

Application Notes & Product Data Sheet

Primary Batteries— Alkaline, & Heavy Duty

I. General Information

Definition of a Battery

A battery is a portable energy source that is made up of three basic components—an anode, a cathode and an electrolyte.

The anode is the negative portion of the battery, the cathode is the positive portion and the electrolyte is a liquid solution that aids in the flow of energy.

These three components can be made up of many different materials and combined in an almost endless array of sizes and shapes. The choice of materials used, and the quality, grade and density of these materials will play a major role in determining the energy levels and performance of batteries.

II. Chemical Systems and Construction

Primary batteries were first made in the mid-1800's. These early batteries were known as zinc carbons. Zinc carbon technology is still around but it has been updated with purer, quality grade materials and a different electrolyte. This formulation is now called zinc chloride (heavy duty).

Today, many designers choose alkaline manganese batteries. These batteries provide a much higher energy output which is needed for the fast growing demand for portable power.

Rayovac has played an important role in this battery history. Founded in 1906, Rayovac is an international manufacturer and marketer of alkaline, and heavy duty batteries.

Alkaline

Alkaline batteries provide the longest service life for high drain devices. They will last more than twice as long as heavy duty batteries in certain applications. Alkaline batteries get their long life from their unique construction and the purity of the materials used. (Diagram 1)

The alkaline cathode is a mixture of manganese dioxide, graphite, and electrolyte. This mixture is granulated, aged in storage, and then compacted into a pressed cylindrical assembly. This mixture is inserted into a steel can. The steel can and the mixture become the cathode of the alkaline battery. An indentation is made near the top of the can and sealant is placed just above it. These two steps help safeguard the battery against leakage.

Cutaway of an Alkaline Battery

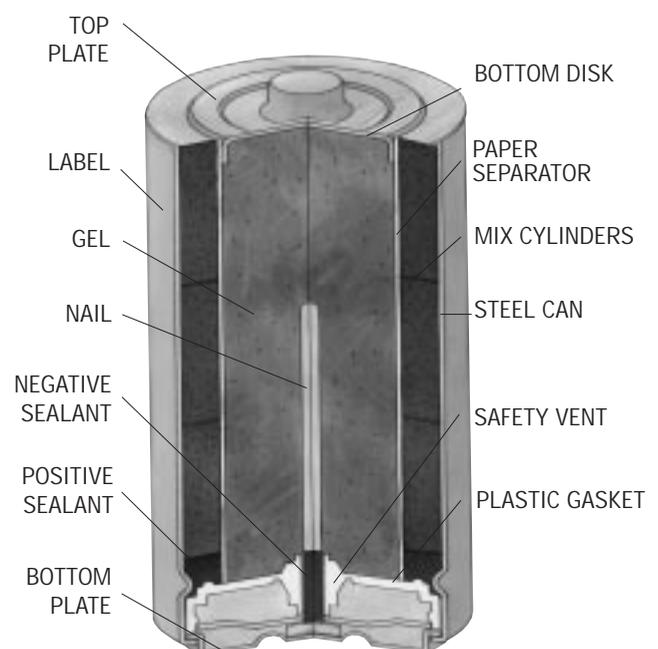


Diagram 1

If the cathode and anode come in contact with each other, a very active chemical reaction would occur. A barrier must be between the two. A paper separator soaked with an electrolyte that promotes ionic or electrolytic conductivity is used as this barrier. The anode portion is a gel made up of zinc powder and several other materials. The anode is then inserted into the steel can against the paper separator.

To insure a long shelf life, the battery must be sealed. The seal is made of a brass nail (which acts as the current collector), a plastic gasket, a steel washer and metal endcap. The four items are preassembled and inserted into the middle of our steel can up against the indentation (which was formed earlier). A top plate is welded to the other end of the can to provide the positive polarity safety feature.

The batteries are then stored, given another voltage test and a decorative, insulating outer label is applied.

Rayovac has further developed the alkaline system and introduced Rechargeable Alkaline™ Batteries. (Refer to OEM Designer's Guide OEM-150)

Zinc Chloride

Heavy duty zinc chloride batteries are the result of technological advances in zinc carbon battery manufacturing.

The type and purity of the mix ingredients is why a zinc chloride battery lasts up to twice as long as the older zinc carbon formulations. (Diagram 2)

A powdery mix serves as the cathode component of the zinc chloride battery. The mix is made of manganese dioxide (the active ingredient), carbon

black (for electrical conductivity and moisture absorption), and zinc chloride electrolyte (which assists the chemical reaction).

Cutaway of a Zinc Chloride Battery

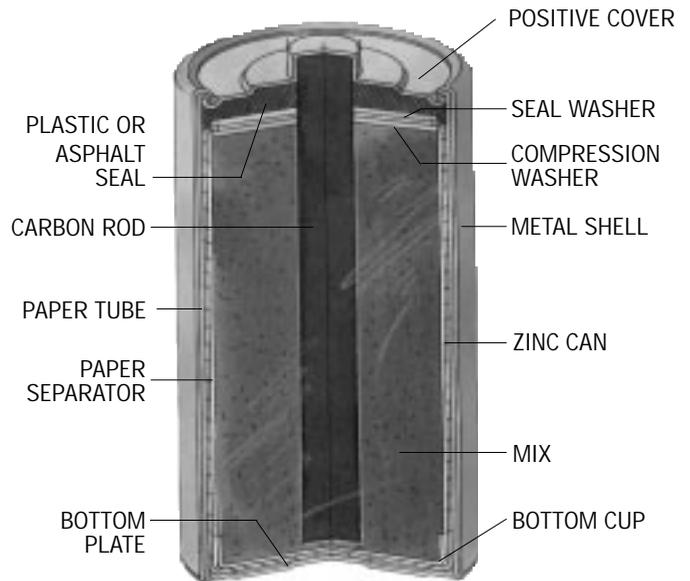


Diagram 2

The anode portion of a zinc chloride battery is a pure zinc can. Besides acting as the anode, the zinc can also serves as a container for the remaining battery components.

A paper separator and bottom cup is used to keep the components from coming in contact with each other.

	Alkaline	Heavy Duty
Chemical System	Alkaline Manganese	Zinc Chloride
Features	Best for high drain applications	Best for medium drain applications
Applications	<ul style="list-style-type: none"> - CD Players - Camera Flash - Calculators - Cassette Players - Flashlights - Toys 	<ul style="list-style-type: none"> - Portable Radios - Smoke Detectors - Calculators - Clocks - Toys - Remote Control Units

Table 1

The mix is then inserted in the can. A compression washer is placed on top and a carbon rod is inserted through the mix. This carbon rod serves as the current collector for the battery and provides the outside contact.

Next, the top of the zinc can is curled inward. The battery is placed inside a paper tube that has a metal bottom plate. A seal washer is placed on top of the carbon rod. Finally this entire assembly is placed inside a protective outer shell.

The paper tube acts as an electrical insulator, keeping the negative and positive ends of the battery from contacting the outside protective shell. The shelled battery is then sealed which keeps the internal components of our battery fresh.

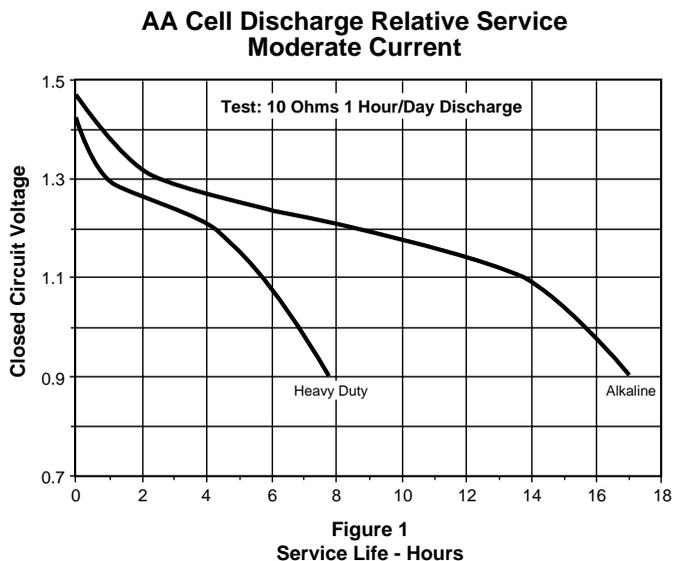
Finally, a metal cap (the positive contact of our battery) is embedded on top of the battery and the metal shell is curled over the cap.

III. Recommended Usage of Chemical Systems

Rayovac offers top performing, quality built alkaline, and heavy duty batteries enabling you to meet every power requirement you have. Table 1 describes the features and applications of these two systems.

The open circuit voltage of fresh cylindrical batteries is approximately 1.55 volts. The closed circuit voltage declines gradually as a function of the depth of discharge; therefore, greater hours of service are obtained as the functional end point is lowered.

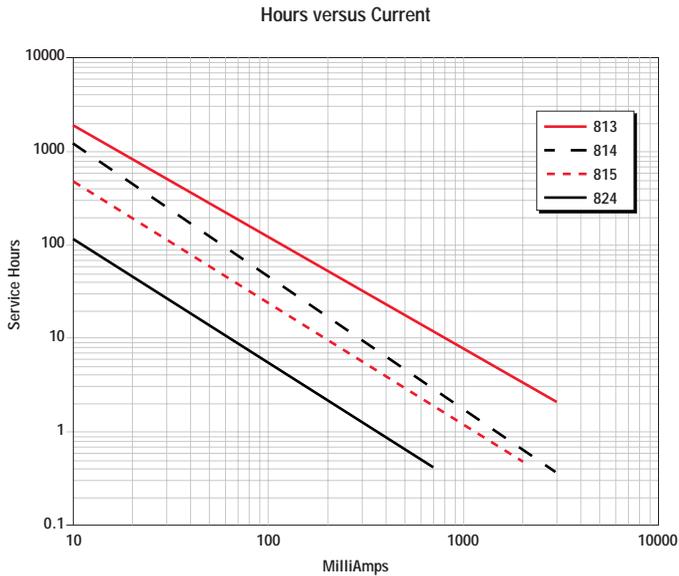
Figure 1 illustrates the typical service life to 0.9 volts of a AA Alkaline and Heavy Duty battery on a cassette player used one hour per day. Figure 2 outlines the number of service hours versus current drain to 0.9 volts.



IV. Technical Data

	Alkaline	Heavy Duty
Nominal Voltage/Cell	1.5 volts	1.5 volts
Maximum Continuous Current	High	Medium
Maximum Pulse Current	High	Medium
Temperature Range	-30°C to 55°C (-20°F to 130°F)	-20°C to 55°C (0°F to 130°F)
Capacity Retention	Greater than 97% after 12 months @ 21°C (70°F) Greater than 85% after 5 years	Greater than 93% after 12 months @ 21°C (70°F) Greater than 85% after 4 years

Table 2



V. Rayovac Batteries and The Environment

All Rayovac batteries, alkaline, and heavy duty, use a no Mercury added formulation. Rayovac alkaline and zinc chloride batteries do not contain Cadmium as an active ingredient.

Rayovac Alkaline and Heavy Duty batteries are recognized by the U.S. Environmental Protection Agency (EPA) as standard, household waste. World-wide regulations vary from country to country. Contact Rayovac's Environmental and Safety Department or the OEM/Technical products group for the latest environmental updates and legislation.

VI. Storage

Batteries depend on internal chemical reactions to produce power. Chemical reactions are accelerated by high temperatures and retarded by low temperatures. Therefore, to minimize power loss during storage, batteries should ideally be stored at a maximum temperature of 77°F (25°C). Refrigerated storage is neither necessary nor recommended.

The following storage procedures should be observed to assure maximum battery power.

1. Rotate inventory stock. Make sure your customer receives the freshest possible product by rotating your stock on a "first in - first out" basis.
2. Avoid storage in high temperature areas. Make sure that batteries are stored away from radiators, hot air vents, motors, and equipment that generates heat. Do not store batteries near windows where sunlight could heat up the batteries.

VII. Handling and Shipping

Batteries are vulnerable to short circuiting if not handled properly. Those battery types which have their "+" and "-" terminations in close proximity to each other are particularly susceptible to short circuiting. Examples of these battery types are the Rayovac A1604, and D1604 batteries. Rayovac packaging engineers design all packaging to assure that Rayovac batteries can be shipped and stored in their original cartons without damage.

To avoid potential short circuit and shipping damage situations:

1. **Always store the batteries in the trays and/or cartons in which they were shipped.**
2. **Whenever possible, re-ship the batteries in their original trays and/or cartons.**
3. **Broken package shipments of Rayovac batteries can be safely made by putting each battery in a sealed plastic bag.**
4. **General precautions:**
 - A. **Never place or dump batteries on conducting surfaces, such as metal tables or shelves.**
 - B. **Never ship batteries in anti-static bags or conductive foam as these materials will short out the battery.**
 - C. **Insulate metal micrometers and calipers with non-conductive tape to avoid short circuiting batteries during dimensional checks.**

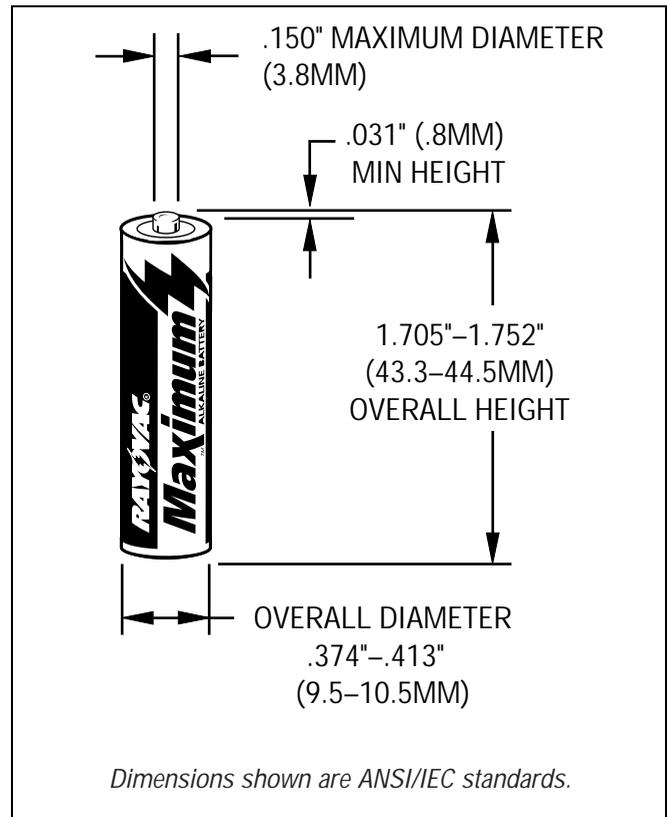
If you have any questions please contact your Rayovac sales representative.

VIII. Dimensional Specifications

A. Alkaline

a. AAA Size Alkaline Battery

Rayovac No.:	824
Nominal Voltage:	1.5 volts
System:	Primary Alkaline
ANSI/NEDA No.:	24A (AAA)
IEC No.:	LR03
Approximate Volume:	0.2 cu. in. (3.3 cu. cm.)
Approximate Weight:	0.4 oz. (11 gm.)
Terminals:	Flashlight
Shell:	Plastic
Environmental:	Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



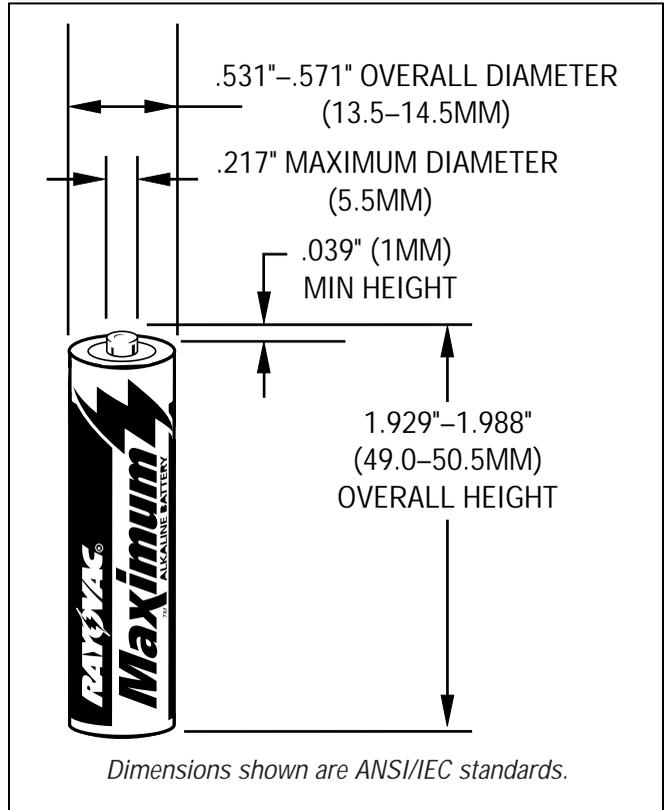
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	75	16	47	54	63	68	1123
Cassette (1 Hr/Day)	10	120	3	6	7	8	958
Cassette (Continuous)	10	120	2	6	7	8	963
Flashlight (4 Min/Hr – 8 Hrs/Day)	5.1	235	1	2	3	4	834
Photo (15 Sec/Min – 24 Hrs/Day)	3.6	333	—	—	—	666	841

Quality Systems Certification:



b. AA Size Alkaline Battery

Rayovac No.: 815
 Nominal Voltage: 1.5 volts
 System: Primary Alkaline
 ANSI/NEDA No.: 15A (AA)
 IEC No.: LR6
 Approximate Volume: .48 cu. in. (7.87 cu. cm.)
 Approximate Weight: 0.8 oz. (22.9 gm.)
 Terminals: Flashlight
 Shell: Plastic
 Environmental: Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



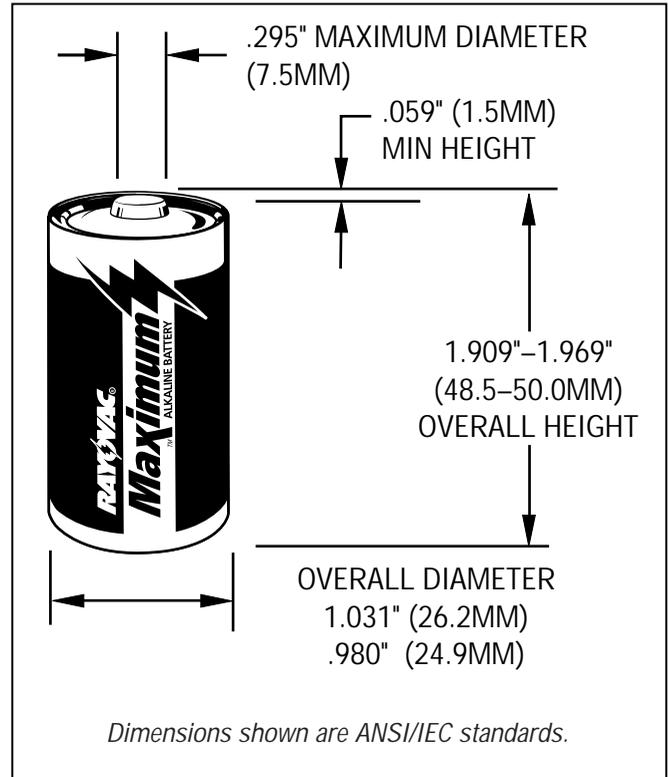
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	43	28	59	69	80	88	2535
Cassette (1 Hr/Day)	10	120	10	14	16	19	2216
Toy/Game (1 Hr/Day)	3.9	308	2	4	6	7	1907
Flashlight (Continuous)	3.9	308	2	4	5	6	1785
Photo (15 Sec/Min – 24 Hrs/Day)	1.8	667	—	—	—	660	1646

Quality Systems Certification:



c. C Size Alkaline Battery

Rayovac No.: 814
 Nominal Voltage: 1.5 volts
 System: Primary Alkaline
 ANSI/NEDA No.: 14A (C)
 IEC No.: LR14
 Approximate Volume: 1.6 cu. in. (26.2 cu. cm.)
 Approximate Weight: 2.5 oz. (70 gm.)
 Terminals: Flashlight
 Shell: Plastic
 Environmental: Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



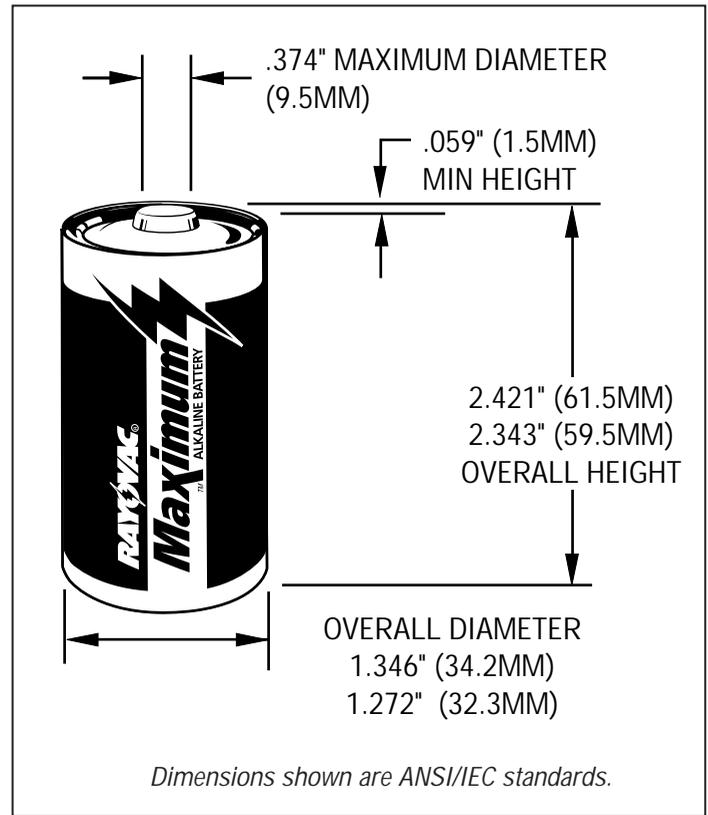
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	20	60	79	96	108	117	7245
Cassette (1 Hr/Day)	6.8	176	18	28	33	36	6365
Flashlight (4 Min/Hr – 8 Hrs/Day)	3.9	308	8	14	19	20	6133
Toy/Game (1 Hr/Day)	3.9	308	7	13	17	20	5822
Flashlight (Continuous)	3.9	308	5	11	16	19	5539

Quality Systems Certification:



d. D Size Alkaline Battery

Rayovac No.: 813
 Nominal Voltage: 1.5 volts
 System: Primary Alkaline
 ANSI/NEDA No.: 13A (D)
 IEC No.: LR20
 Approximate Volume: 3.4 cu. in. (55.7 cu. cm.)
 Approximate Weight: 5.0 oz. (144 gm.)
 Terminals: Flashlight
 Shell: Plastic
 Environmental: Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



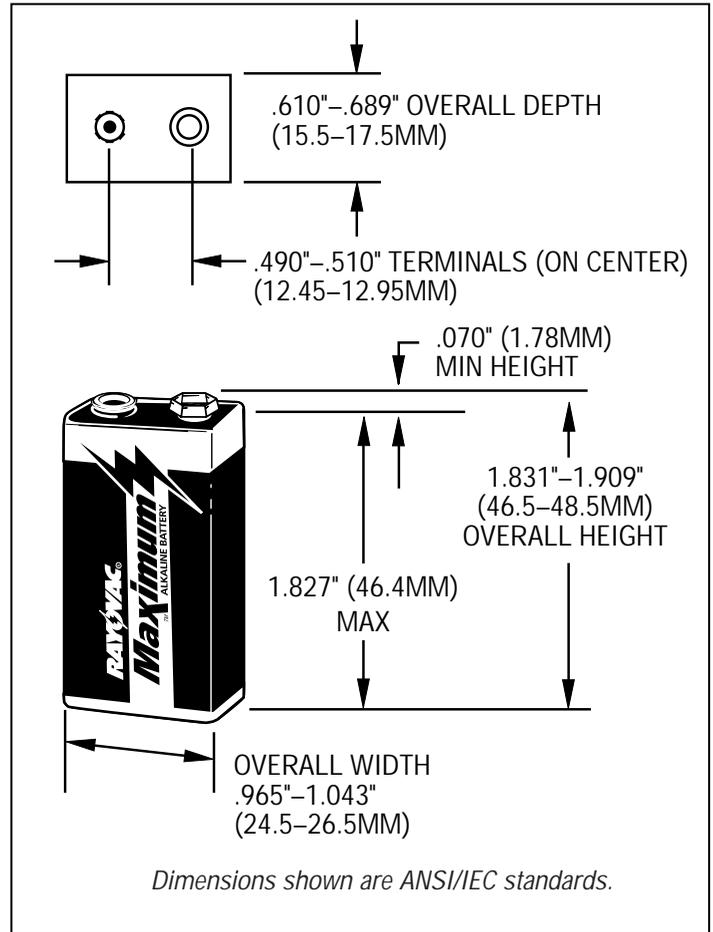
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	10	120	80	101	112	126	15,453
Cassette (1 Hr/Day)	3.9	308	21	32	38	43	13,118
Toy/Game (1 Hr/Day)	2.2	545	6	14	19	22	11,635
Flashlight (4 Min/Hr - 8 Hrs/Day)	2.2	545	9	16	21	24	12,782
Flashlight (Continuous)	2.2	545	6	12	17	21	10,600
Flashlight, K2 Krypton Bulb (4 Min/14 Min - 8 Hrs/Day)	1.5	800	3	7	12	15	10,837

Quality Systems Certification:



e. 9-Volt Alkaline Battery

Rayovac No.: A1604
 Nominal Voltage: 9 volts
 System: Primary Alkaline
 ANSI/NEDA No.: 1604A (9v)
 IEC No.: 6LR61
 Approximate Volume: 1.2 cu. in. (19.7 cu. cm.)
 Approximate Weight: 1.6 oz. (45.4 gm.)
 Terminals: Snap
 Shell: Steel
 Environmental: Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



Application & Duty Cycle	Load (ohms)	Current (mA at 7.2V)	Estimated Average Service At 70°F (Hours)					Approx. mAh Capacity to 4.2V
			Cutoff Voltage					
			7.8V	6.6V	6.0V	5.4V	4.8V	
Low Rate (Continuous)	6000	1	251	424	473	522	531	662
Radio (2 h/d)	620	12	12	39	44	48	52	609
Toy/Game (1 h/d)	270	27	3	16	18	20	22	569
Calculator (30 m/d)	180	40	2	10	12	13	14	551

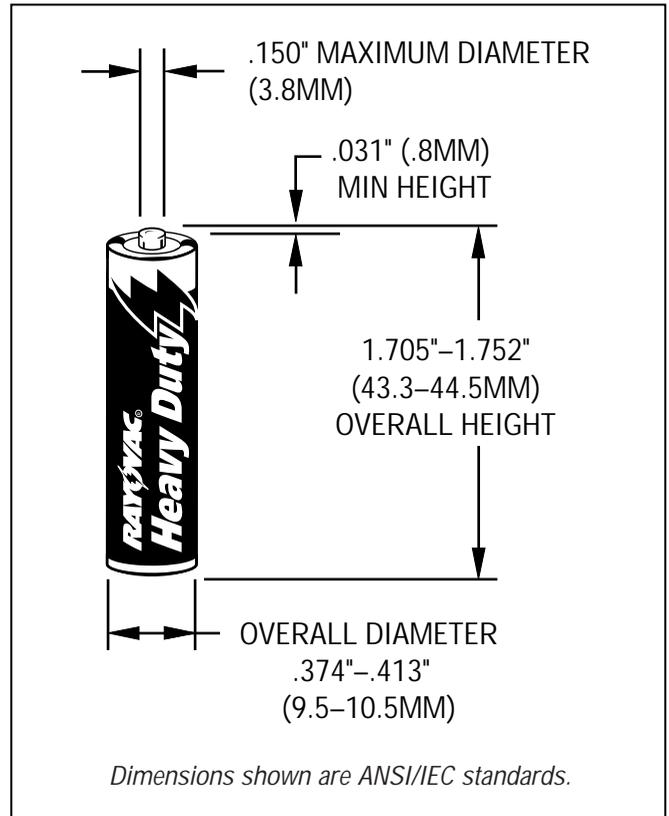
Quality Systems Certification:



B. Heavy Duty

a. AAA Size Heavy Duty Battery

Rayovac No.:	3AAA
Nominal Voltage:	1.5 volts
System:	Zinc Chloride
ANSI/NEDA No.:	24D (AAA)
IEC No.:	R03
Approximate Volume:	.2 cu. in. (3.3 cu. cm.)
Approximate Weight:	3 oz. (9 gm.)
Terminals:	Flashlight
Shell:	Plastic
Environmental:	Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



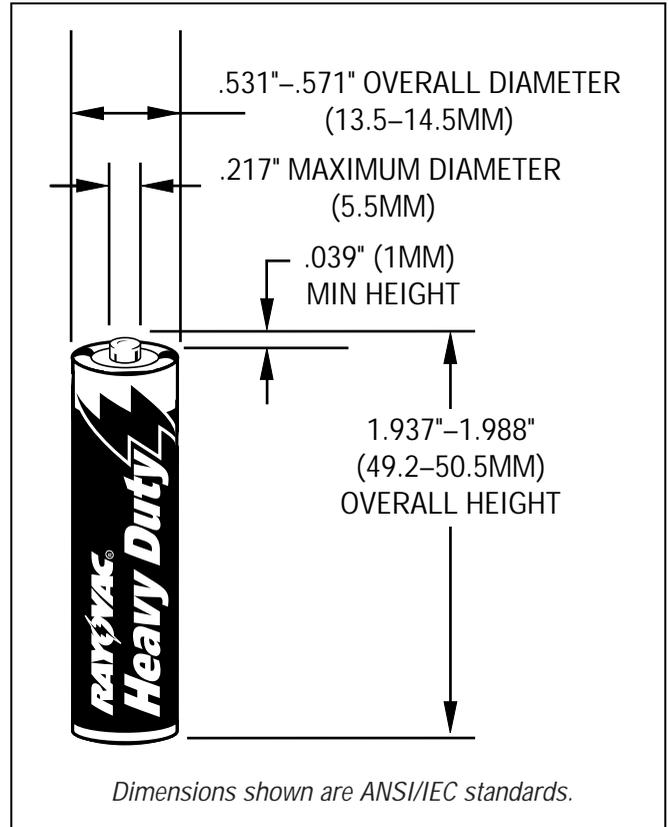
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	75	16	25	29	31	33	550
Cassette (1 Hr/Day)	10	120	0.7	1.7	2.5	2.8	320
Flashlight (4 Min/Hr – 8 Hrs/Day)	5.1	235	0.2	0.7	1.2	1.5	320
Photo (15 Sec/Min - 24 Hr/Day)	3.6	333	—	—	—	210 Pulses	—

Quality Systems Certification:



b. AA Size Heavy Duty Battery

Rayovac No.: 5AA
 Nominal Voltage: 1.5 volts
 System: Zinc Chloride
 ANSI/NEDA No.: 15D (AA)
 IEC No.: R6
 Approximate Volume: 0.48 cu. in. (7.87 cu. cm.)
 Approximate Weight: 0.65 oz. (18.4 gm.)
 Terminals: Flashlight
 Shell: Steel
 Environmental: Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



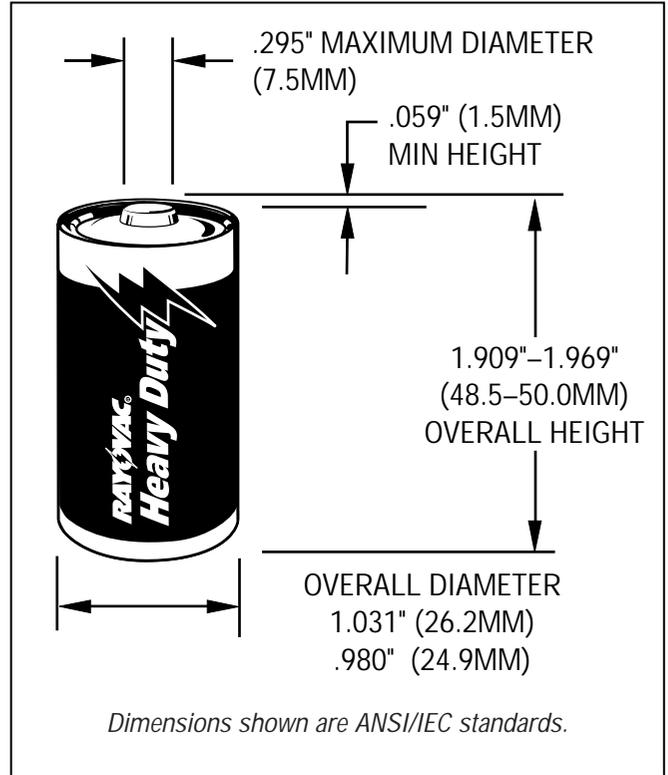
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	43	28	27	33	36	37	1100
Cassette (1 Hr/Day)	10	120	4.2	5.7	6.8	7.7	925
Toy/Game (1 Hr/Day)	3.9	256	0.4	1.1	1.7	2.2	635
Photo (15 Sec/Min – 24 Hrs/Day)	1.8	667	—	—	—	194 Pulses	—

Quality Systems Certification:



c. C Size Heavy Duty Battery

Rayovac No.: 4C
 Nominal Voltage: 1.5 volts
 System: Zinc Chloride
 ANSI/NEDA No.: 14D (C)
 IEC No.: R14
 Approximate Volume: 1.6 cu. in. (26.2 cu. cm.)
 Approximate Weight: 1.5 oz. (50 gm.)
 Terminals: Flashlight
 Shell: Steel
 Environmental: Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



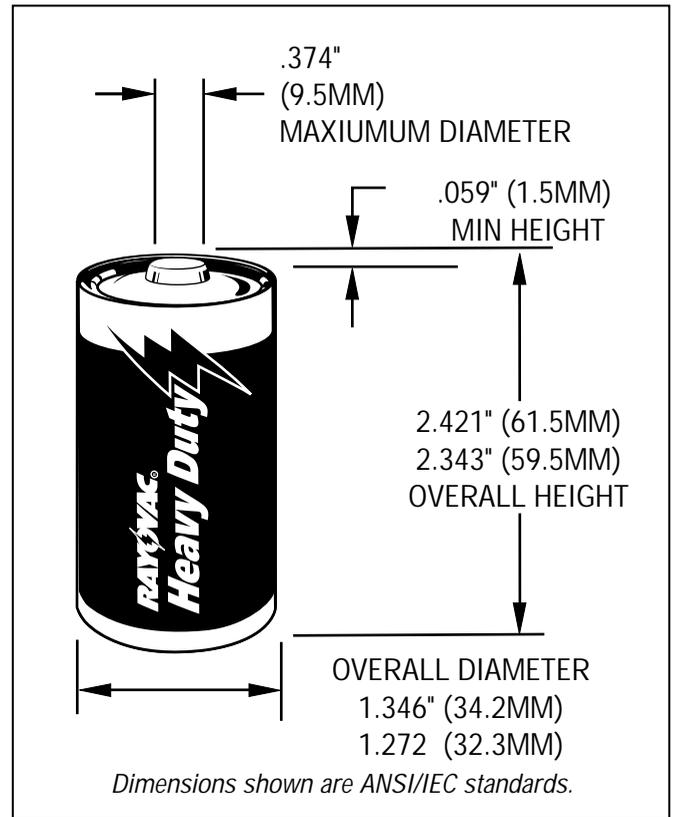
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	20	60	33	40	43	44	2780
Cassette (1 Hr/Day)	6.8	176	6.7	10.9	13.7	14.5	2550
Flashlight (4 Min/Hr – 8 Hrs/Day)	3.9	308	2.4	5.0	7.3	8.2	2400
Toy/Game (1 Hr/Day)	3.9	308	1.7	4.3	6.6	7.8	2230

Quality Systems Certification:



d. D Size Heavy Duty Battery

Rayovac No.: 6D
 Nominal Voltage: 1.5 volts
 System: Zinc Chloride
 ANSI/NEDA No.: 13D (D)
 IEC No.: R20
 Approximate Volume: 3.4 cu. in. (55.7 cu. cm.)
 Approximate Weight: 3.3 oz. (96 gm.)
 Terminals: Flashlight
 Shell: Steel
 Environmental: Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



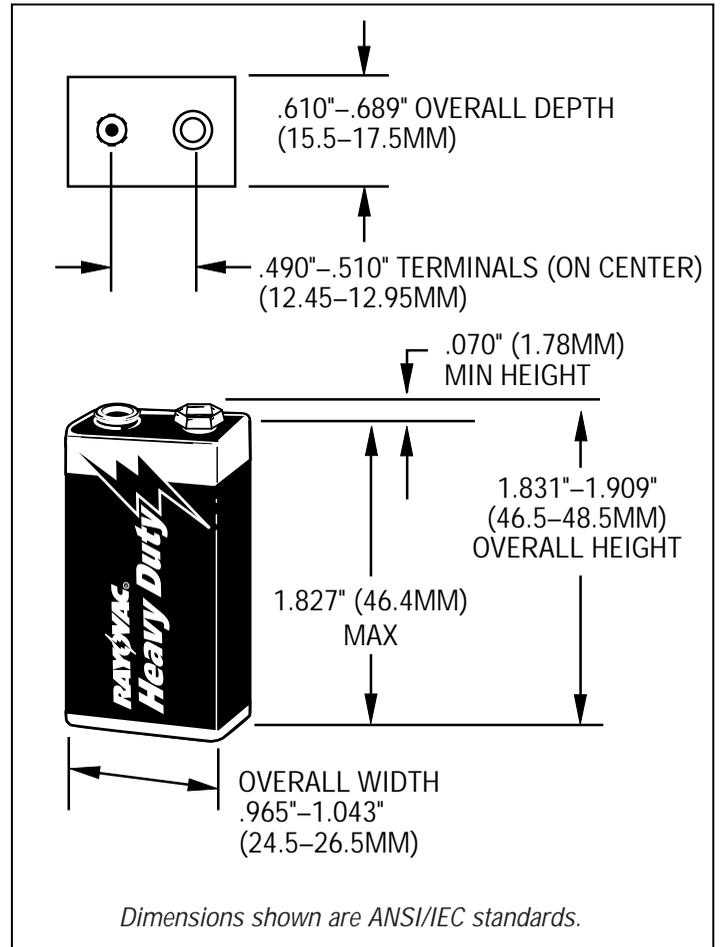
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	10	120	36	47	53	56	6880
Cassette (1 Hr/Day)	3.9	308	7.8	13.4	17.7	20.5	6075
Flashlight, PR2 Vacuum Bulb (4 Min/Hr - 8 Hrs/Day)	2.2	545	2.4	5.2	8.5	10.9	5470
Toy/Game (1 Hr/Day)	2.2	545	1.6	4.4	7.1	9.5	4725

Quality Systems Certification:



e. 9-Volt Heavy Duty Battery

Rayovac No.: D1604
 Nominal Voltage: 9 volts
 System: ZINC CHLORIDE
 ANSI/NEDA No.: 1604D (9v)
 IEC No.: 6F22
 Approximate Volume: 1.2 cu. in. (19.7 cu. cm.)
 Approximate Weight: 1.5 oz. (42.5 gm.)
 Terminals: Snap
 Shell: Steel
 Environmental: Meets Environmental Protection Agency (EPA) requirements for landfill disposal. No mercury added formulation.



Application & Duty Cycle	Load (ohms)	Current (mA at 7.2V)	Estimated Average Service At 70°F (Hours)					Approx. mAh Capacity to 4.2V
			Cutoff Voltage					
			7.8V	6.6V	6.0V	5.4V	4.2V	
Low Rate (24 Hrs/Day)	6000		188	326	351	364	385	485
Radio (2 Hrs/Day)	620	12	7.7	25.5	31.3	35.1	39.1	435
Toy/Game (1 Hr/Day)	270	27	0.9	7.5	10.3	12.2	16.6	390
Calculator (30 Min/Day)	180	40	0.3	3.7	5.5	7.2	10.3	350
Cassette (1 Hr/Day)	180	40	0.3	3.5	5.5	7.1	10.3	350

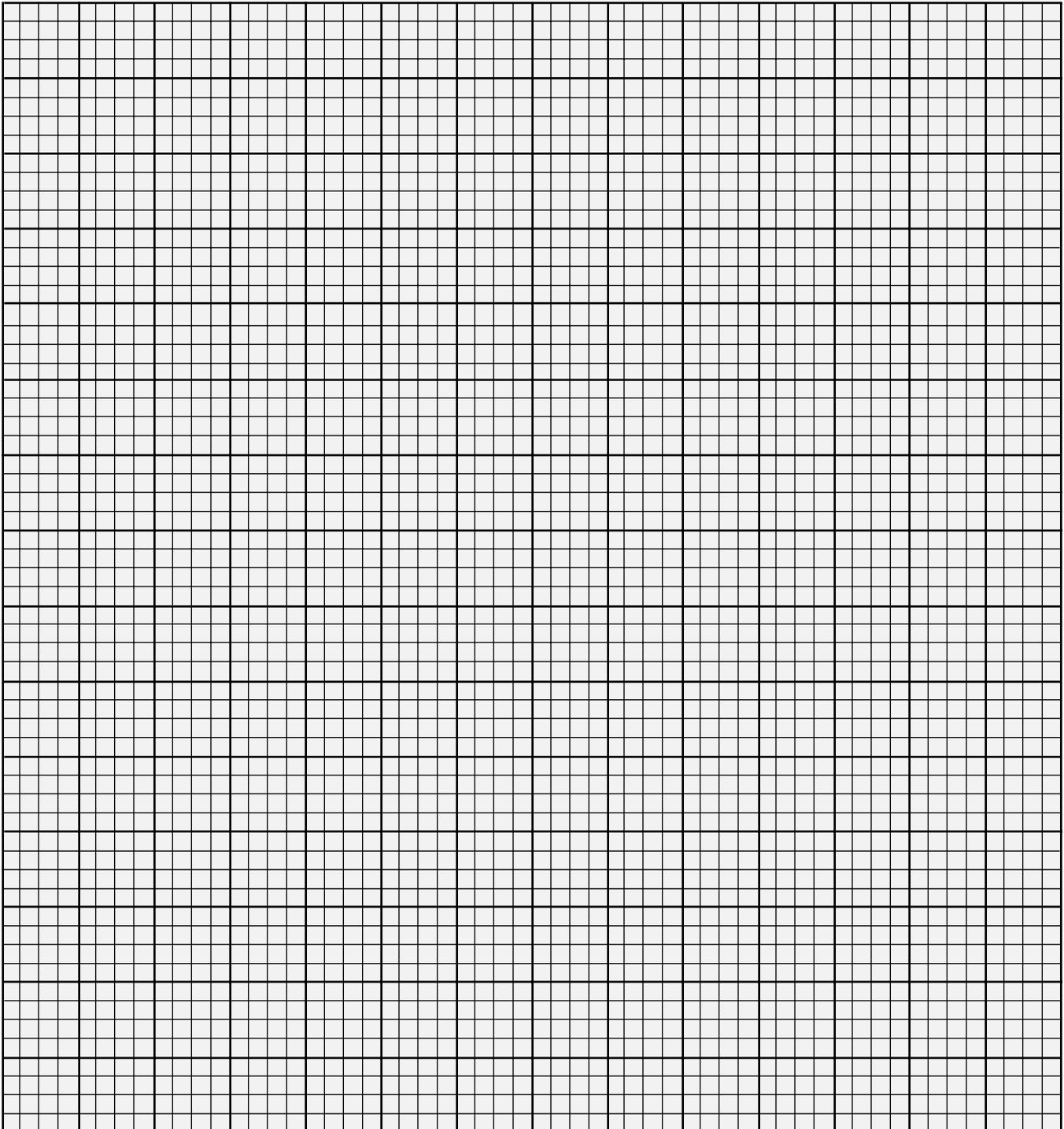
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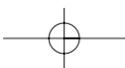


IX. Product Availability

Rayovac batteries are available in various packaging options including bulk, carded, and multi-packs. For information, call your Rayovac representative.

ENGINEERING NOTES



**Notice**

This publication is furnished only as a guide. It is the user's responsibility to determine suitability of the products described for the user's purpose (even if the use is described herein) and to take precautions for protection against any hazards attendant to the handling and use of the products. Rayovac recommends prospective users test each application.

The battery products and arrangements described herein may be covered by patents owned by Rayovac or others. Neither this disclosure nor the sale of products by Rayovac conveys any license under patent claims covering combinations of battery products with other elements or devices. Rayovac does not assume liability for patent infringement arising from any use of the products by the purchaser.

The technical data contained herein are not designed to be the basis for specifications. Rayovac's Quality Assurance Department can furnish data that can serve as the basis for specifications.

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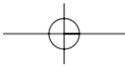
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RAYOVAC BATTERY CARE

BATTERY CARE

Tips and tricks to keep your device going stronger, longer

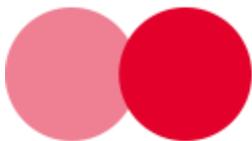
There are tons of myths about alkaline batteries, but here's what you actually need to know to ensure your RAYOVAC® batteries are providing the performance we stand behind.

Tips and tricks:



Never mix battery types (Alkaline, NiMH, Zinc Carbon)

When the lower-performance batteries are exhausted, the longer-lasting batteries will force discharge current through them, which can cause corrosion and hydrogen gas formation. No fun!



Never mix old & new batteries

If you mix old and new batteries, you'll only get the performance of the old, lower-performance battery. Plus, you'll risk the same issues as above: corrosion and hydrogen gas formation. Stick to new batteries only.



Remove batteries from any device that will be stored

Many devices don't turn off completely when not in use, so they still use a small amount of power. If a device is stored this way for an extended period of time, like months or years, the batteries can run out and corrode. Not what you want when you dig that old toy out of the closet!



Don't leave battery-powered devices switched on

If your batteries have died, make sure you turn your device off and remove the old batteries. Even when the device won't work, it still uses a small amount of power that is left in the battery, which causes hydrogen gas to form inside the battery. This can cause corrosion in as little as two weeks. Turn that device off!



Don't immediately throw away batteries that have been in a cold environment

Cold temperatures (below freezing) decrease battery power, so let your batteries warm up to normal temperature and try them again, before you decide to replace them. Let yourself warm up, too!



Store your batteries at room temperature

Heat over 85°F can shorten battery life and power delivery, so store your batteries in a cool, dry place. Think closet, instead of garage.