

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

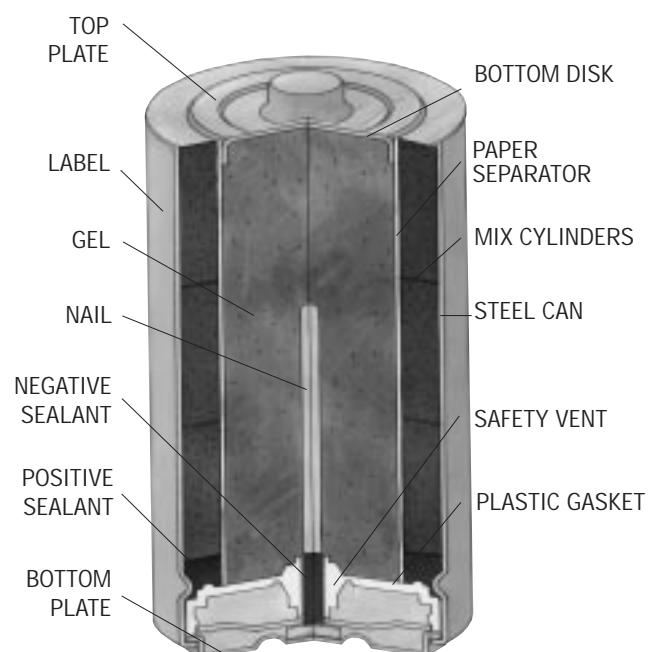


Diagram 1

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

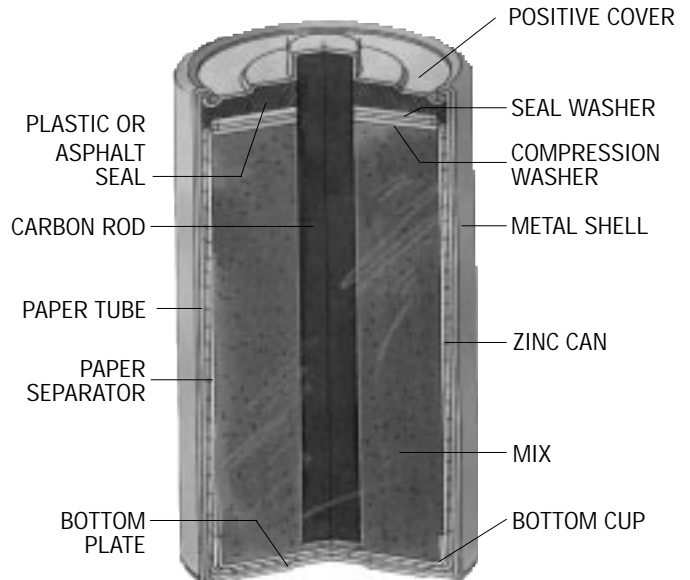


Diagram 2

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.

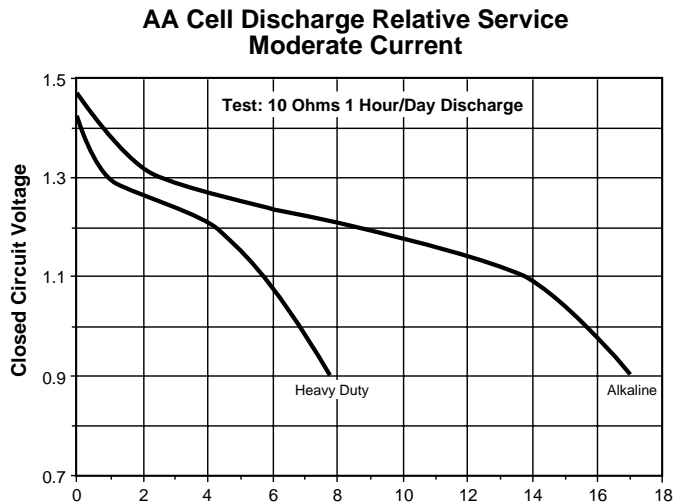
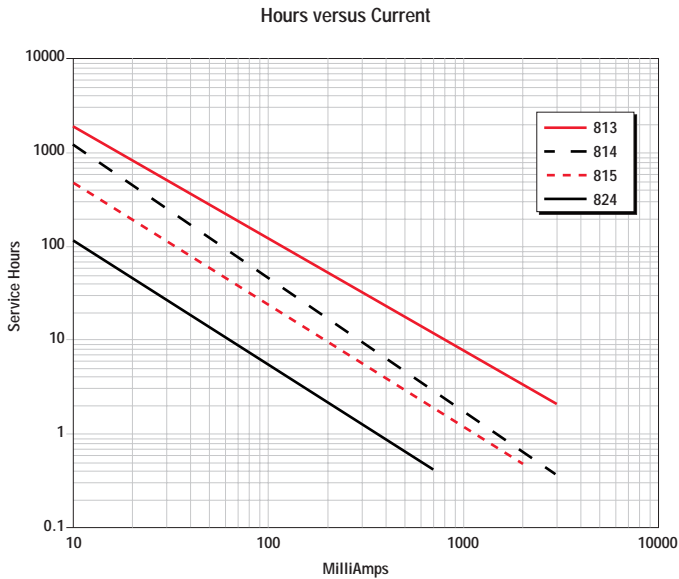


Figure 1
Service Life - Hours

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.**

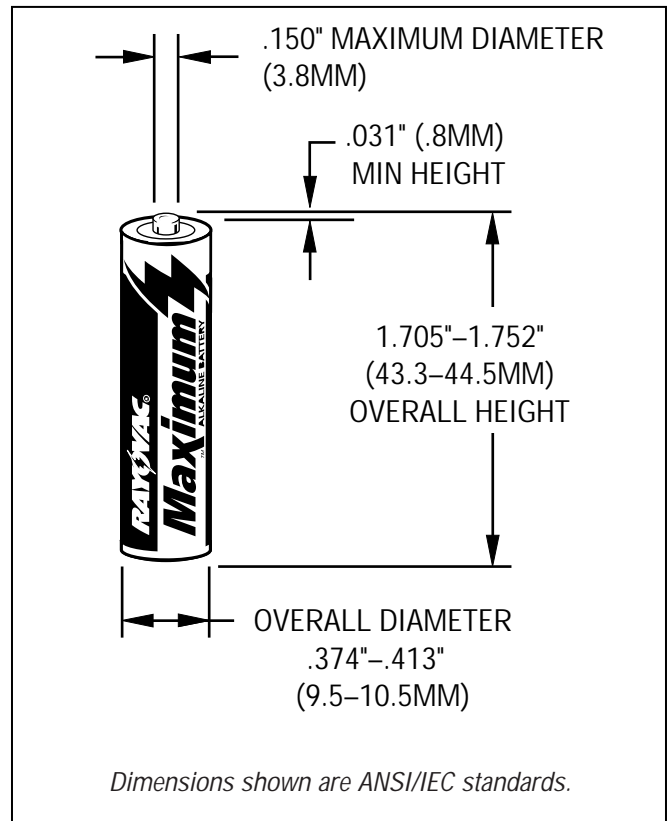
If you have any questions please contact your Rayovac sales representative.

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.



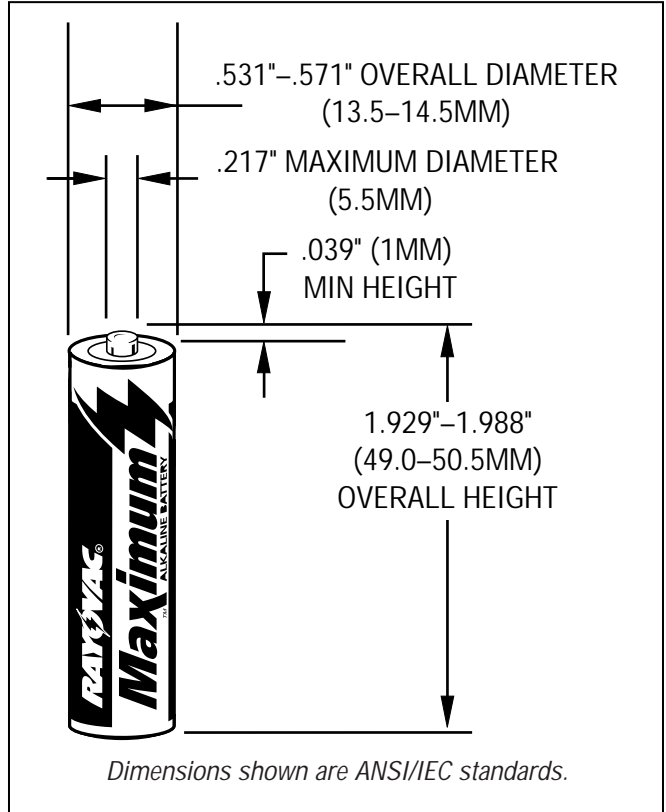
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	75	16	47	54	63	68	1123
Cassette (1 Hr/Day)	10	120	3	6	7	8	958
Cassette (Continuous)	10	120	2	6	7	8	963
Flashlight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



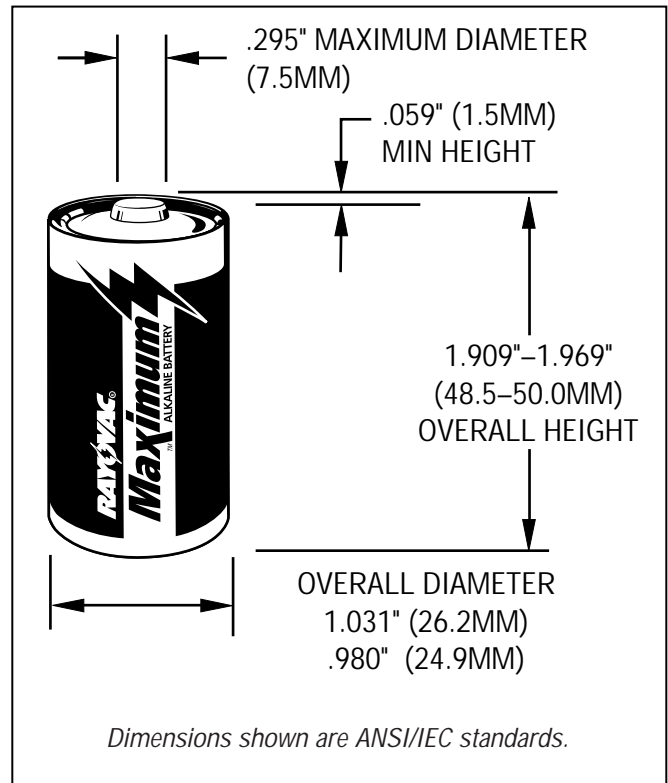
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	43	28	59	69	80	88	2535
Cassette (1 Hr/Day)	10	120	10	14	16	19	2216
Toy/Game (1 Hr/Day)	3.9	308	2	4	6	7	1907
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:



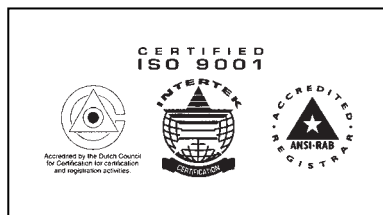
c. C Size Alkaline Battery

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.



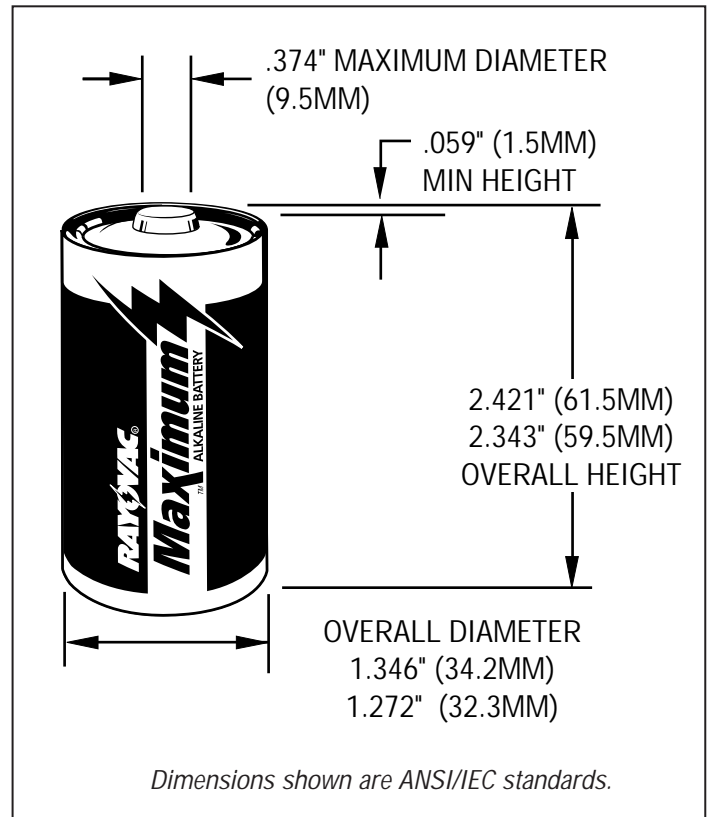
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	20	60	79	96	108	117	7245
Cassette (1 Hr/Day)	6.8	176	18	28	33	36	6365
Flashlight (4 Min/Hr – 8 Hrs/Day)	3.9	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.



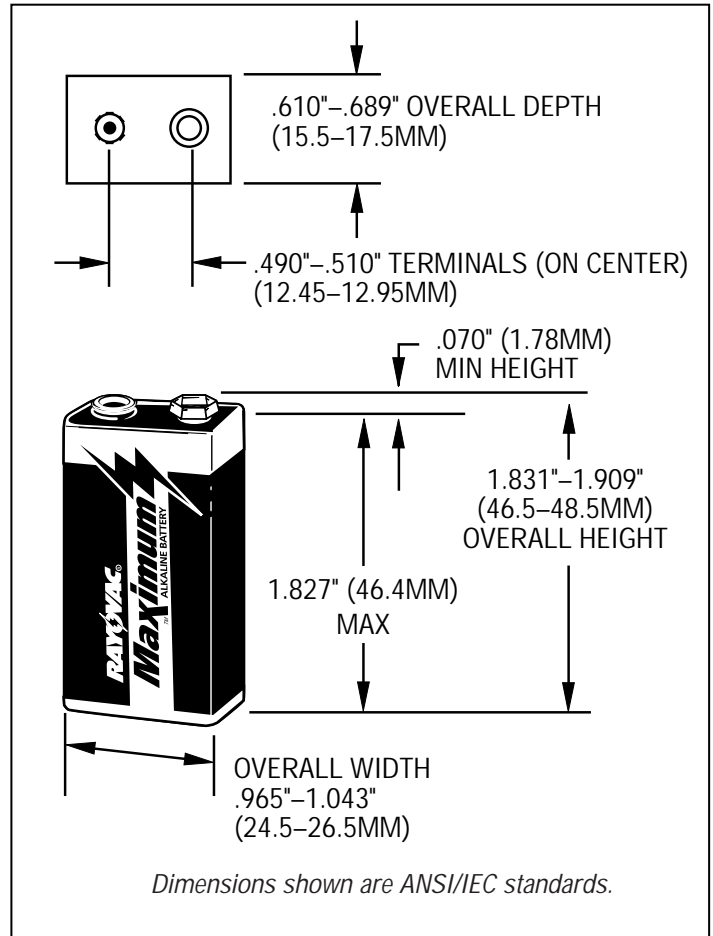
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	10	120	80	101	112	126	15,453
Cassette (1 Hr/Day)	3.9	308	21	32	38	43	13,118
Toy/Game (1 Hr/Day)	2.2	545	6	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:



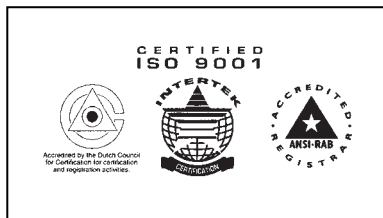
e. 9-Volt Alkaline Battery

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

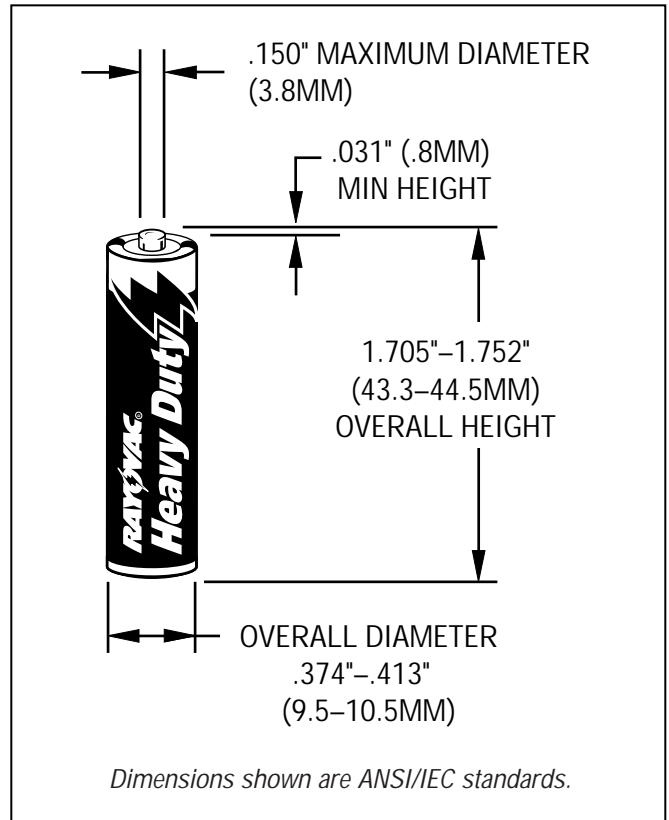
Quality Systems Certification:



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.



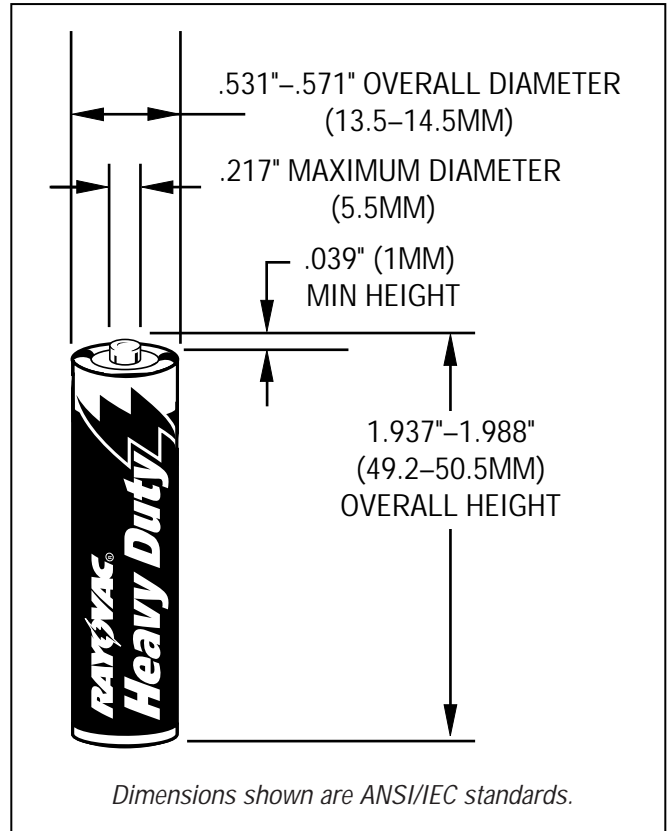
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	75	16	25	29	31	33	550
Cassette (1 Hr/Day)	10	120	0.7	1.7	2.5	2.8	320
Flashlight (4 Min/Hr – 8 Hrs/Day)	5.1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



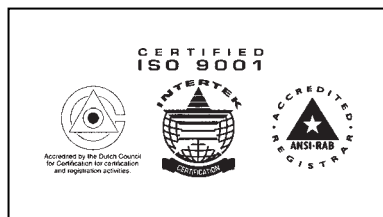
b. AA Size Heavy Duty Battery

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.



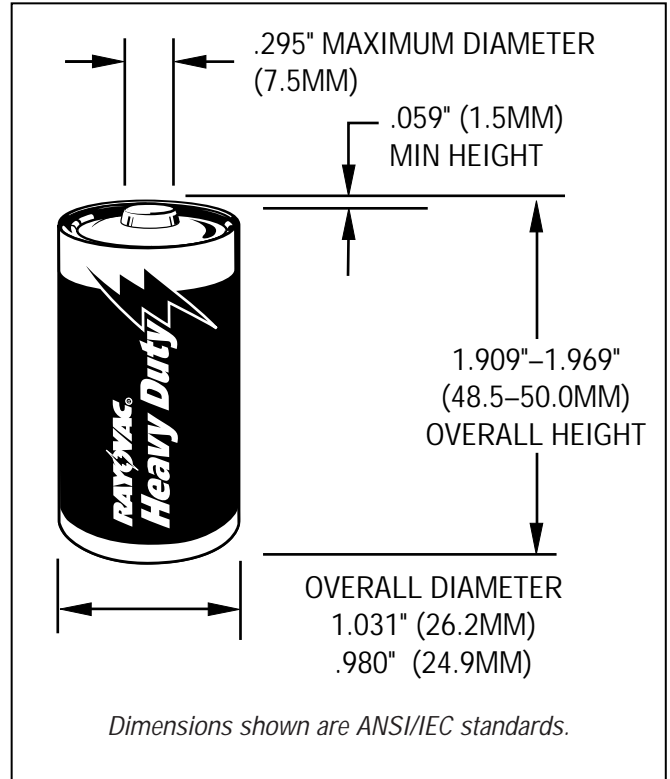
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	43	28	27	33	36	37	1100
Cassette (1 Hr/Day)	10	120	4.2	5.7	6.8	7.7	925
Toy/Game (1 Hr/Day)	3.9	256	0.4	1.1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



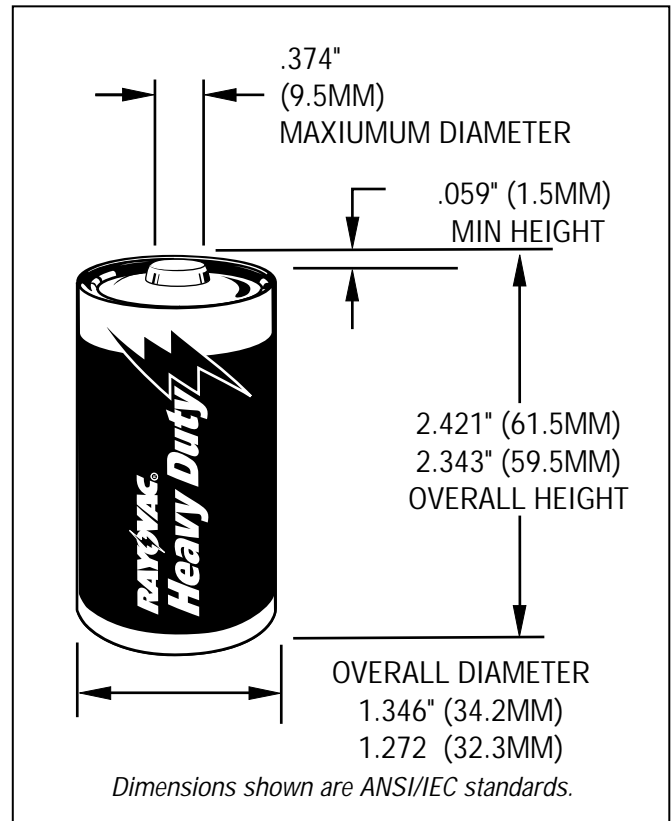
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	20	60	33	40	43	44	2780
Cassette (1 Hr/Day)	6.8	176	6.7	10.9	13.7	14.5	2550
Flashlight (4 Min/Hr – 8 Hrs/Day)	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:



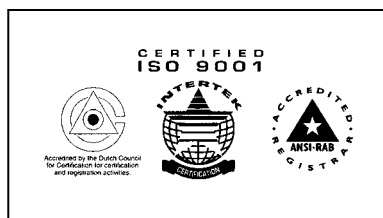
d. D Size Heavy Duty Battery

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.



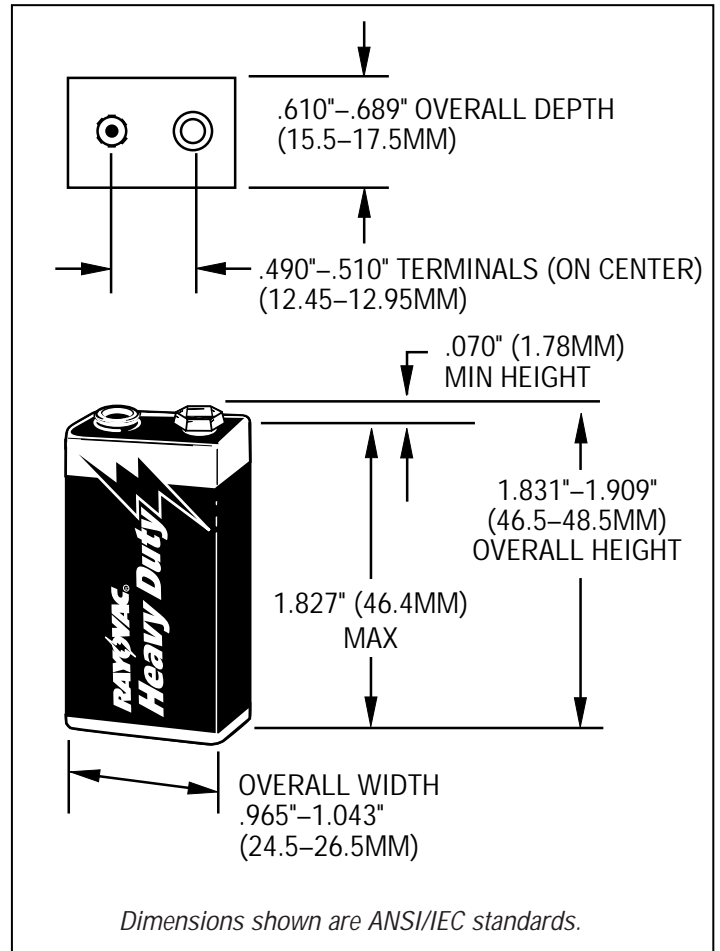
Application & Duty Cycle	Load (ohms)	Current (mA at 1.2V)	Estimated Average Service At 70°F (Hours)				Approx. mAh Capacity to 0.9V
			Cutoff Voltage				
			1.2V	1.1V	1.0V	0.9V	
Radio (4 Hrs/Day)	10	120	36	47	53	56	6880
Cassette (1 Hr/Day)	3.9	308	7.8	13.4	17.7	20.5	6075
Flashlight, PR2 Vacuum Bulb (4 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:



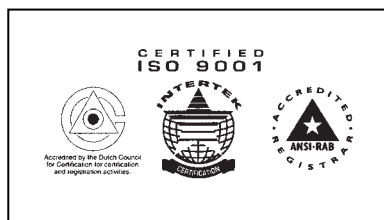
e. 9-Volt Heavy Duty Battery

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

Quality Systems Certification:



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.

Application Notes & Product Data Sheet

I: Introduction

Lithium has become a generic term representing a family of battery systems in which Lithium metal is used as the active anode material or negative electrode. Variations in the cathode material, or positive electrode, and the cell electrolyte result in hundreds of possible combinations of Lithium batteries. Rayovac® Lithium Carbon-monofluoride (BR) batteries are a solid-cathode type which optimizes reliability, safety, cost and performance.

II: Features

- Outstanding shelf life and excellent performance over a wide temperature range
- Stable discharge voltage
- High energy density and voltage (3V)
- Enhanced safety by the use of Carbon-monofluoride electrode material and a non-corrosive, non-toxic electrolyte
- Excellent leak resistance
- Shelf life of ten years or more
- Pre-tinned terminals are solderable
- Available with many wave-solderable terminal configurations

III: Quality Systems Certification



Intertek

Lithium Carbon-monofluoride (BR) Coin Cells and FB Encapsulated Lithium Coin Cells

IV: Applications

The following devices are examples of good uses for BR coin cells:

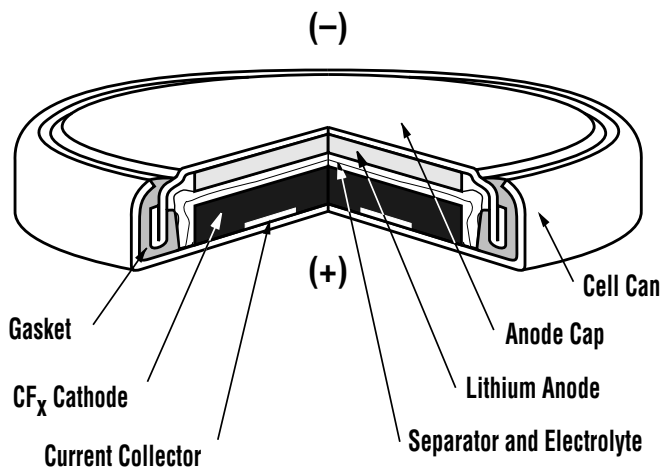
- Computer Memory and Real Time Clock Backup
- Electronic Counters, Process Controllers
- Portable Instruments
- Time/Data Protection
- Industrial Controls
- Electronic Gas, Water and Electric Meters
- Communication Equipment
- RF Tags, Toll Tags, and ID Tags
- Portable Electronic Devices

Application Considerations

Rayovac® BR coin cells and batteries should be considered for applications that are characterized by a need for:

- Miniaturization
- Leakage resistance
- Lightweight
- Shock and vibration tolerance
- Low to moderate current drains
- Environments requiring extended operation or storage at a wide range of temperatures
- The need for flat discharge voltage and consistent source impedance
- Long shelf life
- An extended service life due to low self-discharge rate
- Enhanced safety and reduced product liability concerns
- U.L. recognized components

V: Construction



VI: Battery Selection

Component Class Batteries and Cells

Today's circuit designers recognize the capabilities of BR Lithium coin cells and FB batteries to function as permanent components in their circuits. FB batteries exhibit reliability rates similar to diodes and resistors. The combination of very low power Complementary Metal-Oxide Semiconductor (CMOS) memory devices with high energy, long life batteries now allow for batteries to be used as life-of-product components.

The traditional approach to product design is to provide sufficient energy to meet a design target for a stated period, at which time the batteries would be replaced. The decision to provide component or expendable power is fundamental to the product concept of the device being powered. Component batteries allow the designer to increase the reliability and functionality of the device by eliminating the need for consumer replacement of batteries. Component batteries eliminate the problems of reversed polarity, wrong chemical system, mismatched capacities, and higher operating costs. However, component batteries require careful selection. The batteries must assure adequate energy for the expected load to compensate for self-discharge and the thermal environment expected, and the batteries must also have a high reliability connection to the circuit.

Today's demand for high performance, small footprint, reliable, and cost-effective electronic products can be realized by identifying the best match between the battery and its application. To

do so requires a good understanding of the device's power requirements and the environment in which it is used as well as how the battery reacts to those loads and environments.

It is important that the battery be considered early in the design process. This will allow the optimization of battery life through the selection of power conserving circuit components. Moreover, early battery selection will also minimize circuit and mechanical layout changes later in the design process. The following is a list of basic application characteristics and conditions that must be considered for an optimum selection of a lithium Carbon-monofluoride power source.

Electrical Characteristics

- Voltage: maximum/minimum
- Current drain
- Pulse currents
- Pulse time/frequency of occurrence

Application Goals

- Duty cycle
- Service life goal
- Shelf life goal
- Reliability
- Safety
- Battery availability

Packaging

- Shape
- Terminals
- Weight
- Contact materials
- Case materials

Environmental

- Operating temperature range
- Storage temperature range
- Humidity
- Shock and vibration
- Atmospheric pressure

VII: Calculating Battery Life

The design of an electronic circuit powered by a component class battery requires the designer to consider two interacting paths that determine a battery's life: consumption of active electrochemical components and thermal wear-out.

To optimize battery life in powered devices, today's designers are first selecting power conserving circuit components, and then specifying high reliability component Lithium batteries. Battery selection is based on an understanding of the thermal capabilities, effects of the operating environment, and the battery life requirements of the powered device.

Figure 1, at right, gives an estimate of years of service at various discharge currents for BR Lithium coin cells at room temperatures.

Consumption of Active Battery Components

Batteries produce electrical current by oxidation and reduction of their active electrochemical components. Once these components are consumed, the battery ceases to produce current. The sum of the energy consumed by the circuit over its expected life plus the electrochemistry's inherent loss of energy due to self-discharge, represents the first path in determining battery life.

Thermal Wear-Out

The second path in determining battery life is thermal wear-out, which is the loss of capacity caused by thermal mechanisms. Generally, thermal wear-out rates accelerate as temperatures in the operating environment rise.

It is very important to hold the paths of self discharge and thermal wear-out as separate issues. This is because self-discharge can sometimes be compensated for by increasing the specified battery capacity, while thermal wear-out can only be addressed by selecting a more thermally capable battery.

Drain vs. Duration

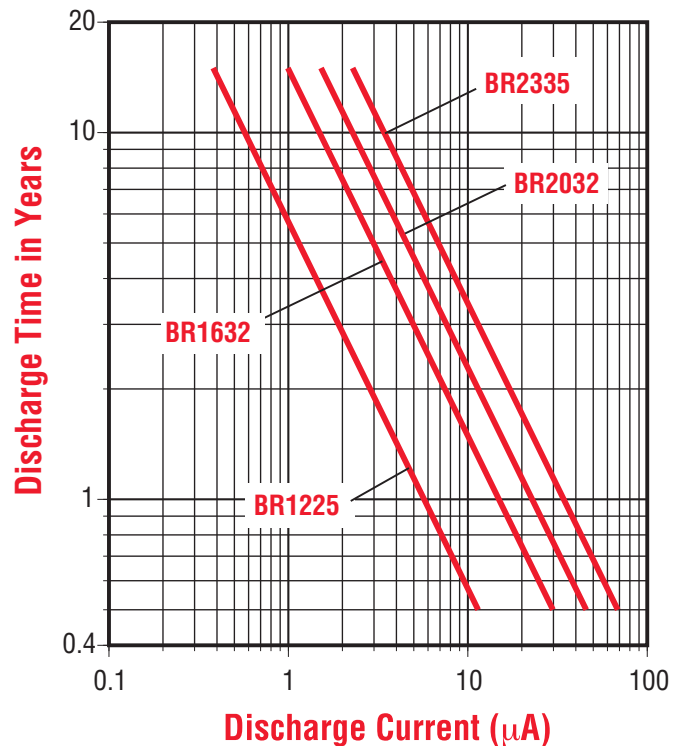


Figure 1

Battery Life and Capacity Estimates

Rayovac has accumulated over 200 million device hours of accelerated reliability testing with a major semiconductor manufacturer. This data has allowed us to gain a better understanding of the time and temperature dependent wear out of BR Lithium coin cells and FB batteries during storage. Please contact Rayovac's OEM Division for more information.

VIII: Performance Characteristics

A. System Self-Discharge Comparison

BR Lithium Carbon-monofluoride cells offer substantially lower self-discharge rates compared to other battery chemistries. **Figure 2** compares the capacity loss due to self-discharge over a range of temperatures for various battery chemistries. BR Lithium coin cells provide self-discharge rates of less than 0.3% per year and Lifex FB™ batteries less than 0.2% per year.

System Self-Discharge Rate vs. Temperature

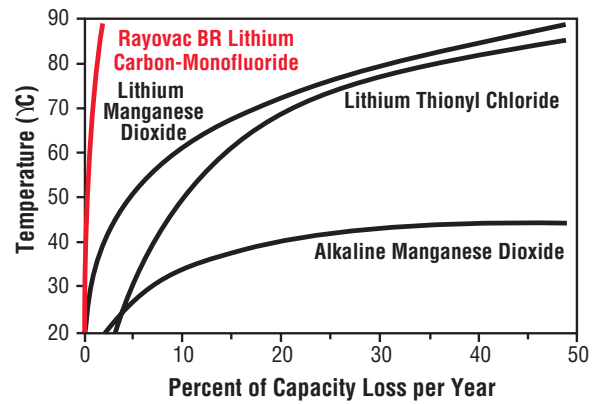


Figure 2

B. Thermal Wear-Out

At high temperatures, Rayovac's BR Lithium coin cells and FB batteries offer significantly lower failure rates over competing coin cells. **Figure 3** shows the relationship between temperature and the years to 1% failure of 12.5mm diameter cells of-similar capacity. A failure is defined as a closed circuit voltage less than 2.0 volts on a 250Kff load of 0.5 second duration.

Lithium Coin Cells Temperature/Life Relationship

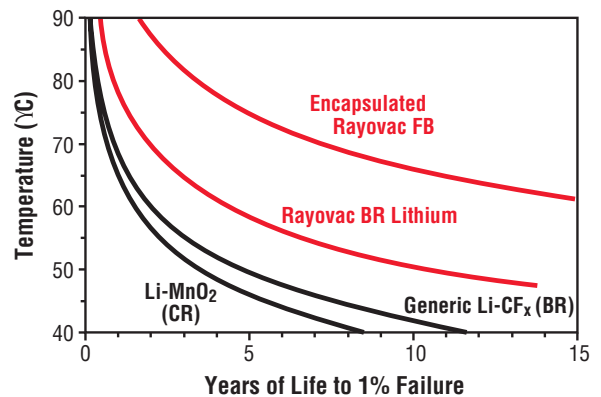


Figure 3

C. System Internal Resistance Comparison

Rayovac® BR Lithium coin cells provide more stable internal resistance throughout discharge compared to lithium manganese dioxide coin cells as shown in **Figure 4**. This is due to the formation of conductive carbon as a discharge by-product in the cell cathode during discharge. This carbon prevents a change in internal resistance until the active components of the cell are consumed.

Internal Resistance During 30KΩ Discharge BR2032 Cell vs. CR2032 Cell

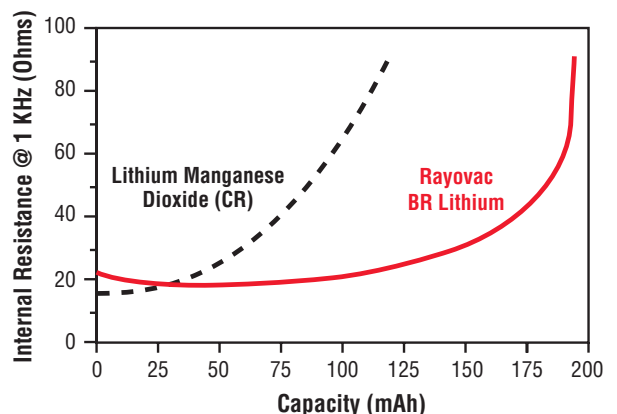


Figure 4

D. Internal Operating Resistance During Discharge

Figure 5 (right) shows how the internal resistance and voltage changes on a BR1225 cell as a percent of discharge. Similar profiles with slightly different values are observed with other cell sizes. The typical initial 1KHz AC internal resistance for each cell size is shown in Figure 6.

Typical Initial Internal Resistance at 1 KHz AC

Cell Size	Internal Resistance (Ohms)
BR1225	85
BR1632	34
BR2032	25
BR2335	21

Figure 6

Internal Resistance and CCV of BR1225 Cell During 30KΩ Discharge

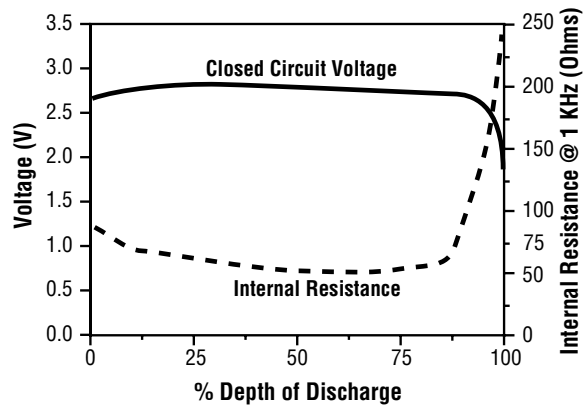


Figure 5

E. Operating & Storage Temperature Range

Rayovac® BR Lithium coin cells and FB batteries provide excellent performance over a wide range of temperatures. The operating and storage temperature ranges are:

BR Lithium Coin Cells	-40° C to +85° C -40° F to +185° F
FB Batteries	-40° C to +100° C -40° F to +212° F

F. Safety

Figure 7 below compares the safety of the three most common Lithium systems. The figure demonstrates that the Rayovac® BR Lithium battery components are extremely safe.

Rayovac® BR Lithium batteries have been granted U.L. Component Recognition (file no. MH12542). The battery's components are both chemically and thermally stable before, during, and after discharge. The electrolyte is both non-corrosive and non-toxic.



RECOGNIZED UNDER THE COMPONENT PROGRAM OF UNDERWRITERS LABORATORIES® INC. □

Safety Comparisons of Lithium Systems

Figure 7

Battery System/IEC Nomenclature	Class	Cathode Material	Cathode	Electrolyte Salt Material	Electrolyte Salt Property	Electrolyte Solvent
Lithium Carbon-Monofluoride Li/(CF) _x BR	Solid Cathode	Poly-Carbon Monofluoride	Solid Stable	Lithium Tetra Fluoroborate LiBF ₄	Stable	Propylene Carbonate & 1,2 Dimethoxyethane (PC & DME)
Lithium Manganese Dioxide Li/MnO ₂ CR	Solid Cathode	Manganese Dioxide	Solid Stable	Lithium Perchlorate LiClO ₄	Explosive	PC & DME
Lithium Thionyl Chloride LiSOCl ₂	Solid Cathode	Thionyl Chloride	Liquid Toxic Corrosive	Lithium Tetra Chloroaluminate LiAlCl ₄	Corrosive	Thionyl Chloride (SOCl ₂)

G. Charging Characteristics

Although any charging of BR Lithium cells is to be avoided, some charging may occur even in a well designed electrical circuit due to leakage current of the protecting diodes. The diode used in a circuit design with a BR Lithium cell should minimize leakage to within 3% of the rated capacity of the cell over the lifetime of the cell's use. **Figure 8** below provides the maximum total charge allowance for all cell sizes. **Figure 9**, which illustrates these limits as they apply to the BR1225 cell size at various drain rates, follows.

Formula to calculate charge current:

$$I_{\max} (\text{nA}) = \frac{114.15 \times c}{t}$$

Where: I_{\max} = Maximum allowable charge current in nanoAmperes (nA)

c = Maximum total charge capacity in mAh from table above

t = Time on charge in years

Maximum Total Charge Allowance

Cell Size	Rated Capacity	3% of Capacity
BR1225	50 mAh	1.50 mAh
BR1632	130 mAh	3.90 mAh
BR2032	195 mAh	5.85 mAh
BR2335	300 mAh	9.00 mAh

Figure 8

Maximum Total Charge Allowance

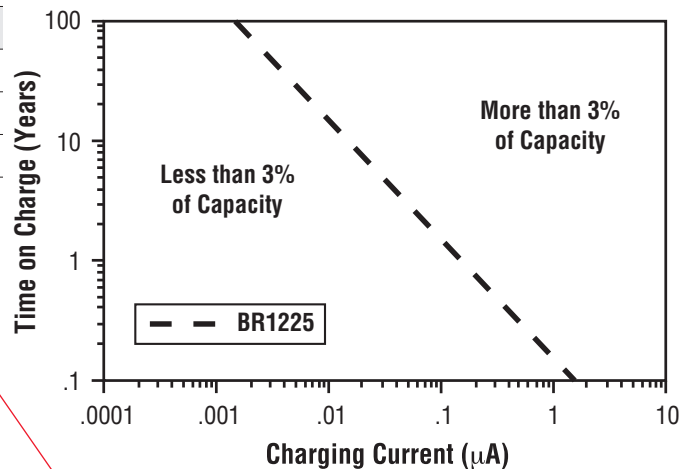


Figure 9

H. High Altitude Exposure

It is possible for components to be exposed to-reduced pressures during shipment by air. Rayovac® BR Lithium batteries that were tested at reduced pressures of 3 mm mercury for 10 days and then discharged at normal rates exhibited the following-results:

1. No change in cell appearance.
2. No observed leakage.
3. No change in resulting capacity.

I. Leakage Resistance

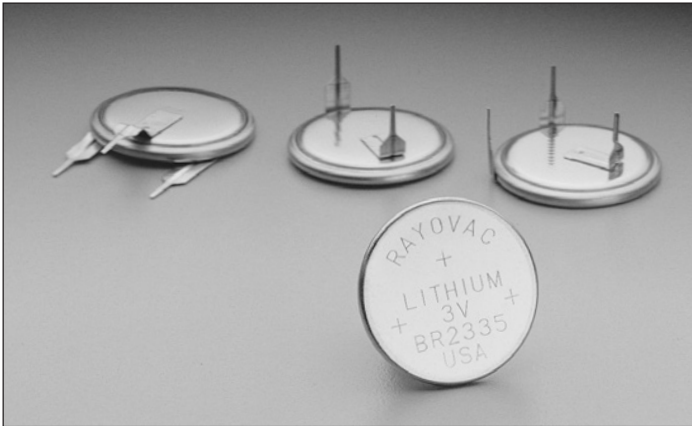
The electrolyte in BR Lithium batteries is based on an organic solvent instead of a corrosive alkaline or acidic solution found in most conventional batteries. This greatly improves the cell's leakage resistance and guards against the negative effects caused by leakage.

J. Orientation

Since Rayovac® batteries use solid active components, the performance characteristics described are obtained regardless of the installation position.

IX: Product Specifications

BR Lithium Coin Cell



A. Specification Table

Rayovac® BR Lithium coin cells are available in a wide variety of tab and pin mounting configurations. See Product Availability Table (page 14) for a list of the most popular items.

Part Number	Rated Nominal Capacity (mAh)	Nominal Pulse Capability (mA*)	Dimensions				NEDA Number	IEC Number
			Diameter (mm)	Height (mm)	Weight (g)	Volume (cc)		
BR1225	50	5	12.5	2.5	0.8	0.30	5020LB	BR1225
BR1632	130	10	16.0	3.2	1.6	0.63	Not Assigned	BR1632
BR2032	195	10	20.0	3.2	2.4	1.00	5004LB	BR2032
BR2335	300	10	23.0	3.5	3.4	1.45	Not Assigned	BR2335

Figure 10

* Consult Rayovac® OEM Engineering Division for assistance in determining pulse capability for your application.

B. Typical Discharge Curves

BR1225

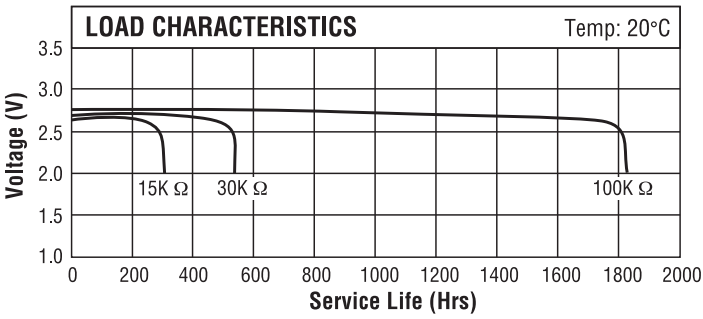


Figure 11

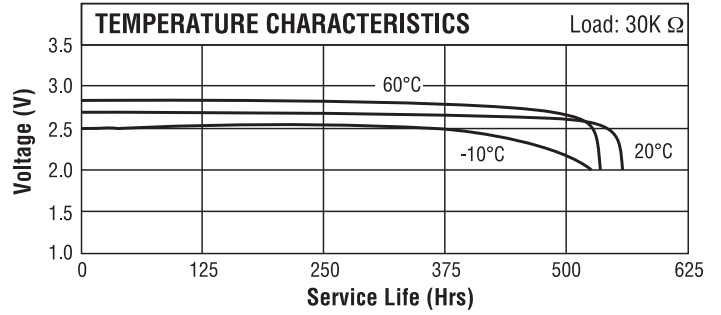


Figure 12

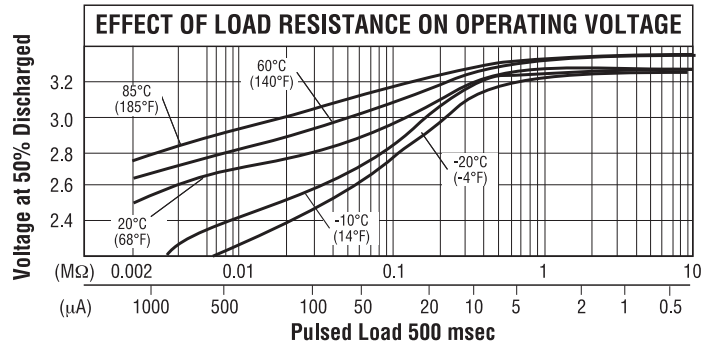


Figure 13

BR1632

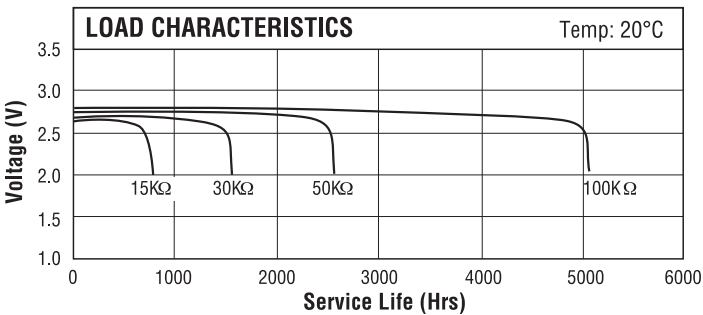


Figure 14

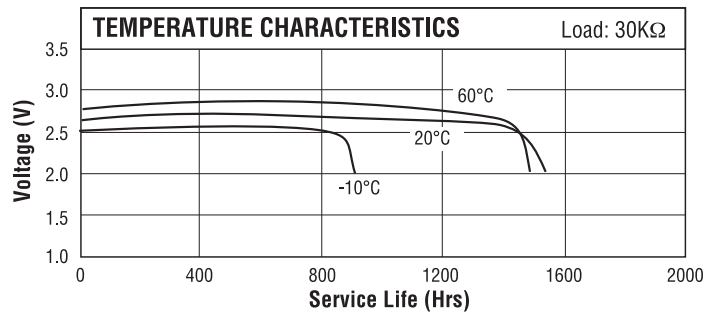


Figure 15

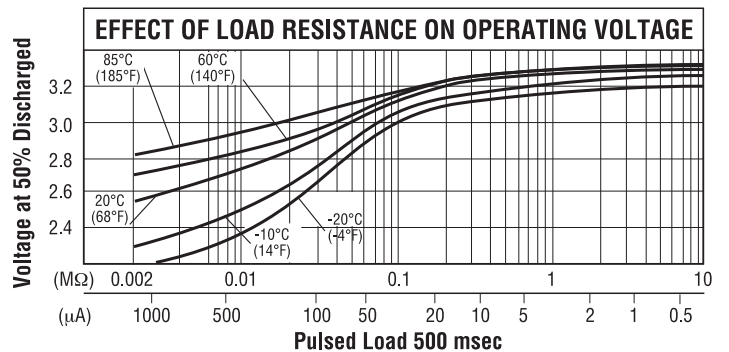


Figure 16

BR2032

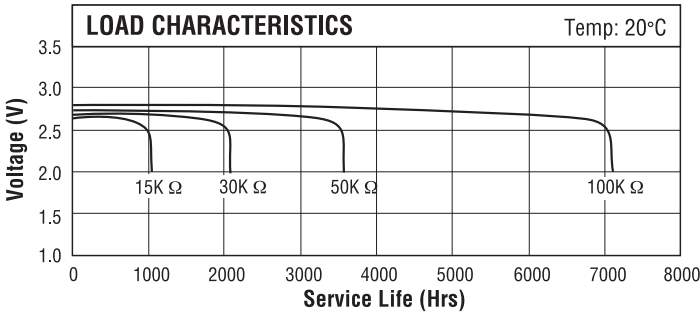


Figure 17

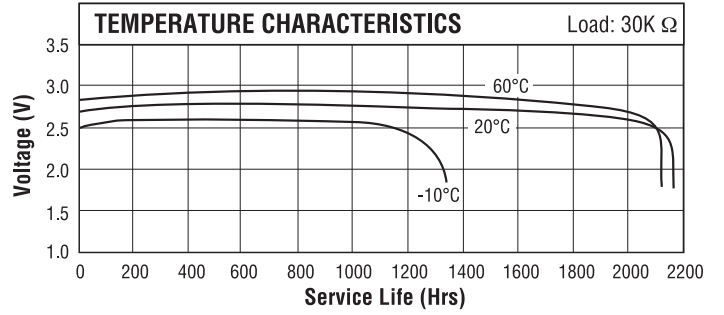


Figure 18

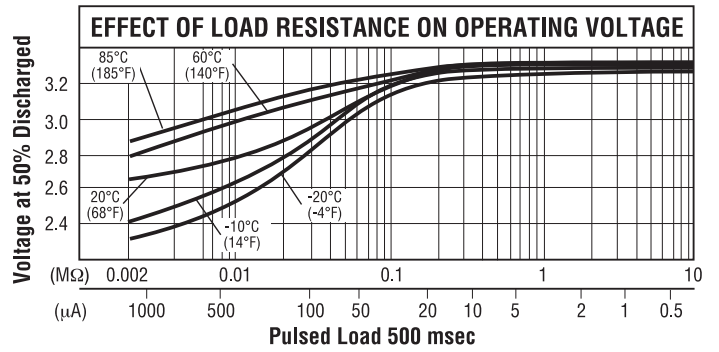


Figure 19

BR2335

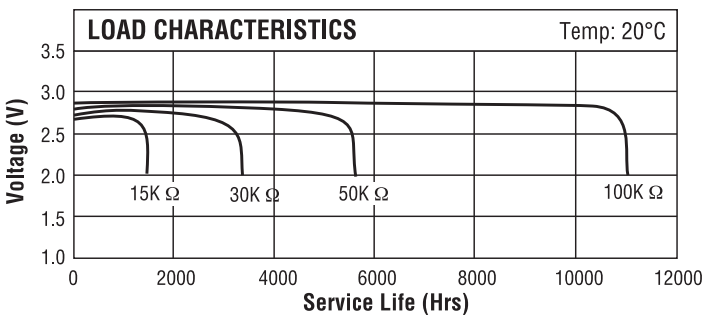


Figure 20

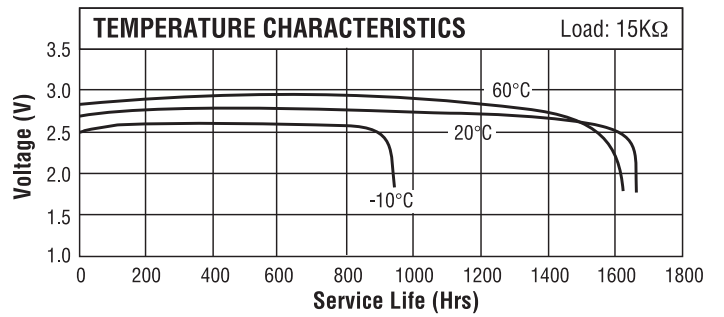


Figure 21

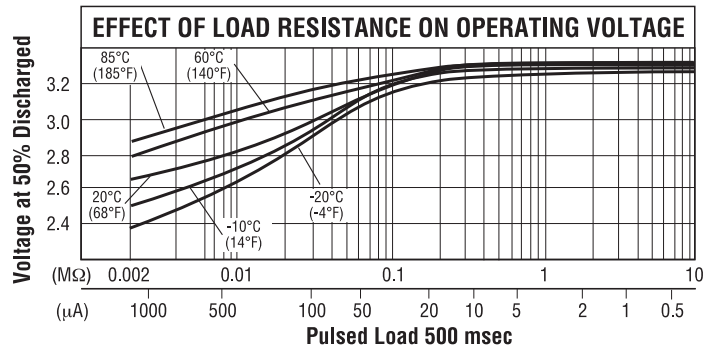


Figure 22

C. Dimensional Drawing

For illustration only. Contact Rayovac for complete specifications.

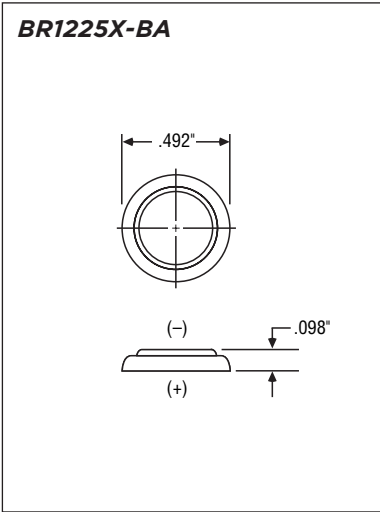


Figure 23

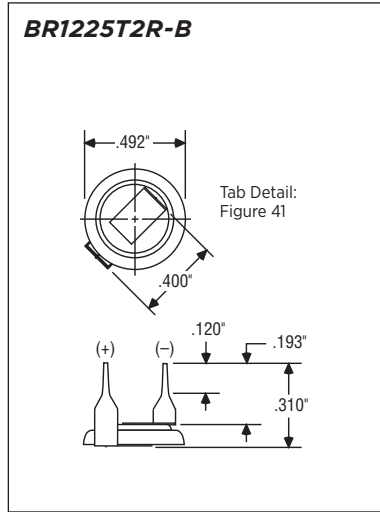


Figure 24

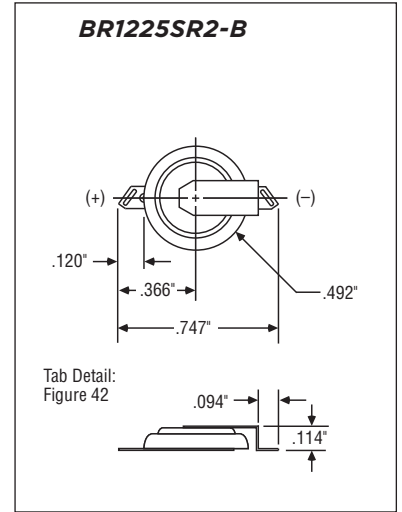


Figure 25

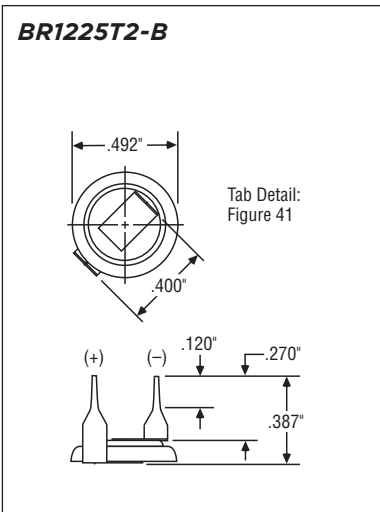


Figure 26

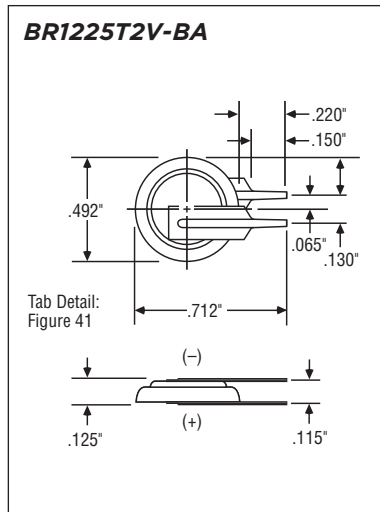


Figure 27

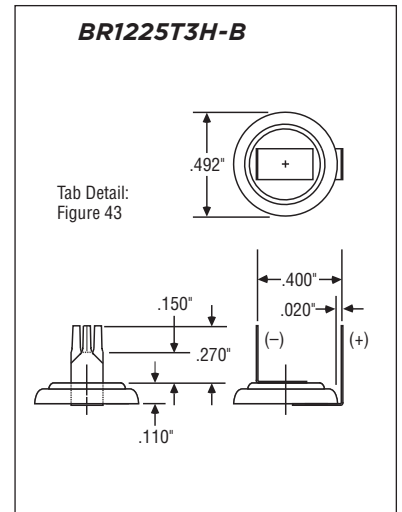


Figure 28

Please Note: Current Rayovac® BR Lithium products are not compatible with Surface Mount Technology (SMT) soldering processes due to the extreme temperatures required for reflow. Batteries should be added as a secondary operation.

For illustration only. Contact Rayovac for complete specifications.

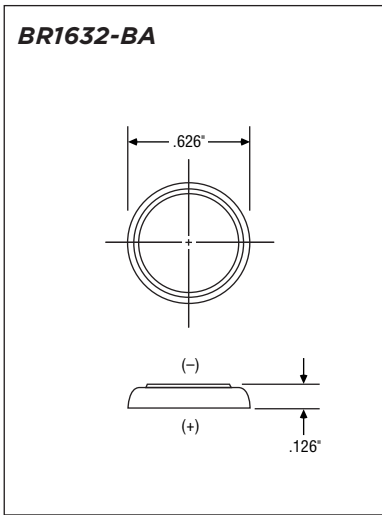


Figure 29

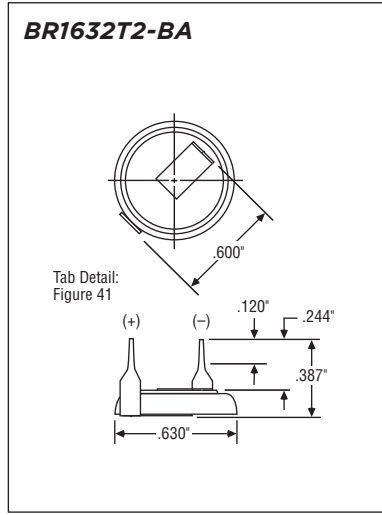


Figure 30

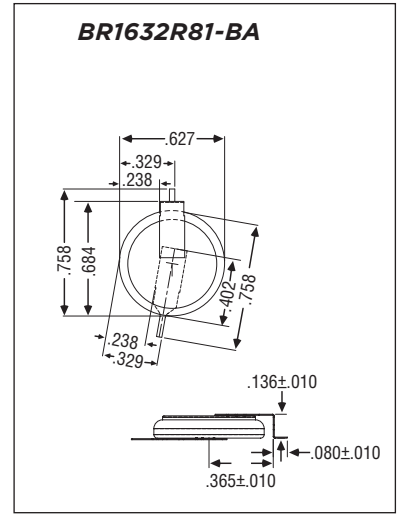


Figure 31

Conversion Chart

Inches	Millimeters
0.020	0.51
0.065	1.65
0.094	2.39
0.098	2.49
0.102	2.59
0.110	2.79
0.114	2.90
0.115	2.92
0.120	3.05
0.125	3.18
0.126	3.20
0.130	3.30
0.138	3.51
0.150	3.81
0.153	3.89
0.154	3.91
0.180	4.57
0.193	4.90
0.200	5.08
0.216	5.49

Inches	Millimeters
0.220	5.59
0.231	5.91
0.242	6.14
0.244	6.20
0.266	6.76
0.270	6.86
0.288	7.32
0.300	7.62
0.310	7.87
0.357	9.07
0.359	9.12
0.366	9.30
0.387	9.90
0.400	10.16
0.415	10.54
0.417	10.59
0.492	12.50
0.550	13.97
0.600	15.24
0.625	15.88

Inches	Millimeters
0.626	15.90
0.630	16.12
0.684	17.37
0.700	17.78
0.712	18.08
0.747	18.97
0.770	19.56
0.787	19.99
0.800	20.32
0.817	20.75
0.898	22.81
0.928	23.57
0.984	24.99
1.018	25.90
1.130	28.70
1.250	31.80
1.270	32.30
2.040	51.82

Please Note: Current Rayovac® BR Lithium products are not compatible with Surface Mount Technology (SMT) soldering processes due to the extreme temperatures required for reflow. Batteries should be added as a secondary operation.

For illustration only. Contact Rayovac for complete specifications.

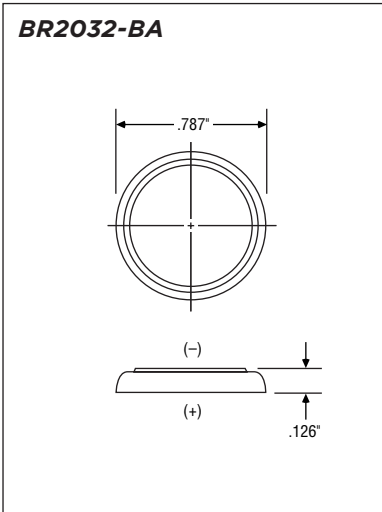


Figure 33

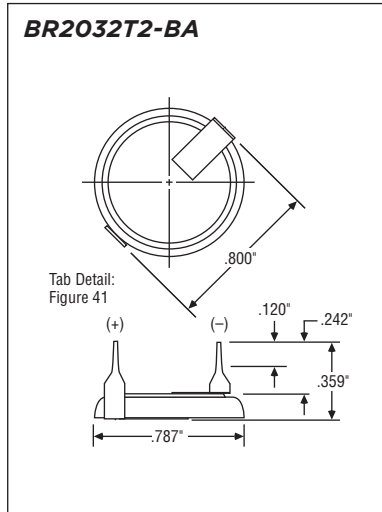


Figure 34

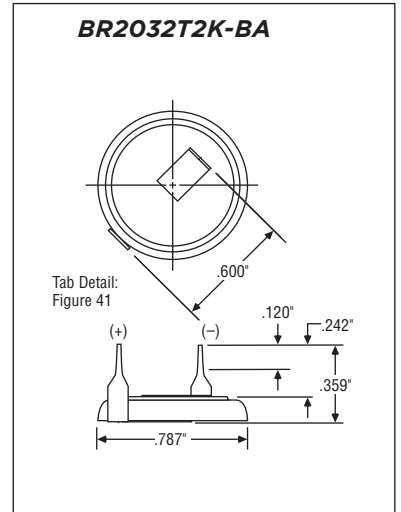


Figure 35

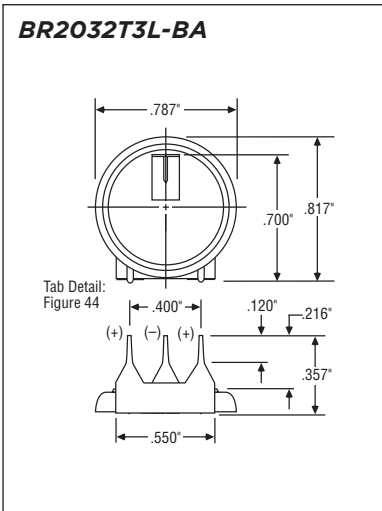


Figure 36

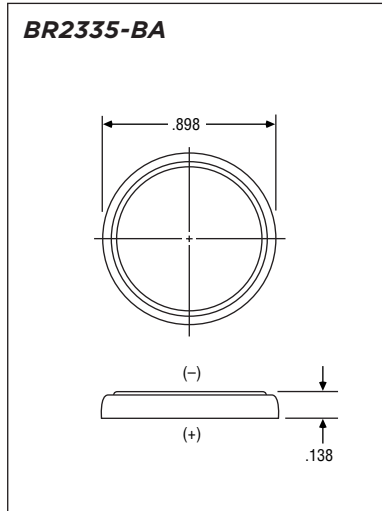


Figure 37

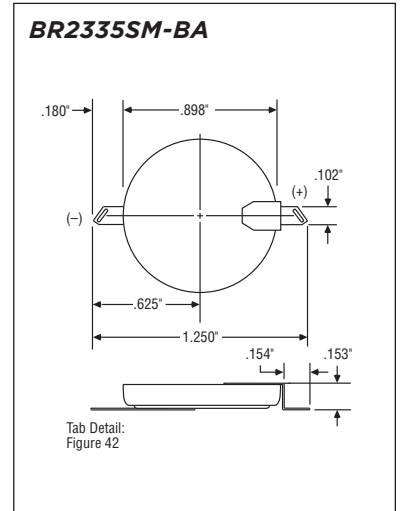


Figure 38

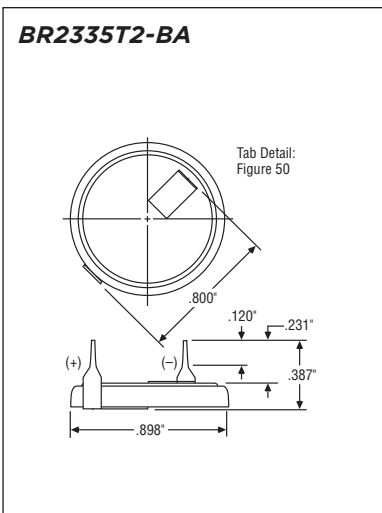


Figure 39

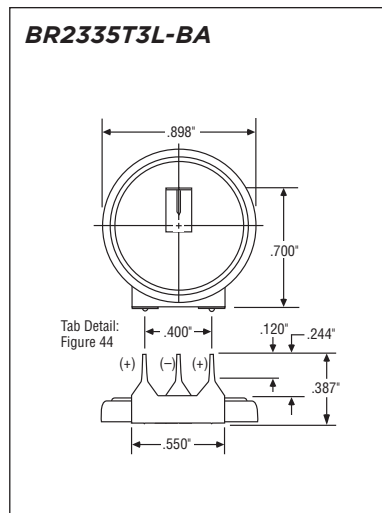


Figure 40

Please Note: Current Rayovac® BR Lithium products are not compatible with Surface Mount Technology (SMT) soldering processes due to the extreme temperatures required for reflow. Batteries should be added as a secondary operation.

Tab and Pin Detail

For illustration only. Contact Rayovac for complete specifications.

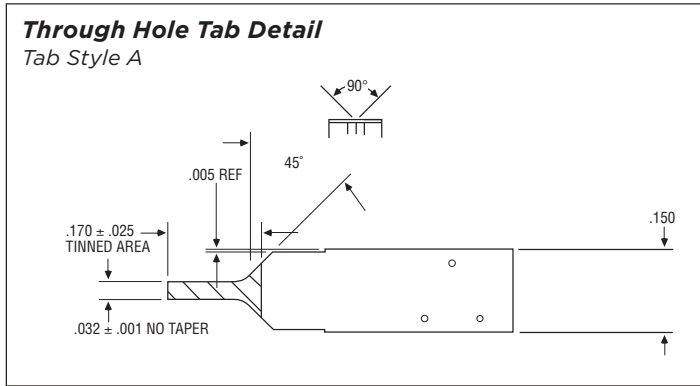


Figure 41

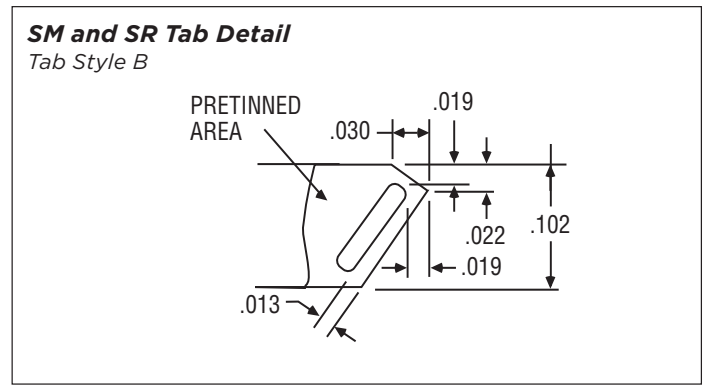


Figure 42

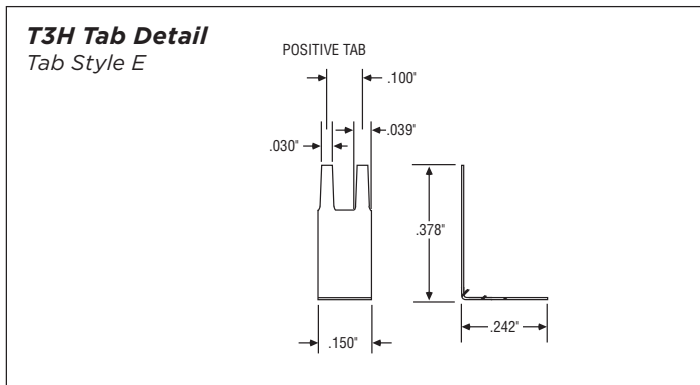


Figure 43

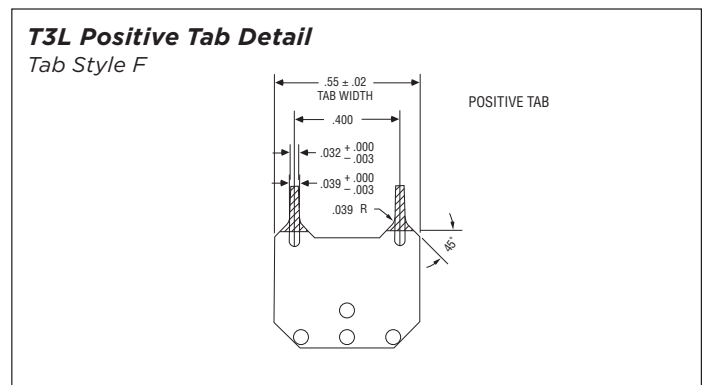


Figure 44

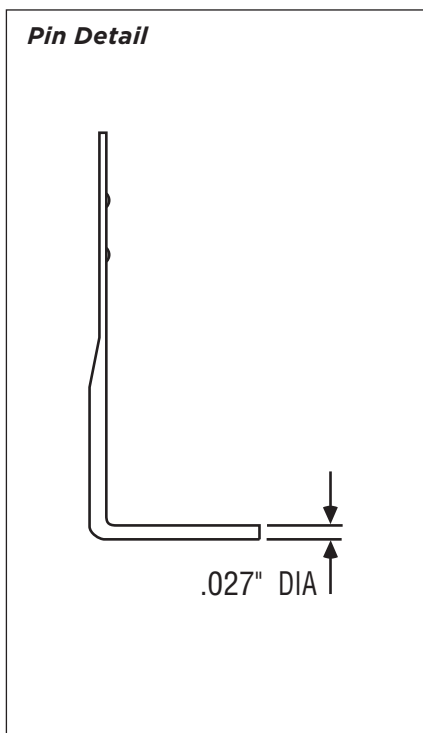


Figure 45

Please Note: Current Rayovac® BR Lithium products are not compatible with Surface Mount Technology (SMT) soldering processes due to the extreme temperatures required for reflow. Batteries should be added as a secondary operation.

X: Product Availability & Cross Reference Table

Stock Number	Description	Interchangeable Numbers	Figure Numbers	Tab Style	Case Quantity
BR1225X-BA	3.0 volt, 50 mAh coin cell	BR1225	23	N/A	1,680
BR1225T2R-B	BR1225 with 2 tabs	-	24	A	1,000
BR1225SR2-B	BR1225 Surface Mount Style	-	25	B	1,540
BR1225T2-B	BR1225 with 2 tabs	BR1225-1HB	26	A	800
BR1225SM-B	BR1225 Surface Mount Style	-	-	B	1,540
BR1225T2V-BA	BR1225 with 2 tabs - Vertical Mount	BR1225-1VB	27	A	1,690
BR1225T3H-B	BR1225 with 2 tabs, 3 stands - Horizontal Mount	-	28	E	1,000
BR1632-BA	3.0 volt, 130 mAh coin cell	-	29	N/A	740
BR1632T2-BA	BR1632 with 2 tabs	-	30	A	450
BR1632R81-BA	BR1632 Surface Mount Style	-	31	A	1,000
BR2032-BA	3.0 volt, 195 mAh coin cell	BR2032	33	N/A	680
BR2032T2-BA	BR2032 with 2 tabs	BR2032-1HE1	34	A	500
BR2032T2K-BA	BR2032 with 2 tabs	BR2032-1HSE*	35	A	539
BR2032T3L-BA	BR2032 with 2 tabs, 3 stands	BR2032-1GS**	36	F	500
BR2335-BA	3.0 volt, 300 mAh coin cell	BR2330**	37	N/A	560
BR2335SM-BA	BR2335 Surface Mount Style	-	38	B	450
BR2335T2-BA	BR2335 with 2 tabs	BR2330-1HE**	39	A	500
BR2335T3L-BA	BR2335 with 2 tabs, 3 stands	BR2330-1GU**	40	F	500
FB1225H2-B	3.0 Parallel Series, 6.0 Series	-	48	N/A	384
FB2032H2-BA	3.0 Parallel Series, 6.0 Series	-	49	N/A	150

* Suffix "A" is to designate new case quantity

* Suffix "B" designates bulk packaged

** Height difference - closest equivalent

XI: FB Lithium Carbon-monofluoride Batteries



Rayovac® FB batteries consist of two Lithium Carbon-monofluoride coin cells encapsulated within a glass filled polyester molded housing. The FB series of batteries are configured to allow for series or parallel interconnection between the cells.

FB batteries utilize Rayovac® BR Lithium Carbon-monofluoride technology to assure the greatest reliability at very wide temperatures and the lowest self-discharge rate.

A. Features

- Meets or exceeds typical hermetically sealed battery shelf life vs. temperature capability
Operating Temperature Range:
-40°C to + -100°C (-40°F to +212°F)
- PCB mountable, wave solderable, and process tolerant
- Inherently safe chemistry
- Application flexibility
- Robotically placeable

B. Typical Applications

- Time/data protection
- Industrial control
- Communication equipment
- Application flexibility
- Portable Instruments

C. Specification Table

Part Number	Nominal Voltage (volts)	Nominal Capacity (mA)	Nominal Pulse Capacity (mA*)	Dimensions				
				Width	Length	Height**	Weight	Volume
FB1225H2-B	3.0 Parallel 6.0 Series	100 Parallel 50 Series	16 Parallel 8 Series	15.9 mm (0.625")	15.9 mm (0.625")	10.3 mm (0.405")	4.2 g (0.15 oz.)	2.00 cc (6.12 in ³)
FB2032H2-BA	3.0 Parallel 6.0 Series	390 Parallel 195 Series	20 Parallel 10 Series	25.4 mm (1.000")	25.4 mm (1.000")	10.8 mm (0.425")	11.9 g (0.42 oz.)	6.14 cc (0.375 in ³)

* Consult Rayovac OEM Engineering Division for assistance in determining pulse capability for your application.

** Height above circuit board. NEDA and IEC numbers have not been assigned to FB products.

D. Typical Discharge Curves

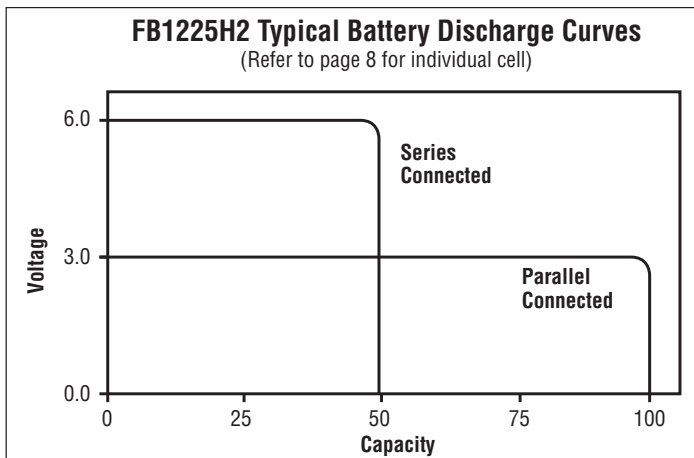


Figure 46

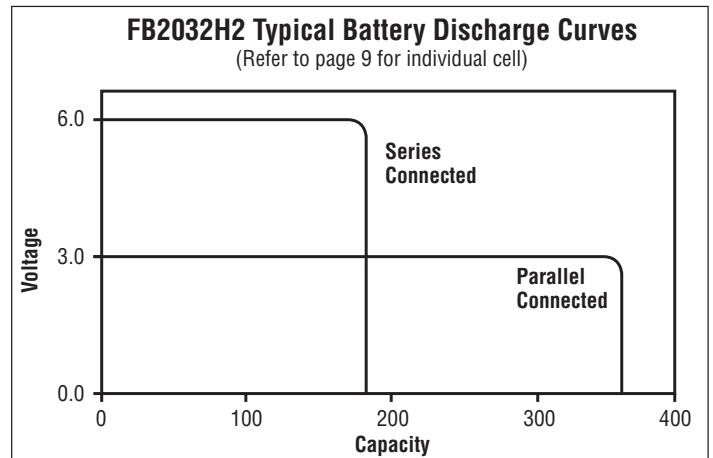


Figure 47

E. Dimensional Drawing

For illustration only. Contact Rayovac for complete specifications.

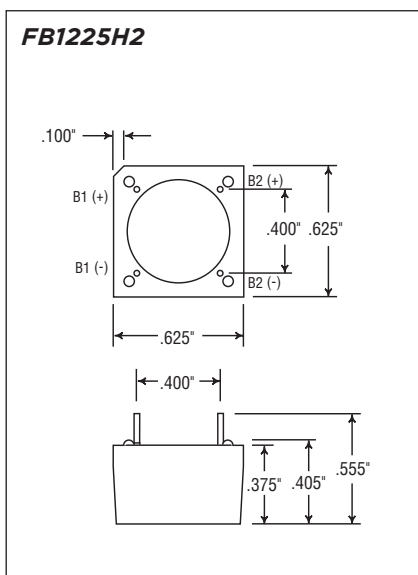


Figure 48

Conversion Chart	
Inches	Millimeters
0.100	2.5
.375	9.5
.395	10.0
.400	10.2
.405	10.3
.425	10.8
.555	14.1
.575	14.6
.625	15.9
.700	17.8
1.000	25.14

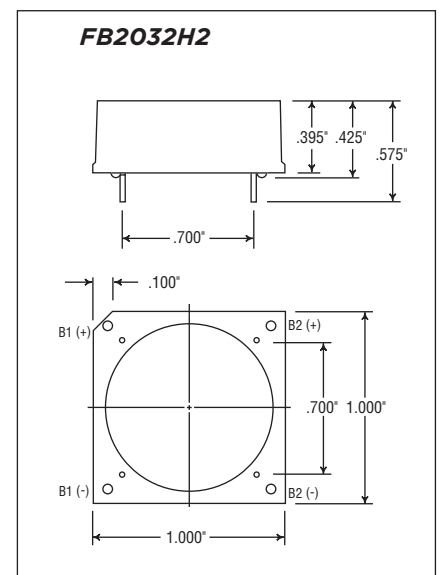


Figure 49

Please Note: Current Rayovac® BR Lithium products are not compatible with Surface Mount Technology (SMT) soldering processes due to the extreme temperatures required for reflow. Batteries should be added as a secondary operation.

XII: Recommended Storage, Handling and Disposal Procedures

A. Storage and Date Codes

BR Lithium cells and FB Lithium batteries are electrochemical devices which depend upon internal chemical reactions to produce electrical power. These reactions are accelerated by high temperatures and retarded by low temperatures. Therefore, to minimize power loss during storage, batteries should be stored at ambient temperature, 21°C (70°F). Storage at lower temperatures is not necessary nor recommended due to the possibility of shorting from moisture condensation.

To maximize battery power, the following storage procedures should be observed:

1. Rotate inventory. Maintain a first in, first out method of stock storage and usage. The manufacture date of Rayovac® cells and batteries are identified by a date code stamped on the individual products.
2. Avoid storage in high temperature areas. Make sure that cells and batteries are stored away from hot air vents, radiators, motors, and equipment that generates heat. Avoid storage near windows or skylights where the sun can generate heat.

B. General Precautions

- BR Lithium cells & FB Lithium batteries should not be inserted improperly, recharged, or disposed of in fire
- Take precautions to insure correct polarity of the battery in the device
- Recharging of batteries may cause leakage
- Never short-circuit, disassemble, or subject batteries to excessive heat
- Never expose Lithium to moisture
- Do not solder directly to battery case
- Improper welding can damage internal components and impair battery performance
- Damaged or penetrated batteries could present a fire hazard. Handle all damaged batteries with this caution in mind.

C. Handling and Shipping

Batteries are vulnerable to short circuiting if not handled, packaged, or transported properly. Cell types which have their positive and negative terminations in close proximity to each other, or tabbed cells, are particularly susceptible to short circuiting if not handled properly. In prototyping and assembly operations, care should be taken to avoid placing these products on conductive antistatic mats.

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. Whenever possible, reship the batteries in undamaged original trays and/or cartons.
2. Rayovac offers individually packaged cells and batteries, designated by a “-1” suffix on the part number. This allows for the safe handling and transport of batteries in smaller quantities.
3. Never ship batteries or completed circuit boards with installed batteries in anti-static bags as the bags are conductive and will short out the battery.
4. Use caution with measuring equipment. Insulate metal micrometers and calipers with tape to avoid short circuiting batteries during dimensional checks.
5. Make sure batteries installed in equipment are securely or permanently installed prior to packaging.

D. Transportation Regulations

Transportation of Lithium batteries is regulated by the U.S. Department of Transportation (USDOT), the International Civil Aviation Organization (ICAO), International Air Transport Association (IATA) and the UN International Maritime Organization (IMO). For Rayovac® BR and FB solid cathode Lithium metal coin cells and batteries, the quantity of Lithium metal is one of two key determinants that define the applicable regulations and requirements with the other key being the mode of transportation.

For the Lithium quantity: Rayovac® BR Lithium coin cells contain less than 0.3 grams of Lithium metal and Rayovac® FB Lithium batteries contain less than



.03 gram of Lithium metal.

All of Rayovac’s BR Lithium cells and FB Lithium batteries meet the following requirements:

1. Ground/Domestic

- a. USDOT Code of Federal Regulations, Title 49, Part 173.185.
USDOT requires a label on all shipping cartons noting the Lithium metal cells/batteries are forbidden on passenger aircraft, even on those cartons shipped only via highway, rail or vessel transportation.

These Rayovac® cells and batteries must be packaged in an inner carton and a strong shipping carton meeting the requirements of part 178, subparts L and M at the Packing Group II performance level. They must be packed in a manner to prevent short circuits including movement that could lead to short circuits.

2. Air

ICAO and IATA, these cells or batteries can qualify for Packing Instruction (PI) 968-II when shipped alone. Note this exemption only allows

one package at 2.5 kg per consignee per day. PI 968-II requires the Lithium battery warning label, Cargo Aircraft Only label and a warning letter on the carton. When shipping multiple cartons of Lithium metal cells or batteries per consignee per day see PI 968-IB. It requires the Lithium Battery warning label, Cargo Aircraft Only label, Class 9 label, UN # & proper shipping name and a warning letter on each carton. Overpacks are permitted. See PI 969 for Lithium metal cells or batteries packed with equipment and PI 970 for Lithium metal cells or batteries contained in equipment as the shipping requirements will be different.

3. Ocean

International Maritime Dangerous Goods Code (IMDG). See special provision 188 and 230. The Rayovac® cells and batteries must be packed in strong shipping cartons and packed to prevent short circuits.

4. ROHs compliant Lead Free (pb Free)

Transportation Regulations

The table below summarizes the specific requirements for each agency.

	United States	International
Regulatory Agency	U.S. Department of Transportation (DOT)	1. International Civil Aviation Organization (ICAO) 2. International Air Transportation Association (IATA)
Regulation	Title 49 CFR 173.185	IATA Dangerous Goods Regulations
Authorized Modes of Transportation	All modes (Air - by cargo aircraft only)	Air - by cargo aircraft only
Testing Required	These Rayovac® cells and batteries have passed the UN Model Regulations, Manual of Test and Criteria, Part III, subsection 38.3	These Rayovac® cells and batteries have passed the UN Model Regulations, Manual of Test and Criteria, Part III, subsection 38.3
Special Packaging	Use an inner carton inside a strong outer shipping carton	Use an inner carton inside a strong outer shipping carton. Gross weight can be no more than 2.5 kg. For PI. 968-II
Hazard Class and Required Shipping Name	UN3090, Class 9. See exceptions for smaller cells or batteries in 173.185	UN3090, Class 9 but exempted by meeting the requirements of PI 968-II
Labels Required	Forbidden on passenger aircraft - all. Lithium warning label	Lithium warning label cargo aircraft only label
Lithium Metal Limits	Cells: 1.0 gram Batteries: 2.0 grams	Cells: 1.0 gram Batteries: 2.0 grams

E. Disposal

This statement is provided as a service to those who may want information concerning the safe disposal of waste Rayovac® BR and FB (Lithium Carbon-monofluoride) battery products for the USA. These products may be distinguished from other battery products by the presence of the letters BR or FB in the product designation, and are manufactured in a disk or “coin” shape and square modules.

This information does not apply to any other Lithium chemistry or Lithium Carbon-monofluoride products in other form factors.

Note: Where regulations regarding management of spent/waste Lithium batteries exist outside of the USA, they generally differ significantly from United States regulations.

Regarding Rayovac® BR Lithium cells and FB Lithium battery waste battery management in the USA: Waste BR Lithium cells and FB Lithium batteries are neither listed nor exempted from the USEPA hazardous waste regulations. Waste BR and FB Lithium products can be considered reactive hazardous waste if there is a significant amount of unreacted, or unconsumed Lithium remaining. This potential problem may be avoided by discharging waste cells and batteries prior to disposal. One tested method for doing this is to place small quantities of BR Lithium cells or FB Lithium batteries into a metal container with sufficient graphite to cover and surround the individual cells.

This procedure will discharge the cells in approximately two weeks to the point where no reactive Lithium remains. The cells may then be disposed of as nonhazardous waste in an ordinary landfill under Federal regulations. The graphite can be reused many times, as needed, or can be disposed of as nonhazardous waste.

Other Disposal Methods

For a list of facilities with demonstrated ability to manage waste BR Lithium cells and FB Lithium battery products as hazardous waste, please click [here](#). The list is not guaranteed to be all inclusive, nor does it seek to exclude potential service suppliers. Rayovac provides it as a customer service to assist the customer in determining what their

management options could be. Always review your choice of firm before sending wastes.

Cautions

Under United States Federal law, waste generators are responsible for their wastes. Be sure to check your regional, national, or local regulations as they may differ significantly. Always remember that waste battery products may still have considerable energy remaining in them. Handle such products with care and in accordance with applicable USDOT, IATA, or ICAO regulations.

F. Soldering

Rayovac's BR and FB component class Lithium batteries are suitable for direct soldering onto printed circuit boards (PCB). A welded tab or pin soldered to a PCB will ensure the highest contact reliability available. Observe these precautions to assure life-of-product reliability:

1. Hand Soldering

Never solder directly to cell cases. The resultant heat will cause permanent internal damage to the cell. Soldering of tabbed batteries should be accomplished with a low wattage soldering iron by applying heat just long enough to achieve a good connection.

2. Wave Soldering

During the period when the battery tabs or pins are in the solder bath, the battery is short circuited. If this period is kept to under 5 seconds the battery capacity loss will be minimized. Following a short circuit the battery voltage will recover to above 2.5 volts almost immediately while full recovery to its final working voltage may take hours or even days. This characteristic must be taken into account when making electrical measurements on recovering batteries or when establishing manufacturing pass/fail points.

3. Surface Mount Technology

Rayovac offers a full line of surface mount Lithium cells configurations. These cells are indicated by the suffix “SM” or “SR” in the stock number. The surface mount batteries have configurations that allow for easy board mounting.

Current BR and FB Lithium products are not compatible with Surface Mount Technology (SMT) soldering processes due to the extreme temperatures required for reflow. Batteries should be added as a secondary operation.

Mixed technology boards that utilize both SMT and traditional through-hole components have been successfully fabricated.

These cells should not be connected in series with any other (other than the allowed number of cells in series) power source that would increase the forward current through the cells

5. The circuit for these cells should include one of the following:
 - A. Two suitable diodes or the equivalent in series with the cells to prevent any reverse (charging) current. The second diode is used to provide protection in the event that one should fail. Quality control, or equivalent procedures shall be established by the device's manufacturer to insure the diode polarity is correct for each unit.

- or -

- B. A blocking diode or equivalent to prevent reverse (charging) current, and in the event of diode failure, the cell shall be further protected against reverse (charging) current in excess of the values shown in chart to the right. The measurement of this current shall include appropriate abnormal tests.


Maximum Reverse Charging Currents for Rayovac® BR Lithium Coin Cells

Cell Models	Maximum Current (mA)
BR1225	3.0
BR1632	3.0
BR2032	3.0
BR2335	5.0
FB1225	3.0
FB2032	3.0

G. Washing

It is important that PCB wash techniques are compatible with Rayovac's Lithium BR and FB batteries. The seals of these batteries are polypropylene and solvents that attack this material should be avoided. The most common Freon types and deionized water have shown to be acceptable cleaning solvents. Rayovac should be consulted if there is any possibility of process related battery damage.

XIII: U.L. Component Recognition

Rayovac® BR Lithium batteries have been accepted by Underwriters Laboratories under their Component Recognition Program and carries U.L. File Number MH 12542. All recognized Lithium batteries can be identified by the  symbol located on the data sheet.

For use in UL listed devices, these Lithium batteries must be used in accordance to the following U.L. conditions of acceptability.

A. Conditions of Acceptability

The use of these cells may be considered generally acceptable under the conditions given below:

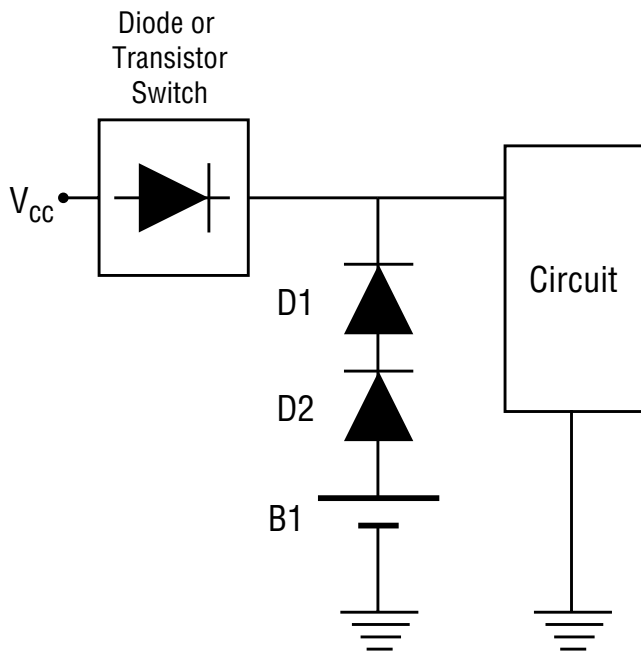
1. The cells are identified with producer's name and model designation on the cell.
2. These cells are intended for use as components in devices where servicing of the circuitry involving the cells and replacement of the Lithium cells will be done by a trained technician.
3. These cells are intended for use at ordinary temperatures where anticipated high temperature excursions are not expected to exceed 100°C (212°F).
4. These cells can be used in series up to a maximum of four cells of the same model number. When used in series, they should all be replaced at the same time using fresh cells only.

Please Note: Current Rayovac® BR Lithium products are not compatible with Surface Mount Technology (SMT) soldering processes due to the extreme temperatures required for reflow. Batteries should be added as a secondary operation.

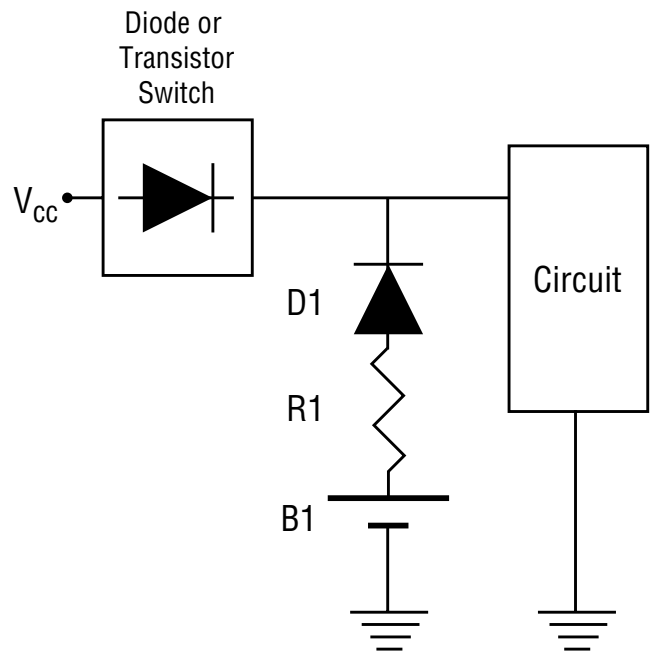
B. Protective Battery Circuits

For D1/D2 use Low reverse leakage current Silicon diodes.
Do not use low power Schottky diodes.

Protective Redundant Diodes



Protective Diodes and Limiting Resistor



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 OEM Engineering Division can furnish data that can serve as the basis for specifications.