Policy

It is the policy of Rayovac to establish and publish performance standards on all products we ship to customers. It is the responsibility of each manufacturing location to establish documented programs that assure compliance to these standards are achieved and maintained.

Scope

This specification defines the performance requirements for the AA nickel-metal hydride ready to use rechargeable battery providing a rated capacity of 1350 mAh.

Purpose

To specify performance requirements to insure that nickel-metal hydride batteries procured under this specification meet or exceed Rayovac's marketability claims and our customers' expectations.

Reference Documents

Number	Title
ANSI C18.2M, Part 1	Portable Rechargeable Cells and Batteries – General and Specifications
UL 2054, August 2008	Standard for Safety for Household and Commercial Batteries
CEI / IEC 61951-2: 2003	International Standard Secondary Cells and Batteries – Nickel Metal Hydride
JIS C 8708: 2004	Sealed Nickel-Metal Hydride Rechargeable Single Cells
S1000231	Date Coding (HUM)
S1002120	Manufacturer Code
S4000977	Quality Requirements For Duplex PVC/PET Labels
MSDS	Material Safety Data Sheet
	Test Methods for Evaluation of Solid Wastes, SW 846 3rd Edition

1 Ratings

1.1 Ratings After Charge

1.1.1	Nominal Operating Voltage	1.2 volt (discharged at $0.2I_tA$ to 1.0 V at 20 ± 5°C)
1.1.2	Nominal (C_5) Capacity	1350 mAh
1.1.3	Minimum Individual (C_5) Capacity	1256 mAh
1.1.4	Constant Current Charge Methods	Standard: at $0.1I_tA$ for 16 hrs, (1.2) Rapid: at $1I_tA$ to –dv = 3 - 8 mv, (1.3)
1.1.5	Max. Continuous Discharge Current	$2I_tA$ at 21 ± 2°C
1.1.6	Temperature Range of Operation	Charge: 0°C to 45°C at a max RH of 85% Discharge: -10°C to 45°C at a max RH of 85%
1.1.7	Nominal Weight	24 g

1.2 Standard charge

Standard charge is defined as charging at a constant current of $0.1I_tA$ for a16 hour period followed by a 60-minute rest period. The environmental conditions during charge and rest include a temperature range of 20 ± 5°C and a relative humidity range of 50 ± 15%. The I_tA nomenclature used in the document is based on IEC guidelines. The reference I_tA value is defined as $I_tA = C_nAh / 1h$ where:

I_t is the reference test current in amperes
C_n is the rated capacity in ampere-hours
n is the time, based in hours, for which the rated capacity is based, which is 5.

1.3 Rapid Charge

Rapid charge is defined as charging at a constant current of $1I_tA$ to a –dv = 3 - 8 mv cutoff followed by a 30-minute rest period. The environmental conditions for charge and rest are listed in section 1.2.

1.4 Shipping Condition

1.4.1 All batteries shall be shipped (except Latin America) at a state of charge of 75-90% from the factory

1.4.2 All batteries shipped to Latin America are to be shipped at a state of charge of 55-65% from the factory

1.4.3 All batteries shall contain a top external insulator and a full protective label that covers both the insulator and sides of the battery prior to shipment.

1.4.4 All batteries shall be shipped by a method that prevents the battery terminals from shorting against each other, against the shipping container and against other materials that they may reasonably encounter during shipment.

1.4.5 All packaged batteries shall be shipped in a refrigerated container where the temperature inside the container is 20 - 23°C and does not exceed 27ºC.

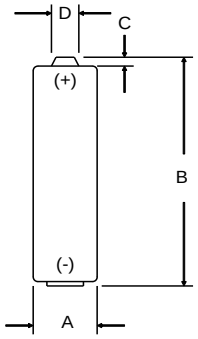
2 Physical Requirements

2.1 Dimensions

The battery shall meet the dimensions in Figure 1.

Figure 1: Dimensions

A	13.5 – 14.5 mm DIA (0.531” - 0.571”)
B	49.5 – 50.5 mm (1.949 – 1.988”)
C	1.0 mm (0.039”) MIN
D	5.5 mm (0.217”) MAX DIA



2.2 Date Coding

Identify manufacture date of battery using Rayovac date coding per Specification S1000231. Preferred location of date code is on jacket of battery although negative terminal is also acceptable. Date code must be printed clearly and legibly on each battery. Other methods of age traceable coding may be acceptable but must be pre-approved by Rayovac Corporate Quality.

2.3 Manufacturer Coding

Identify the manufacturer of the battery using the Rayovac manufacturer coding method per Rayovac Specification S1002120. The preferred location of the manufacturer code is adjacent to the date code on the jacket of the battery although negative terminal is also acceptable. Manufacturer code must be permanent, clear and legible on each battery. Other methods of manufacturer code may be acceptable but must be pre-approved by Rayovac Corporate Quality.

2.4 Visual Inspection

Visual inspection shall be performed to insure that defects are not shipped. Examples of defects include but are not limited to:

- Surface scratches, wrinkles, holes or improper wrap of label
- Smudged or non-registered printing on labels
- Wrong hues (colors) or distorted artwork on label graphics
- Illegible, or missing date code
- Missing external top insulator
- Misshapen cans
- Broken, bent or loose terminals
- External leakage

3 Electrical Requirements

The cells used to determine electrical and battery service life requirements. Charge each cell at $0.1I_tA$ for 16 hours, (section 1.2). Unless otherwise specified, all testing is conducted at a standard temperature of 20 ± 5°C and a standard relative humidity of 50 ± 15%. The measurements are to be taken within 48 hours of the completion of the charge step.

3.1 Open Circuit Voltage (OCV)

Charge at $0.1I_tA$ for 16 hours, (section 1.2), then measure with a voltmeter having a minimum internal resistance of 1MΩ/volt.

Lot Criteria	Minimum Average of 1.365 V
Individual Criteria	Average ± 25 mV

3.2 AC Internal Impedance

Charge at $0.1I_tA$ for 16 hours, (section 1.2), then measure impedance using the 1Khz AC method.

Lot Criteria	Maximum Average of 40 mΩ
Individual Criteria	Average ± 5 mΩ

3.3 Closed Circuit Voltage (CCV)

Apply standard charge, (section 1.2), then measure the CCV after 500 milli-seconds on a load of 3.9 Ω.

Lot Criteria	Minimum Average of 1.34 V
Individual Criteria	Average ± 25 mV

4 Battery Service Life

Perform all testing at 20 ± 5°C unless otherwise specified

4.1 Capacity Testing

4.1.1 Rated (C_5) Capacity

Charge at $0.1I_tA$ for 16 hours, (section 1.2), then discharge at $0.2I_tA$ to a 1.0 end point voltage.

Average Capacity (cycles 3-5): 1350 mAh
Minimum individual capacity (93% of Average Capacity): 1256 mAh

4.1.2 Constant Current (1C/1C) Capacity

Charge at $1I_tA$ to a –dv = 3 - 8 mv cutoff, (section 1.3) then discharge at $1I_tA$ to a 0.9 end point voltage.

Average Capacity (cycles 3-5): 1256 mAh
Minimum individual capacity (cycles 3-5): 1168 mAh

4.1.3 Digital Camera Application Test

Charge at 0.1I_tA for 16 hours, (section 1.2), store according to the durations specified below, then discharge per the following test regime:

Test Regime Step	Duration	EPV
1) Discharge 1500mW	2 Seconds	1.05V
2) Discharge 650mW	28 Seconds	1.05V
3) Run load steps 1 and 2 a total of 10 Times (5 Minutes Total)		
4) Rest	55 Minutes (each hour)	1.05V
5) Repeat steps 1-4 until EPV (1.05V) is reached		

One pulse is defined to be one complete load period (Steps 1 and 2)
Reference: ANSI 18.3 Part 1M-2005, Spec. Sheet 15LF

Storage Conditions and Capacity Requirements:

Storage Time:	Temp.	Minimum Average	Minimum Individual
No Delay	20ºC	270 Pulses	251 Pulses

4.2 Cycle Life Testing: 20°C

Discharge unit initially to establish State of Charge as received. Continue testing following charge, discharge and rest steps as executed, at 20 ± 5°C.

4.2.1 Rated (C_5) Capacity Cycle Life

Discharge: 0.2I_tA to a 1.0 end point voltage (Initial State of Charge) then cycle as follows:
Charge: 0.1I_tA for 16 Hours, (section 1.2)
Rest: 30 minutes between *each* charge and discharge half cycle
Discharge: 0.2I_tA to a 1.0 end point voltage

Minimum average capacity as received:	75% of initial average capacity
Minimum average capacity at cycle 50:	98% of initial average capacity
Minimum average capacity at cycle 100:	90% of initial average capacity
Minimum average capacity at cycle 200:	75% of initial average capacity
Minimum average capacity at cycle 500:	60% of initial average capacity

4.2.2 Consumer Cycle Life

Charge: 1I_tA to a –dv = 3 - 8 mv cutoff, (section 1.3)
Rest: 30 minutes between each charge and discharge half cycle
Discharge: 1I_tA to a 0.90 end point voltage

Minimum average capacity at cycle 100:	90% of initial average capacity
Minimum average capacity at cycle 200:	80% of initial average capacity
Minimum average capacity at cycle 500:	60% of initial average capacity

4.3 Maximum Charge Temperature Using Constant Current Charge Regime

The outer case temperature of the cell measured at 25°C should not exceed 45°C during constant current charge regimes listed in sections 4.1 and 4.2.

4.4 Charge Capacity Retention

Charge: 0.1I_tA for 16 Hours, (section 1.2)
Store: As indicated in table
Discharge: 0.2I_tA to 1.0V end point voltage to determine average

4.5 Requirements:

Storage Temp	Storage Time	Minimum Ave. % Retained vs. Rated Capacity (1.1.2)
20°C	28 days	85%
20°C	91 days	82.5%
20°C	182 days	80%
20°C	365 days	60%
45°C	28 days	60%
45°C	14 days	80%
60°C	7 days	75%

4.6 Discharge Capacity Recovery

Charge: 0.1I_tA for 16 Hours, (section 1.2)
Rest: 60 minutes between charge and discharge half cycles
Discharge: 0.2I_tA to 1.0V end point voltage
Store: As indicated in table
Charge: 0.1I_tA for 16 Hours, (section 1.2)
Rest: 60 minutes between charge and discharge half cycles
Discharge: 0.2I_tA to 1.0V end point voltage
Repeat for 3 cycles and report maximum retained average.

Storage Temp	Storage Time	Recovered vs Rated Capacity (1.1.2)
20°C	28 days	100%
20°C	90 days	98%
45°C	14 days	95%
60°C	7 days	95%

4.7 Standard 0.1I_tA Overcharge at 20°C ± 5°C

Confirm that the cells will withstand overcharge at the 0.1I_tA rate, (section 1.2).
0Rest: Between 1and 4 hr
Discharge: 0.2I_tA to end point voltage of 1.0V

Minimum individual cell capacity: 95% of minimum C_5 capacity, (section 1.1.3)

4.8 Over-discharge at 20°C ± 5°C

Confirm that the cells will withstand constant current over-discharge at the 0.2I_tA rate.
Charge: 0.1I_tA for 16 Hours, (section 1.2)
Discharge: 0.2I_tA for minimum of 10 hrs
Rest: between 1 and 4 hr
Charge: 0.1I_tA for 16 Hours, (section 1.2)
Rest: 60 minutes before discharge
Discharge: 0.2I_tA to end point voltage of 1.0V

Minimum individual cell capacity: 95% of minimum C_5 capacity, (1.1.3)

5 Battery Leakage

All samples must be fully charged using standard charge (section 1.2) prior to leakage testing.

5.1 Thermal Cycle Storage – Leakage

Subject battery to the repeating thermal cycle described. Battery shall not show visible leakage after 4 weeks.
The thermal cycles are as follows:

-30°C ± 2°C (-20°F ± 4°F) 8 hrs ± 0.5 hr.

71°C ±2°C (160°F ± 4°F)	16 hrs ± 0.5 hr.
Transition Times	allow up to 1 hr.
Duration	1 cycle every 24 hr. for 4 weeks

5.2 Room Temperature Storage – Leakage

Store battery at ambient conditions. Battery shall not show visible leakage and must meet requirements of Section 2 after 6 months of storage.

Environment	21°C ± 5°C (70°F ± 9°F)
Duration	6 months

5.3 High Temperature Dry Storage – Leakage

Store battery in a high temperature environment. Battery shall not show visible leakage after 8 weeks.

Environment	71°C ± 2°C (160°F ± 4°F)
Duration	8 weeks

5.4 High Temperature/Humidity Storage – Leakage

Store battery in a high temperature/high humidity environment. Battery shall not show visible leakage after 4 weeks.

Environment	45°C ± 2°C (113°F ± 4°F) 90% ± 4.5% RH
Duration	4 weeks

6 Foreseeable Misuse

Tests described with "UL" listed are based on procedures outlined in UL 2054 Standard for Safety. All testing in section 6 requires that samples be fully charged via standard charge method, (1.2) prior to test. For tests with a "no venting" failure criteria, the cells are to be weighed before and after the testing and the following criteria shall apply:

Mass of cell or battery	Maximum Mass % Loss
Not more than 1 gram	0.5
More than 1.0g but less than 5.0g	0.2
More than 5.0g	0.1

6.1 UL Short Circuit at 20°C (UL-9)

Individually connect the (+) and (-) terminals of each battery through a copper wire having a maximum resistance of 0.1Ω. The sample shall remain on test until the cell case temperature has returned to near ambient temperature.

Failure Criteria: Battery may not explode or catch fire. The external cell case temperature shall not exceed 150°C.

6.2 UL Short Circuit at 55°C (UL-9)

After the units have reached equilibrium at 55 ±2ºC as applicable, individually connect the (+) and (-) terminals of each battery through a copper wire having a maximum resistance of 0.1Ω. The sample shall remain on test until the cell case temperature has returned to near ambient temperature.

Failure Criteria: Battery may not explode or catch fire. The external cell case temperature shall not exceed 150°C.

6.3 UL Projectile Test (UL-22)

Each test sample cell or battery is to be placed on a platform table having a 4-inch (102 mm) diameter hole in the center covered by a screen. The screen is to be constructed of steel wire mesh having 20 openings per inch (25.4 mm) and a wire diameter of 0.017 inch (0.43 mm). An eight-sided covered wire cage, 2 feet (610

mm) across and 1 foot (305 mm) high, made from metal screening is to be placed over the test sample. See Figure 23.1 in the UL2054 procedure document. The metal screening is to be constructed from 0.010 inch (0.25 mm) diameter metal wire with 16-18 wires per inch (25.4 mm) in each direction. The sample is to be placed on the screen covering the hole in the center of the table and is to be heated with a direct flame until it explodes, or until it is destroyed.

Failure Criteria: When subjected to the test described, no part of an exploding cell or battery shall penetrate the wire screen such that some or all of the cell or battery protrudes through the screen.

6.4 UL Shock Test (UL-16)

The cell is to be secured to the testing machine by means of a rigid mount, which supports all mounting surfaces of the cell. Each cell shall be subjected to a total of three shocks of equal magnitude. The shocks are to be applied in each of three mutually perpendicular directions unless it has only two aces normal to the face of the cell. For each shock the cell is to be accelerated in such a manner that during the initial 3 milliseconds the minimum average acceleration is 75 g, (where g is the local acceleration due to gravity). The peak acceleration shall be between 125 and 175 g. Cells shall be tested at a temperature of 20 $\pm$ 2°C

Failure Criteria: The samples shall not explode or catch fire. In addition, the samples shall not vent of leak.

6.5 UL Vibration Test (UL-17)

A battery is subjected to simple harmonic motion with an amplitude of 0.03 inch, (0.8 mm) with a total maximum excursion of 0.06 inch, (1.6 mm). The frequency is to be varied at the rate of 1 hertz per minute between 10 and 55 hertz and return in not less than 90 or more than 100 minutes. The battery is to be tested in three mutually perpendicular directions. For each battery that has only two axes of symmetry, the battery is to be tested perpendicular to each axis.

Failure Criteria: The samples shall not explode or catch fire. In addition, the samples shall not vent or leak.

6.6 UL Heating Test (UL-23)

A charged cell is to be heated in a gravity convection or circulating oven. The temperature of the oven is to be raised at a rate of 5 $\pm$ 2°C per minute to a temperature of 150 $\pm$ 2°C. The oven is to remain for 10 minutes at 150 $\pm$ 2°C before test is discontinued.

Failure Criteria: The samples shall not explode or catch fire.

6.7 UL Abnormal Charge(UL Sect 10)

6.6.1 The battery is to be subjected to a charging current of three times the current Ic, specified by the manufacturer by connecting it in opposition to a dc-power supply. The minimum charging time is to be the time required to reach the manufacturers specified end-of-charge condition plus 7 hours.

The test charging time is to be calculated using the formula:

$T_c = 2.5C / 3(I_c)$

In which:
tc is the charging time in hours,
C is the capacity of the cell/battery in ampere-hours, and
Ic is the maximum charging current, in amperes, specified by the manufacturer

6.6.2 The maximum temperature reached on the exterior of the cell, T_{max}, shall be recorded.

6.6.3 Failure Criteria: The samples shall not explode or catch fire.

6.8 Temperature Cycling Test (UL Sect. 24)

6.8.1 The batteries are to be placed in a test chamber and subjected to the following cycles:

a) Raising the chamber-temperature to 70 ±3°C (158 ±5°F) within 30 minutes and maintaining this temperature for 4 hours.
b) Reducing the chamber temperature to 20 ±3°C (68 ±5°F) within 30 minutes and maintaining this temperature for 2 hours.
c) Reducing the chamber temperature to minus 40 ±3°C (minus 40 ±5°F) within 30 minutes and maintaining this temperature for 4 hours.
d) Raising the chamber temperature to 20 ±3°C (68 ±5°F) within 30 minutes.
e) Repeating the sequence for a further 9 cycles.
f) After the 10th cycle, storing the batteries for a minimum of 24 hours, at a temperature of 20 ±5°C (68 ±9°F) prior to examination.

6.8.2 Failure Criteria: The samples shall not explode, catch fire, vent or leak. In addition, Any mass loss exceeding 0.1% after is considered a failure.

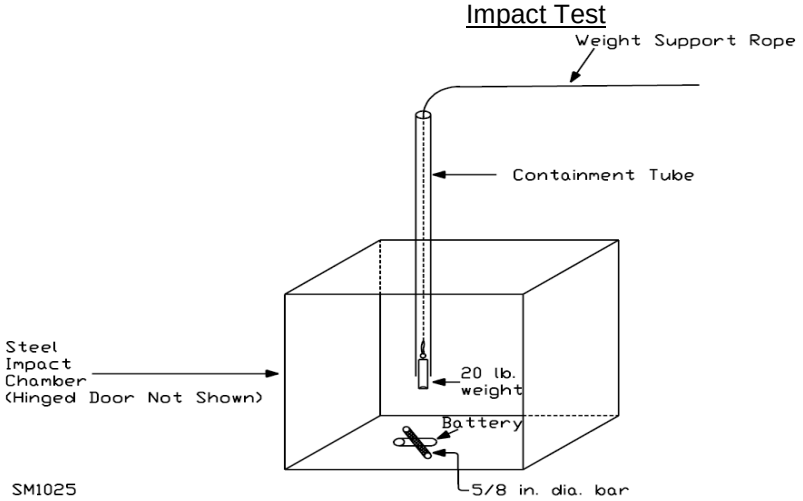
6.9 Impact Test (UL Sect. 15)

6.9.1. Perform x-ray imaging of each pre-conditioned group to determine initial void volume of the batteries inner windings

6.9.2. The battery is to be impacted with its longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the 5/8 inch (15.8 mm) diameter curved surface lying across the center of the test sample.

6.9.3. The testing sequence is to be performed as follows:
6.2.3.1. The test sample battery is to be placed on a flat surface.
6.2.3.2. A 15.8 mm (5/8 inch) diameter bar is placed across the center of the sample.
6.2.3.3. A 9.1 ±0.46 kg (20 ±1 pound) weight is to be dropped from a height of 610 □25 mm (24 ±1 inch) onto the sample.
6.2.3.4. Each sample battery is to be subjected to only a single impact.

Impact Test



6.9.4. Failure Criteria: The sample shall not explode or catch fire.

7 Packaging and Labeling Requirements Labels shall be duplex type per Rayovac Specification S4000977.

7.1 Shrinkage Test

Place a drop of whiteout on the label overlap 1 cm from (+) end of battery. Subject battery to 68°C ± 2°C (154°F ± 3.5°F) for 7 days. Measure the distance between the two halves of the drop of whiteout.

Failure Criteria: Battery may not have any can metal exposed due to label shrinkage. Nominal shrinkage = 1.75 mm (0.070")

7.2 High Temperature/High Humidity Label Test

Subject batteries to 45°C ± 2°C (113°F ± 4°F), 90% relative humidity for one week.

Failure Criteria: No discoloration of printing or distortion of label artwork is allowed.

7.3 Packaging Requirement

Packaging for shipment or sales shall conform to a mutually agreed upon packaging specification.

8 Environmental Requirements

8.1 A Material Safety Data Sheet (MSDS) must be provided. (for US and Canada sale only)

8.2 Heavy Metal Limits

The heavy metal contents of the battery shall conform to all applicable regulations (local, national and international) where batteries are to be sold. For US consumption, these additional requirements apply (ppm limits per weight of battery):

Mercury:	Max 1 ppm
Cadmium:	Max 3 ppm
Lead:	Max 250 ppm
Arsenic:	Max 1 ppm
Barium:	Max 100 ppm
Chromium:	Max 50 ppm
Selenium:	Max 10 ppm

8.3 The supplier shall maintain records of analytical data insuring that contents of batteries produced for Rayovac meet the requirements specified in 8.2 and 8.3.

9 Program Requirements

9.1 Lot Definition

A production lot shall consist of one shipment quantity.

9.2 Sample

Samples for performance testing (and any additional audit testing) shall be collected in a way to equally represent the whole production lot in terms of time of manufacture across all cell assembly lines used to create the production lot.

9.3 Conflicts

If there are conflicts between this document and referenced specifications, statements in this specification shall have precedence.

9.4 Product and Process Changes

9.4.1 If any substantial changes are made that will affect the "fit", "form", or "function" of the battery in a device, the supplier must have Rayovac approval in advance of such changes.

9.4.2 Any product or process changes that could affect conformance to the requirements of this specification will necessitate a retest and certification in advance of shipment to Rayovac U.S.A.

9.4.3 The supplier shall keep records of all substantial changes for at least four years in order to enable tracing of problems throughout the expected lifetime of the product.

9.5 Lot Acceptance

9.5.1 Inspection and testing of each lot including initial qualification testing of batteries is the responsibility of the supplier. Spectrum Brands reserves the right to resample and perform any test listed in this specification. Spectrum Brands results will be the determining factor on all issues of lot acceptance.

9.5.2 Any area of non-conformance will be reviewed with Spectrum Brands Purchasing, Corporate Quality and the supplier. Spectrum Brands will decide final disposition.

9.6 Certificate of Compliance

Each lot shipped to Varta or Rayovac will be supported by a Certificate of Compliance containing the information shown in Attachment 1. Certificate of Compliance submission frequency will be agreed between the supplier and Spectrum Brands Corporate Quality.

Revision History			
A	Initial Release		
Material Group:	SAAA	MSDS Required:	☐ Yes ☐ No

Performance Specification	Memo 22651	Number
	Issue A	S4001818
	Plant	
Title	AA 1350mAh R2U NiMH Performance Specification	

Certificate of Compliance

Date of Shipment		Shipping Order		QA Manager Signature:	
Battery Type		Battery Date Code		Date:	
Part Num./ Spec.		Production Plant		Review the Performance Specification for additional information	

Test Description			Supplier – Actual Results						
		Sample Size	Average	Minimum Individual	Maximum Individual	Standard Deviation	Cpk	Histogram	Line Graph
Dimensional:			**Dimensional:**						
A-Diameter		10						Include	
B-Overall Height		10						Include	
C- + Protrusion Height		10						Include	
D- + Protrusion Diameter		10						include	
Visual:									
-Date / Manufacturer Code		200							
-Number of Defects Identified									
Initial Target:			**Initial Target:**						
-Open Circuit Voltage (OCV)		100%							
-Closed Circuit Voltage (CCV)		65							
-Impedance		100%							
Capacity:			**Capacity:**						
	Section 4.1.1	15							Include
	Section 4.1.2	15							Include
	Section 4.1.3	15							Include
	Section 4.1.4	15							Include
Leakage:			**Leakage:**						
-Section 5	As specified	20							
Safety:			**Safety:**						
-Section 6	As specified	10							
Environmental:									
-Section 8	As specified								