dr., Suite 3202, Chicago, IL, 60601.

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3.5 cell, bare: Unjacketed cell.

3.6 cell, rechargeable: A reversible electrochemical device that converts chemical energy to electrical energy and vice versa.

3.7 charge and discharge current: The value of current in amperes for the charge or discharge of a cell expressed in multiples of the value C_1, which is the rated capacity of the cell as stated by the manufacturer. For example, 0.1 C_1A designates that the value of the current in amperes is 0.1 times the numerical value of the rated capacity in ampere-hours.

3.8 cylindrical cell: A cell whose height is generally equal to or larger than its diameter.

3.9 effective internal resistance (R_e): The value of resistance within the cell, in milliohms, as measured according to procedures in 12.4. This defines the approximate linear relationship between steady-state discharge and average cell terminal voltage.

3.10 end-of discharge voltage (EODV): The voltage of the cell at the end of discharge. EODV may be specified, as in the case of voltage terminated discharge, or simply measured, as in the case of a time-controlled discharge.

3.11 life cycle performance: The capacity values that are stated by the manufacturer as the minimum to be expected at specific numbers of charge/discharge cycles in accordance with 12.7 of this standard.

3.12 safety vent: A safety mechanism that opens and releases pressure in the cell in a controlled manner at a pressure above the normal operating pressure of the cell, but well below the pressure necessary to rupture or burst the cell container. These mechanisms may be of either the reclosing or nonreclosing type.

3.13 self discharge: The reduction in capacity with storage time as a function of temperature resulting from internal parasitic reactions.

3.14 voltage, rated: The nominal terminal voltage delivered by the cell during discharge. Rated voltage shall be 1.2 volts per cell.

4 Theory of operation

The nickel-cadmium sealed cell is designed so that the electrochemical reactions that occur during charge and discharge can be accomplished repeatedly and are essentially reversible. During charge, the positive electrode becomes fully charged and at this point, is evolving oxygen. The oxygen generated at the positive electrode migrates to the negative electrode and recombines with the cadmium metal. This oxidation of the negative electrode prevents it from becoming fully charged, which in turn prevents hydrogen evolution. The reaction takes place at a rate just sufficient to offset the input charging current, thus resulting in an equilibrium pressure condition during overcharge that is below the safety-vent-opening pressure.

5 Nomenclature

Jacketed batteries are listed by the numbers in the National Electronic Distributors Association (NEDA) *Battery Cross-Reference Guide*. These numbers are used for identification purposes only and do not imply compliance with ANSI Standards unless stated by the manufacturer.

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6 Dimensions

6.1 Bare cells

Sealed cylindrical nickel-cadmium cells shall be designated by the letters KR followed by two groups of figures separated by a solidus, as in Table 1, for example.

The overall height of any individual cell shall be measured inclusive of the specific configuration of the positive terminal. Three standard configurations are available in the industry:

a. the positive terminal projects above the height of the cylindrical case
b. the positive terminal is nominally the same height as the cylindrical case
c. the positive terminal is recessed below the top of the cylindrical case

Table 1 – Sealed nickel-cadmium cylindrical rechargeable bare cells: dimensional designations

Previous Designations	Standard Designations
AAA	KR 103/XXX
N	KR 115/XXX
MP80	KR 126/XXX
1/3-AA	KR 142/XXX
1/2-AA	KR 142/XXX
AA	KR 142/XXX
1/3-Af	KR 160/XXX
2/3-Af	KR 160/XXX
4/5-Af	KR 160/XXX
Af	KR 160/XXX
1/2-C_s	KR 222/XXX
4/5-C_s	KR 222/XXX
C_s	KR 222/XXX
1/2-C	KR 257/XXX
3/5-C	KR 257/XXX
C	KR 257/XXX
C_s-D	KR 334/XXX
1/2-D	KR 334/XXX
D	KR 334/XXX
F	KR 334/XXX
SF	KR 440/XXX

NOTE—The first group of figures in the standard designation indicates the maximum diameter of the bare cell in units of 10^{-4} meters (0.004 inches). The second group of figures (XXX), the values of which should be provided by the manufacturer, indicates the maximum overall height in the same units. The manufacturer should also provide the diameter of the positive terminal and axial dimension of the positive terminal depression, or extension, which is included in the overall dimension.

6.2 Jacketed cells

The jacketed batteries defined in Table 2 are those available to consumers. The dimensions specified are overall height, diameter, and length. Terminals are defined in section 7.

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Table 2 – Nickel-cadmium jacketed batteries

ANSI NEDA	Voltages	Length				Diameter/Width				Height				Terminals
		mm		in		mm		in		mm		in		
		max	min	max	min	max	min	max	min	max	min	max	min	
10013	1.2	---	---	---	---	34.2	32.2	1.346	1.268	61.5	59.5	2.421	2.343	Cap & base
10013HC	1.2	---	---	---	---	34.2	32.2	1.346	1.268	61.5	59.5	2.421	2.343	Cap & base
10014	1.2	---	---	---	---	26.2	24.7	1.031	0.972	50.0	48.5	1.969	1.909	Cap & base
10014HC	1.2	---	---	---	---	26.2	24.7	1.031	0.972	50.0	48.5	1.969	1.909	Cap & base
10015	1.2	---	---	---	---	14.5	13.5	0.571	0.531	50.5	49.0	1.988	1.929	Cap & base
10024	1.2	---	---	---	---	10.5	9.5	0.413	0.374	44.5	42.5	1.752	1.673	Cap & base
10910	1.2	---	---	---	---	12.0	10.7	0.472	0.421	30.2	28.0	1.189	1.102	Cap & base
11604*	7.2	26.5	24.5	1.043	0.965	17.5	15.5	0.689	0.610	48.5	46.5	1.909	1.831	Snap**

* Maximum case height--46.4 mm [1.827 in]
** See Figure 1 for terminal dimensions.

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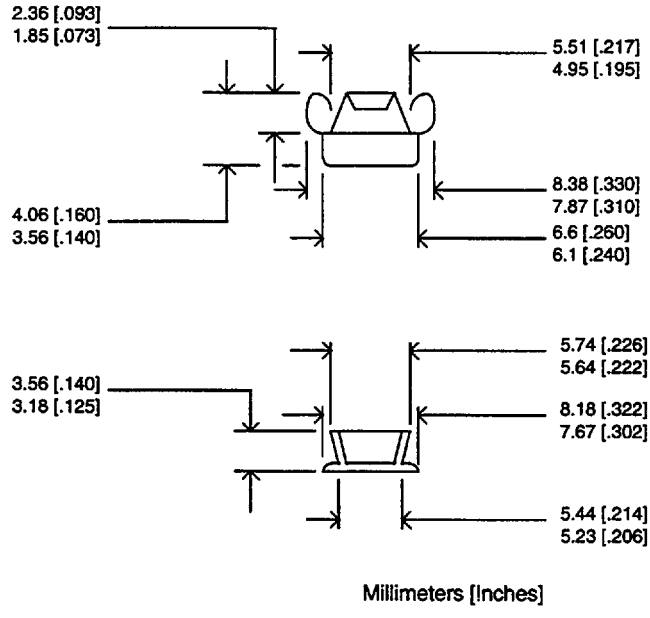


Figure 1 – Snap Terminals—Dimensions

7 Terminals

7.1 Cap and base

This type of terminal is used for batteries that have their dimensions specified according to Table 2, and also those that have the cylindrical side insulated from the terminals. The metal caps on the top and bottom of the battery serve as the terminals.

7.2 Snap

This type of terminal is specified according to Table 2 and consists of a combination comprised of a stud for the positive and a socket for the negative terminal. These shall be made from nickel-plated steel or other suitable material. They shall be designed in such a way as to provide a secure physical and electrical connection when fitted with similar corresponding parts for connection to an electrical circuit.

8 Charging and discharging

Sealed nickel-cadmium cells shall be capable of being charged and overcharged at a constant current. The standard charge and overcharge rate is approximately 0.1 C_1A. Other charge rates may be appropriate if the cells and the charger systems are designed to accommodate these charge rates. For specific capabilities and limitations, consult the manufacturer.

Rated capacity (C_1) of batteries covered in this standard is established at a discharge rate of C_1A and at 21°± 2° C (70°± 4° F) or as otherwise specified. See section 12, "Electrical," for the procedure for evaluating batteries at rates and temperatures not covered by this section.

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9 Materials and workmanship

All materials and workmanship shall be of proven adequacy for the expected life, reliability, and safety of the cell or battery.

10 Safety and reliability guidelines for consumers, and cell and battery manufacturers

NOTE—Safety and reliability of operation of sealed rechargeable nickel-cadmium cells or batteries are enhanced if the cell manufacturer, the original equipment manufacturer (OEM) utilizing these cells, and the end-user follow practices and procedures outlined in this section.

10.1 Measures to be taken by cell manufacturers

Such measures shall be taken by the cell manufacturer as are necessary to ensure the safety of nickel-cadmium cells. These measures include providing cells with:

a. safety vents
b. adequate sealing to prevent electrolyte leakage during normal operation
c. adequate insulation between cell components of opposite polarity to prevent selfshorting.

These and other measures shall also be used to optimize the functional reliability of the nickel-cadmium cell.

10.2 Handling precautions

Notwithstanding the fact that the cells or batteries are provided with certain safety features, it is important that they be used within their design limits as recommended by their manufacturer. Good safety results require the following precautions:

a. Exercise care in handling cells or batteries in order to prevent shorting with conducting materials, such as rings, coins, bracelets, and keys. The cell or battery or the conductor can overheat and cause burns;
b. Do not dispose of in a fire because the cell or battery can burst;
c. Do not open or mutilate a cell. Released electrolyte is corrosive and can cause damage to the eyes or skin. The cell contents can also be hazardous if ingested.

10.3 Equipment design and operational precautions

a. Charging
   1. Charge only cells or batteries identified as "rechargeable."
   2. Charge cells only in accordance with the instructions and limitations specified by the cell manufacturer, particularly for continuous charge or for rapid (high rate) charge controlled by state of charge feedback.
b. Polarity
   1. Insure proper polarity connection of cells or batteries with chargers and devices.
c. Multicell Applications
   1. Use only cells of same design, age, size, capacity rating, and manufacturer.
   2. "Tap" multicell arrangements only with the advice of the cell manufacturer.
d. Battery Compartment and Device Ventilation
   1. A means for gas adsorption or escape from the battery compartment and device shall be provided.

Warning: Failure to comply with these precautions can cause the cell (battery) to overheat, leak, or explode.

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10.4 Reliability

The reliability and life of nickel-cadmium cells or batteries can be enhanced by following the design and operational recommendations in 10.1, 10.2, and 10.3, as well as by:

a. storing between 5° C (41° F) to 25° C (77° F)
b. charging at 21° C (70° F) at a charge rate near 0.1 C_1A
c. avoiding reverse charging or forced over discharging

11 Storage

Cells or batteries are capable of being stored for extended periods of time in any state of charge under suitable conditions. The preferred storage temperature range is 5° C (40° F) to 21° C (70° F). Cells or batteries may be stored at temperatures as low as -40° C (-40° F). Storage at elevated temperatures for prolonged periods will result in rapid self-discharge and can result in separator and seal degradation, which can cause early failure. Repeated temperature shocks and storage at elevated temperatures for prolonged periods of time shall be avoided.

12 Electrical

12.1 General

Section 12 applies to both cells and batteries.

12.1.1 Electrical characteristics

Standard procedures by which the manufacturer's published values for certain electrical characteristics may be confirmed are defined in this standard.
These characteristics are:

a. Rated capacity (C_1)
b. Capacity retention
c. Effective internal resistance (R_e)
d. Discharge rate effect on capacity at -20° C (-4° F)
e. Discharge rate effect on capacity at 21° C (70° F)
f. Life cycle performance
g. Extended overcharge

Values for these characteristics along with Accepted Quality Levels (AQL) may be provided by the manufacturer in standard electrical units or in values that are normalized with respect to C_1.

12.1.2 Control of electrical and environmental variables

In this standard, the accuracy of control or measurement of the electrical and environmental variables, or both, ensures that the actual value, relative to the listed value, is within the following tolerances:

a. Temperature: ± 2° C (4° F)
b. Charge current: ± 5%
c. Voltage: ± 1%
d. Discharge current: ± 1%
e. Time: ± 1%

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12.2 Rated capacity (C_1)

For the purposes of this standard, the sealed cylindrical nickel-cadmium cells are rated by the manufacturer at a discharge rate of 1.0 C_1A. This rated value is designated as C_1. The cell shall be given five stabilizing cycles. The capacity obtained in the last three of the first five successive cycles shall not be less than that stated by the manufacturer as rated capacity (C_1).

The cells shall be charged, discharged, and rested at an ambient temperature of 21° C (70° F). The cells shall be charged at 0.1 C_1A for a period of from 20 to 24 hours, or less if directed by the manufacturer, and rested for a period of from 2 to 4 hours.

The cells shall then be discharged at a constant current of 1.0 C_1A to an EODV of 0.9 volts.

12.3 Capacity retention

The cells, immediately following the 5 cycles of capacity measurement in 12.2, shall be charged in accordance with 12.2. The cells shall then be stored open circuit for a period of t_c days at an ambient temperature, T, and then be discharged in accordance with 12.2. The capacity obtained shall not be less than 37% of that obtained in cycle five of 12.2. Values of t_C should be provided by the cell manufacturer for values of T from 21° C (70° F) to 50°C (122° F). Capacity loss with time is generally expected to be 1% per day or less at 21° C (70° F), and will increase as temperature increases.

12.4 Effective internal resistance (R_e)

The effective R_e shall be measured on the third cycle. The cells shall be fully charged and tested as outlined in 12.2. Cells rated 5 Ah or less shall be discharged at 10.0 C_1A for 2 minutes and then switched to 1.0 C_1A. Cells rated higher than 5 Ah shall be discharged at 5.0 C_1A for 4 minutes and then switched to 1.0 C_1A. The voltage shall be recorded just prior to switching and again upon reaching its maximum value after switching. All voltage measurements shall be made at the terminals of the cell independently of the contacts used to carry current. The effective internal resistance (R_e) shall then be calculated as follows:

$$R_e = \Delta V/\Delta I$$

where:

$\Delta V = V_L - V_H$

and

$\Delta I = I_H - I_L$

I_H and V_H are the current and voltage, respectively, recorded just prior to switching.

I_L and V_L are the current and maximum voltage, respectively, recorded after switching.

The value found shall be within the range given by the manufacturer for the cell.

12.5 Discharge rate effect on capacity at -20° C (-4° F)

The cell shall be charged at 21° C (70° F) in accordance with 12.2 and immediately stored for 24 hours at an ambient temperature of -20° C (-4° F) prior to each discharge. Discharge at an ambient temperature of -20° C (-4° F) at a constant current at each of the following rates to an EODV of 0.8 volts in the sequence shown: 1.0C_1A, 5.0C_1A, 0.2C_1A.

The manufacturer should, for each discharge rate above, supply the value of capacity to be expected as a percent of that obtained in cycle five of 12.2.

Charging at temperatures below the manufacturer's recommendation should be avoided.

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12.6 Discharge rate effect on capacity at 21° C (70° F)

The cell shall be charged and rested in accordance with 12.2 prior to each discharge. Discharge at a constant current at each of the following rates to an EODV of 0.9 volts in the sequence shown: $1.0C_1A$, $5.0C_1A$, $0.2C_1A$.

The manufacturer should, for each discharge rate above, supply the value of capacity to be expected as a percent of that obtained in cycle five of 12.2.

12.7 Life cycle performance

The cell shall be given five stabilizing cycles in accordance with the procedure outlined in 12.2. Life cycling shall then be initiated with all charging, rest, and discharging at an ambient temperature of 21° C (70° F). A cell temperature rise of more than 5° C (41° F) above ambient may require cooling to prevent degradation of performance due to elevated cell temperatures.

12.7.1 Life cycles 1 through 48

a. Charge 11 hours and 20 minutes at 0.1 C_1A.
b. Discharge immediately at 1.0 C_1A for 40 minutes.
c. No rest

12.7.2 Life cycles 49 and 50

a. Charge for 20 hours at 0.1 C_1A
b. Rest 2 to 4 hours
c. Discharge at 1.0 C_1A to 0.9 volts EODV

12.7.3 Repetition of life cycles

Repeat cycles 1 to 50 as desired.

The capacity at cycle 50, and multiples thereof, shall be no lower than that stated for this procedure by the manufacturer.

12.8 Extended overcharge

The ability of a cell to withstand overcharge should be determined by charging the cell at a constant current of 0.1 C_1A, or at the maximum overcharge rate recommended by the manufacturer, at an ambient temperature of 21° C (70° F) for 6 months. The cell shall at no time show either electrolyte leakage or visual evidence of distortion beyond the standard maximum dimensions furnished by the manufacturer. When discharged in accordance with 12.2, the cell shall have a capacity equal to or greater than the extended overcharge capacity as stated by the manufacturer for this procedure.

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