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# **Energizer Cylindrical Alkaline** Application Manual

## Energizer Cylindrical Alkaline (Zn/MnO<sub>2</sub>) Batteries

## **System Description**

In answer to a growing need for a high rate source of portable power, Energizer technology has developed the Energizer Alkaline, Advanced Formula battery. The Energizer Alkaline system is designed to provide an economical power source for today's devices that require heavy current or continuous use. The general characteristics of the Alkaline system are:

- Better discharge rate capability than Carbon Zinc
- Lower and more stable internal resistance than Carbon Zinc
- Better low temperature performance than Carbon Zinc
- Better service maintenance than Carbon Zinc
- Higher energy density than Carbon Zinc
- More economical than Carbon Zinc in terms of cost per hour of use on high current drains
- Sloping discharge curve
- Relatively insensitive to changes in the discharge rate or duty cycle
- \* Available in voltages ranging from 1.5 to 12.0 and in a variety of shapes and sizes

## **Battery Description**

Cylindrical Alkaline batteries are produced with a high surface area zinc anode, a high density manganese dioxide cathode, and a potassium hydroxide electrolyte. A cutaway of a typical cylindrical Alkaline battery is illustrated in the following diagram:

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## EVEREADY ENERGIZER ALKALINE "D" SIZE

**Cathodes** are a mixture of high purity electrolytic manganese dioxide and carbon conductor. **Anodes** are a gelled mixture of zinc powder and electrolyte

**Separators** of specially selected materials prevent migration of any solid particles in the battery **Steel can** confines active materials and serves as the cathode collector

Brass pin serves as the anode collector

Top and bottom covers provide contact surfaces of nickel-plated steel Non-conductive plastic film label electronically insulates the battery Molded nylon seal provides a safety venting mechanism

#### Electrochemistry

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The rate capability, energy density, service maintenance and low temperature performance of the cylindrical Alkaline system are the result of an electrochemical interaction between:



- A high purity, high density cathode containing a conductive carbon matrix.
- A high purity, high surface area zinc anode.
- A highly conductive, low freezing point electrolyte solution.

The open circuit voltage of fresh cylindrical Alkaline batteries is typically 1.58 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 voltage is lowered. The energy output of Alkaline batteries is less sensitive to variation in the discharge rate and duty cycle than comparable size LeClanche or Zinc Chloride batteries. Typical D size Alkaline performance to a 0.9 volt cutoff is shown in the following diagrams:





The electrochemical inputs of cylindrical Alkaline batteries are greater than that of similar sized Carbon Zinc batteries. This additional energy, in conjunction with high efficiency, gives cylindrical Alkaline batteries a service advantage on simulated application tests of 4 to 9 times that of Carbon Zinc as shown in the following chart:



TEST	LOAD	DUTY CYCLE	E95 vs. 950 Typical Percent of Carbon Zinc Service
Motor Toy	2.2 ohms	1 hr/day	960%
Recorder	3.9 ohms	1 hr/dav	440%
Flashlight	2.2 ohms	4 min/hr, 8 hrs/day	400%
Radio	39 ohms	4 hrs/day	425%

This ability of cylindrical Alkaline batteries to deliver more energy than Carbon Zinc under continuous or heavy duty, high drain conditions is shown by the following discharge curves:



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However, as the drain rate is decreased and the duty cycle on-time reduced, the service difference between the Alkaline and Carbon Zinc systems is reduced. This reduction in the service difference is shown by the following discharge curves:



#### Temperature

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In general, changes in usage temperature affect the service of Alkaline batteries to a lesser degree than comparable size Carbon Zinc batteries.

Heavy drain is defined as current that would discharge the battery within one day at room temperature.

**Moderate drain** is defined as a current that would discharge the battery in approximately one week at room temperature.

**Light drain** is defined as a current that would discharge the battery after one month or more at room temperature.

Service on all drains after storage at high temperatures is eventually reduced by an increase in self discharge.

Because of the high purity of materials used, their basic electrochemical stability, and patented sealing techniques, Energizer Alkaline batteries exhibit excellent service maintenance characteristics. On moderate drains between a 0.75 volt and 0.9 volt Functional End Point (FEP), the following typical service maintenance can be expected at storage periods and temperatures indicated below.

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The testing of cylindrical Alkaline batteries at higher or lower discharge rates can affect the percent of retained ampere-hour capacity by approximately 5% to 10%.



While the storage of Alkaline batteries at temperatures below 21°C will increase their service maintenance, the percentage of ampere-hour capacity saved makes storage at low temperatures uneconomical under most circumstances. Storage at temperatures exceeding 21°C for sustained periods of time will significantly reduce service maintenance. However, in all cases, the high temperature service maintenance of Alkaline batteries is greater than comparable Carbon Zinc. The typical effect of storage temperature on Alkaline service maintenance is shown in the following diagram.

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#### **Internal Resistance**

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The internal resistance ( $R_i$ ) of a battery is its opposition to the flow of current. In all cases, this resistance increases as the temperature of a battery decreases. While the absolute  $R_i$  will vary with the load, the rate at which it increases in cylindrical Alkaline batteries is significantly less than that of Carbon Zinc. The  $R_i$  of a cylindrical Alkaline battery remains relatively constant until it approaches end of service life and then increases rapidly as shown in the following diagram:





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Internal resistance is typically measured in one of two ways:

- 1. As a reduction in closed circuit voltage when the applied load is increased (voltage drop)
- 2. As a maximum short circuit current (flash amps)

The  $R_j$  values obtained are subject to a number of variables and measurement techniques. The effective  $R_j$  values shown on individual data pages were calculated using the voltage drop method which projects the batteries current carrying capability in actual device applications. This calculation involves placing a battery on a constant background load, allowing it to stabilize, and then pulsing it with a heavier load for one second. The resulting voltage drop is then measured and expressed in terms of ohms as shown in the following example:

## **Determination of Internal Resistance**

## Voltage Drop Method

 $\begin{array}{l} \mathsf{R}_{j} = \text{Internal Resistance} \\ \mathsf{R}_{b} \text{ Resistance of Background Load} \\ \mathsf{E}_{b} = \text{Background Voltage} \\ \mathsf{R}_{p} = \text{Resistance at Pulse Load} \\ \mathsf{E}_{p} = \text{Voltage at End of Pulse} \\ \textbf{DE} = \text{Voltage Change} \\ \textbf{D} \ \mathsf{I} = \text{Current Change} \\ \mathsf{I}_{b} = \text{Background Current} \\ \mathsf{I}_{p} = \text{Current at End of Pulse} \end{array}$ 

Although short circuit current (flash amps) does not indicate battery freshness or potential service, circuit designers should be aware of the maximum current that a battery could supply if a component failure occurs. Given below are typical maximum flash amperage values for Energizer Alkaline batteries. These flash amp values can vary widely without affecting battery service in actual applications and will typically be 50 to 60% of maximum shown.

ΔE	
$\mathbf{h} = \mathbf{E}_{\mathbf{h}}$	

$$l_p = \underline{E}_p$$
$$R_{f}$$

$$\begin{array}{c} R_{j} = \underline{\Delta} E = \underline{E_{b}} - \underline{E_{p}} \\ \overline{\Delta} l = l_{p} - l_{b} \end{array}$$

Alkaline Battery Size	Typical Maximum Flash Amperage(total circuit resistance of 10 milliohms or less)
D	16
С	15
AA	10



AAA	9
AAAA	8
N	7
6V	20
9V	9

The exceptional current carrying capability, low and essentially constant internal resistance, shelf life and good low temperature performance of Eveready Energizer Alkaline batteries enables them to meet a wide variety of device application requirements, such as:

Heavy Duty Lighting **Camera Motor Drives** Cassette Players and Recorders Shavers Portable Radios Portable TV's Motor Toys Clocks **Remote Controlled Models** Transceivers Electronic Games **Cellular Telephones** Electronic Photoflashes Security Devices (Alarms, Smoke Detectors) **Compact Disc Players** Pagers **Portable Computers Electronic Organizers** Video Cameras

#### **Battery Testing**

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Measuring the open circuit voltage (OCV) of a battery to determine the amount of service life will yield a rough estimate. A more accurate method is to measure the closed circuit voltage (CCV) of the battery. This is accomplished by putting the battery under load for one to two seconds and measuring the CCV. If the battery voltage is greater than or equal to 1.1 volts, the battery has approximately 20% service left. The load is determined by the size and type of battery. In the case of a single cylindrical 1.5 volt Alkaline or Carbon Zinc battery, the load would be approximately 8 ohms.



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Otherwise, an OCV reading of 1.5 volts or greater for a single cylindrical 1.5 volt Alkaline or Carbon Zinc battery indicates essentially an undischarged battery or one that has been discharged less than 10%.

### Key Factors in Battery Selection

Selecting a battery can be as simple as buying one for a penlight or as complicated as specifying a source of stored energy for a satellite transmitter. Although the many types of batteries and battery systems may seem to make a proper choice difficult, the problem can be somewhat simplified by first outlining the application requirements and then selecting a battery to meet them.

#### **Application Information**

Before a battery or battery system can be specified, the minimum information that must be determined for the application is:

- Koltage
- Current Drains
- Operating Schedule
- 🔆 Required Service Life
- Service Temperatures
- Size and Weight
- Environment
- 🔆 Type of Terminals

If the equipment will not operate below a certain critical voltage, this endpoint voltage should be specified. Both initial and operating current drains may need to be specified. This, along with the discharge schedule and required service life, will determine the capacity for the battery. Service temperatures must be known because they will affect battery capacity, life or both. If the battery will be stored for any period of time before use, the length of time and the temperature should also be indicated. Allowable size and weight will sometimes determine which battery is selected in spite of other requirements.

Shock or vibration criteria may indicate the need for a rugged battery construction. Unusual rates of acceleration or high-altitude operation are also a part of the environmental considerations. Storage time and temperature under any of these conditions should be noted.

Secondary (rechargeable) system should be considered if the battery-operated devices cannot be economically powered by primary batteries.

The discussion of the basic characteristics and features of various battery systems, which can be found in the "Typical Characteristics" table located under the "Battery Information" section of the website, will indicate which system (or systems) is most suitable for the application. Ideal characteristics may not be found in any one battery design nor can the characteristics of one battery always be compared directly



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with those features of others. Therefore, optimum performance of a battery in an application can usually be best achieved by first meeting the critical needs of the application and subordinating the others.

This reference manual contains general information on all Energizer/Eveready batteries within the cylindrical Alkaline chemical system in production at the time of preparation of the manual. Since the characteristics of individual batteries are sometimes modified, persons and businesses that are considering the use of a particular battery should contact the nearest Energizer Sales Office for current information. None of the information in the manual constitutes a representation or warranty by Eveready Battery Company, Inc. concerning the specific performance or characteristics of any of the batteries or devices.

## Warnings

## Charging of Primary Batteries

Charging of primary batteries may cause explosion or leakage which may result in bodily injury. IF ENERGIZER/EVEREADY PRIMARY BATTERIES ARE SUBJECTED TO ANY FORM OF RECHARGING, ALL WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE NULL AND VOID.

#### Metal-Jacketed Batteries

It is important to note that some batteries have metal jackets. Proper design of devices using these batteries should include electrical isolation of the battery jacket from the device circuitry to prevent short circuiting. Short circuits may cause battery explosions or leakage which may result in bodily injury.

#### Plastic Film Labels

It is important to note that some batteries have plastic film labels over the metal raw cell. Proper design of devices using these batteries should include electrical insulation as well as the avoidance of burrs and/or sharp edges and corners that can cut through the plastic and result in battery shorting or inadvertent charging.

#### Other

There are many other conditions to avoid for the proper safe use of batteries. It is imperative to read the section "Design and Safety Considerations" to assure that other safety considerations are not overlooked.