Energizer Manganese Dioxide (Zn/MnO_2)
Application Manual

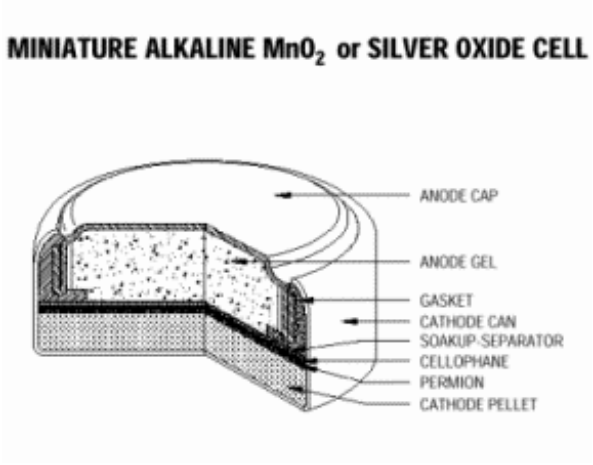
System Description:

The miniature manganese dioxide primary battery is designed to provide an economical power source for device applications that do not require the flat voltage discharge curve characteristic of mercuric and silver oxide batteries. Device applications in which miniature manganese dioxide batteries can be used as substitutes include: calculators, automatic exposure control cameras, some watches and a variety of small toys. The substitution of miniature manganese dioxide batteries for comparable mercuric or silver oxide batteries should only be made where recommended by the device manufacturer. General characteristics of the miniature manganese dioxide systems are:

- Rate sensitivity comparable to silver oxide.
- Good low temperature characteristics.
- Good resistance to shock, vibration, and acceleration.
- Excellent service maintenance; in excess of 90% after storage at 21℃(70°F) for five years.
- Low and essentially constant internal resistance.
- Lower energy density than comparable mercuric or silver oxide batteries.
- Sloping discharge curve.
- Slight bulge on completion discharge.
- Available in voltages ranging from 1.5 to 12.0 volts, in a variety of sizes.

Battery Construction:

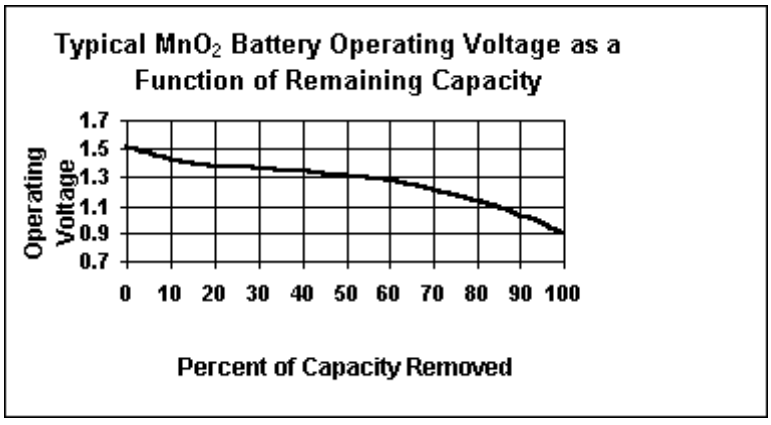
Miniature manganese dioxide batteries are produced with flat circular cathodes and homogeneous gelled anodes. A cutaway of miniature manganese dioxide battery is illustrated in the following diagram:



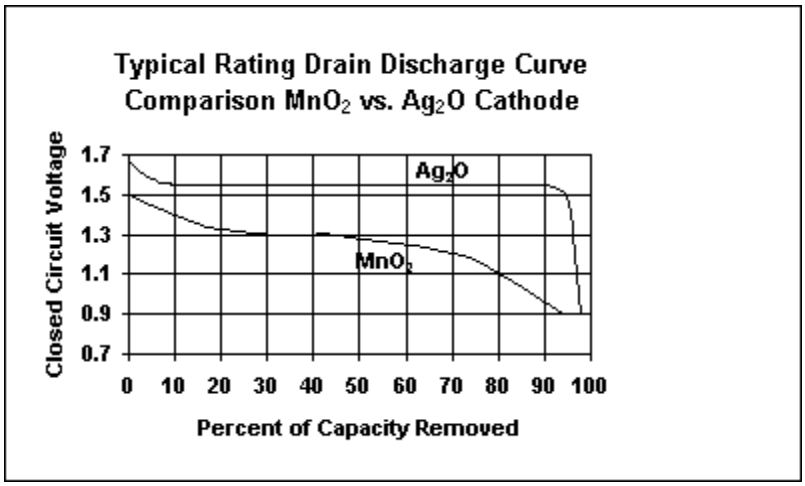
Cathodes are a mixture of MnO_2 and conductor.
Anodes are a gelled mixture of amalgamated zinc powder and electrolyte.
Separators of specially selected materials prevent migration of any solid particles in the battery.
Insulating and sealing gaskets are molded of nylon.
Exterior battery surfaces of nickel are used to resist corrosion and to insure good electrical contact.

Electro-Chemistry:

Miniature manganese dioxide batteries consist of a manganese dioxide cathode, a zinc anode of high surface area, and a highly alkaline electrolyte consisting of potassium hydroxide. The open circuit voltage of miniature manganese dioxide batteries is approximately 1.6 volts. The operating voltage at typical current drains varies with the depth of discharge of the battery as shown in the following diagram:



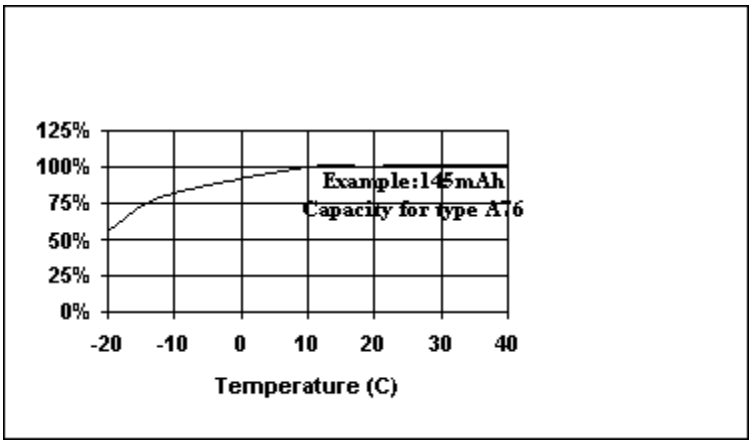
A comparison of manganese dioxide (MnO_2) service versus silver oxide (Ag_2O) is as follows:

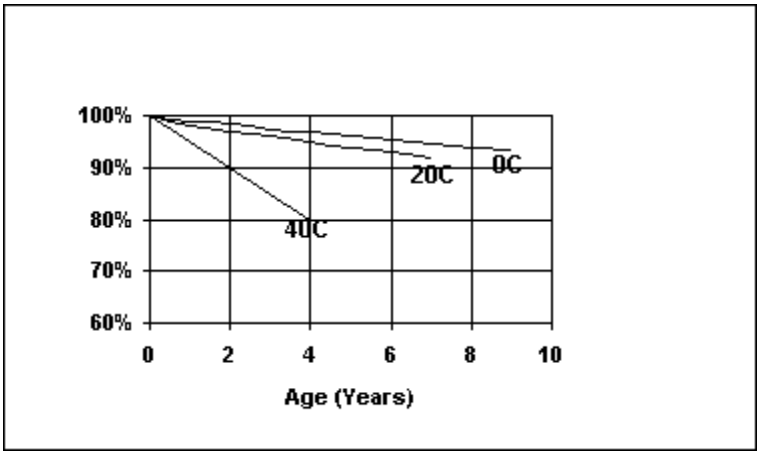


Miniature manganese dioxide batteries typically exhibit an expansion of the cathode on discharge which results in an overall increase in the battery's height. This increase in height is referred to as bulge. While miniature manganese dioxide batteries are designed to minimize bulging, they will typically bulge to a height greater than comparable silver oxide batteries during discharge. Specific bulge data is given on the following individual battery data pages.

Temperature:

Typical temperature effects on miniature dioxide batteries are shown in the following graphs:





Applications:

Manufacturers who plan to recommend the use of miniature manganese dioxide batteries in their devices must accommodate their unique discharge curve shape in the design of their equipment.

Internal Resistance:

The internal resistance (R_j) of a battery is its opposition to the flow of current. In all cases, this resistance increases as the temperature of a battery decreases.

Internal resistance is typically measured as a reduction in closed circuit voltage when a load is applied (voltage drop).

The R_j values obtained are subject to a number of variables and operator techniques. The effective R_j values shown on the following 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:

R_j = Internal Resistance

R_b = Resistance of Background Load

E_b = Background Voltage

R_p = Resistance of Pulse Load

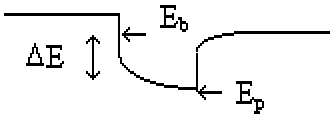
E_p = Voltage at End of Pulse

DE = Voltage Change

D I = Current Change

I_b = Background Current

I_p = Current at End of Pulse



$$I_b = \frac{E_b}{R_b}$$

$$I_p = \frac{E_p}{R_p}$$

$$R_j = \frac{\Delta E}{\Delta I} = \frac{E_b - E_p}{I_p - I_b}$$

This reference manual contains general information on all Energizer/Eveready batteries within the Manganese Dioxide 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.