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1

Introduction

Duracell pioneered the alkaline-manganese dioxide electrochemical system nearly 40 years ago. In the 1960-1970 decade, this battery system rapidly became the popular choice of designers in the ever-widening field of consumer electronics. The product information and test data included in this technical bulletin represent Duracell's newest alkaline battery products.

The zinc/potassium hydroxide/manganese dioxide cells, commonly called alkaline or alkaline-manganese dioxide cells, have a higher energy output than zinc-carbon (Leclanche) cells. Other significant advantages are longer shelf life, better leakage resistance, and superior low temperature performance. In comparison to the zinc-carbon cell, the alkaline cell delivers up to ten times the ampere-hour capacity at high and continuous drain conditions, with its performance at low temperatures also being superior to other conventional aqueous electrolyte primary cells. Its more effective, secure seal provides excellent resistance to leakage and corrosion.

The use of an alkaline electrolyte, electrolytically prepared manganese dioxide, and a more reactive zinc powder contribute to a higher initial cost than zinc-carbon cells. However, due to the longer service life, the alkaline cell is actually more cost-effective based upon cost-per-hour usage, particularly with high drains and continuous discharge. The high-grade, energy-rich materials composing the anode and cathode, in conjunction with the more conductive alkaline electrolyte, produce more energy than could be stored in standard zinc-carbon cell sizes.

2

General Characteristics

The general characteristics listed below are a summary of the significant benefits of the alkaline manganese dioxide system. Each of the benefits is explained in greater detail subsequently in Section 5. This summary provides the designer with general guidelines for evaluating the alkaline-manganese dioxide system for a particular application.

Benefits include:

- Up to ten times the service life of regular zinc-carbon cells.
- Long service life at continuous, high drain discharge.
- No need for "rest periods."
- Low internal resistance.
- Rugged, shock-resistant construction.
- Cost-effective on a cost-per-hour-of-service basis.
- Good low temperature performance.
- Excellent leakage resistance.
- Long shelf life.
- Worldwide availability at retail.

3

Composition and Chemistry

The composition and chemistry of the alkaline-manganese dioxide cells described in Sections 3.1 through 3.4 are typical for all alkaline products.

3.1 Active Components

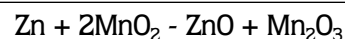
The chemically active components are:

Anode: High purity zinc powder

Cathode: Electrolytically produced manganese dioxide

Electrolyte: Concentrated potassium hydroxide solution

During cell discharge, the oxygen-rich manganese dioxide is reduced and the zinc becomes oxidized, while ions are being transported through conductive alkaline electrolyte. The simplified cell reaction is:



3.2 Anode

The anode material of the alkaline cell is a powdered zinc metal. Manufacturing of the zinc powder is carefully controlled to ensure chemical purity and correct particle size, resulting in good surface area available during the cell reaction. This increased surface area provides greater particle to particle contact within the anode, thereby lowering the cell's internal

resistance, generating higher power density.

Keeping pace with regulatory requirements worldwide, environmentally responsive anode designs have been implemented by Duracell. Contact your local Duracell sales representative for the latest information on these designs.

3.3 Cathode

The cathode material of the cell is a powdered manganese dioxide (MnO_2), produced synthetically through an electrolytic process. Its purity and oxygen availability are far superior to the natural material. This contributes to the cell's increased energy density and performance.

Additives are used in the major cathode components to enhance performance capability. For example,

graphite is mixed with the manganese dioxide to improve conductivity. When mixed with the other ingredients, the electrolytic manganese dioxide provides a cathode of excellent conductivity to assure good cell performance over a wide range of temperatures and discharge rates.

3.4 Electrolyte

The electrolyte consists of a concentrated aqueous solution of potassium hydroxide (KOH) to which zinc oxide is added to retard corrosion of the zinc. This inhibits the dissolution of the zinc anode and extends the shelf life. In some cell designs, a gel-type electrolyte is formed by the addition of a gelling agent.

This electrolyte is alkaline (basic) in contrast to the electrolyte of regular zinc-carbon cells, which is acidic. The concentrated potassium hydroxide solution offers high ionic mobility with a low freezing point.

4 Construction

Although the active materials in alkaline cells are basically the same as in zinc carbon cells, the significant differences are in the electrolyte and cell construction. Its more sophisticated design, combined with the alkaline electrolyte, accounts for its superior performance.

The construction of alkaline-manganese dioxide cells and batteries explained in Sections 4.1 through 4.3 are specific to the products manufactured or distributed by Duracell.

4.1 Cylindrical Cell Construction

A typical cell is designed with active materials and alkaline electrolyte contained in a nickel plated steel can. The manganese dioxide cathode powder mix is pressed against the inner surface of the steel can by one of two processes: pressing the loose cathode powder against the inner steel wall under high pressure; or by preforming the loose cathode powder into high density annular pellets which are inserted into the can and then recompact to make contact with the cell wall. With this intimate cathode-to-cell wall contact, the steel case becomes the cathode current collector and serves as the positive terminal of the cell.

A precise amount of the zinc anode powder is dispensed into the center cavity, located in such a manner as to ensure desired capacity and surface area (a gelling agent is used to help control porosity of the zinc anode structure).

An anode current collector, welded to the external anode cap, extends through a plastic cap into the center of the anode powder mix maintaining intimate contact.

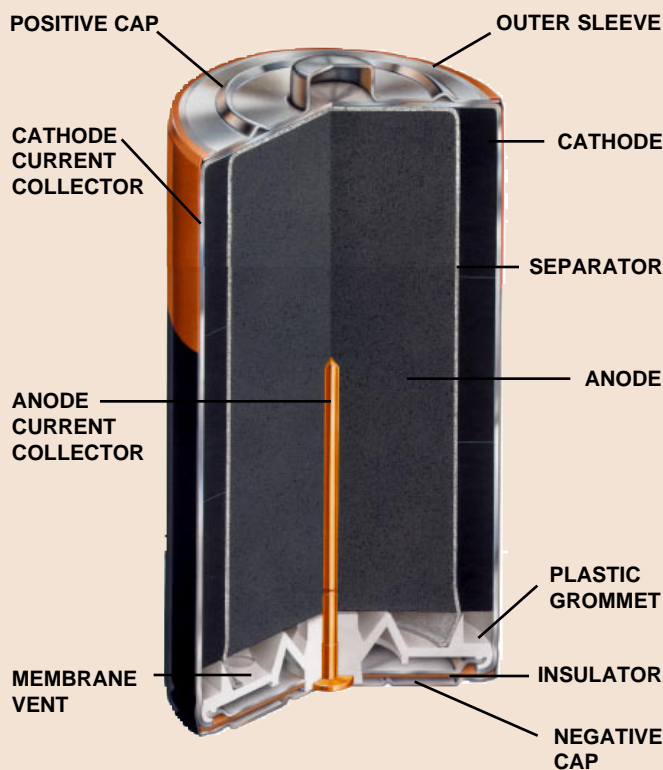
The separator is an essential component which isolates the electrodes. It is a highly absorbent, ion-permeable, and chemically inert material which blocks the migration of anode particles and prevents self-discharge of the cell during periods of non-use.

The porous nature of the anode, cathode, and separator materials allows them to be thoroughly saturated with the alkaline electrolyte solution. The high conductivity of the electrolyte enables the cell to perform well at high discharge rates and continuous service. It is also responsible for the low internal resistance and good low temperature performance.

A plastic cap or grommet is sealed to the cell case by means of radial crimping pressure and a sealant. This resilient material ensures a tight seal to prevent loss of electrolyte. The anode cap is isolated from the positive cell case with an insulator.

A vent mechanism is incorporated into the plastic grommet to protect against cell rupture and damage in the event of misuse under abusive conditions. This vent is designed to relieve excessive gas pressure that may be generated by prolonged short-circuiting, improper disposal in fire, charging, or incorrect insertion in devices. Shown in **Figure 1** is a cutaway of a DURACELL® cylindrical alkaline cell.

Figure 1



DURACELL® cylindrical alkaline cell.

Construction (cont.)

4.2 Multicell Construction

Multicell DURACELL alkaline batteries are designed with two or more alkaline cells in series or parallel connection. All series and parallel connections, as well as cell-to-terminal connections, are welded using a nickel-plated steel tab material. This all-welded

construction enhances the reliability of the battery's performance in comparison to pressure-type contacts. The battery assembly cases are typically made of injection molded plastic or steel.

4.3 Button Cell Construction

The button cell construction consists of an anode subassembly, cathode subassembly and a separator to form a layered design. The anode subassembly includes the cell top, which is made of a bimetal laminate of nickel-plated steel and either copper or tin; a plastic grommet, used to insulate the positive and negative terminals; a pelleted zinc anode, which is placed inside the top; and an absorbent material saturated with electrolyte.

The cathode subassembly includes the cell can; the manganese dioxide cathode consolidation; and a barrier/separator, which allows current to flow but blocks any migration of material.

The cathode subassembly is placed over the anode subassembly and is sealed by crimping the edge of the can over the grommet.

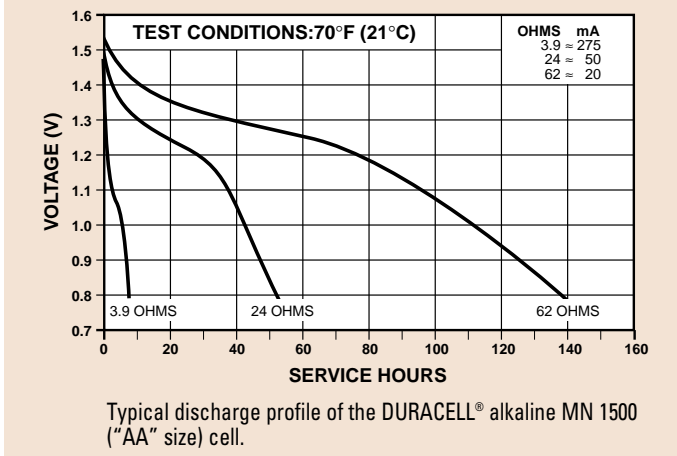
5 Performance Characteristics

The performance characteristics described in Sections 5.1 through 5.9 are those characteristics specific to the alkaline-manganese dioxide products manufactured and distributed by Duracell. The performance data shown is taken from actual test conditions. Conversions, shown in parentheses, are given for reference purposes only.

5.1 Voltage

Open circuit voltage ranges from 1.5 to 1.6 volts. Nominal voltage is 1.5 volts. Operating voltage is dictated by the state-of-discharge and the actual load imposed by the equipment. The voltage profile under discharge is a sloping curve as seen in **Figure 2**. In most instances, 0.8 volts is considered to be the end-voltage.

Figure 2



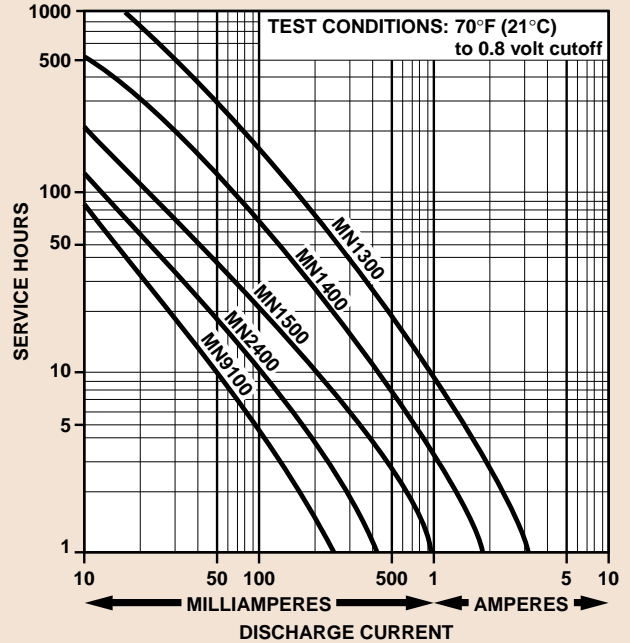
Typical discharge profile of the DURACELL® alkaline MN 1500 ("AA" size) cell.

5.2 Capacity

Capacity is usually expressed in ampere-hours or milliampere-hours. In any given continuous drain application, the average current flowing multiplied by the hours of service equals the rated capacity of the cell. Alkaline cells and batteries are available in button (45 mAh to 110 mAh) and in cylindrical (580 mAh to 15,000 mAh) configurations.

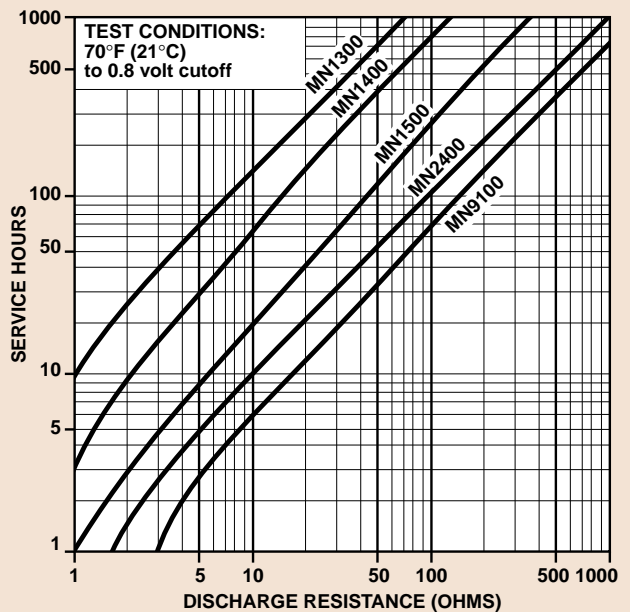
Figure 3 illustrates the typical discharge characteristics of the major cell types when discharged at a constant current at 70°F (21°C) to a voltage cutoff of 0.8 volts. **Figure 4** illustrates typical discharge characteristics when discharged at constant resistance at 70°F (21°C) to a 0.8 volt cutoff.

Figure 3



Typical discharge characteristics with constant current of DURACELL® alkaline cells.

Figure 4



Typical discharge characteristics with constant resistance of DURACELL® alkaline cells.

Performance Characteristics (cont.)

5.3 Type of Discharge

A battery may be discharged under different modes depending on the equipment load. The type of discharge mode selected will have a significant impact on the service life delivered by a battery in a specified application.

Three typical modes under which a battery may be discharged are;

1. Constant Resistance (“R”): In this mode, the resistance of the equipment load remains constant throughout the discharge

2. Constant Current (“C”): In this mode, the current drawn by the device remains constant during the discharge

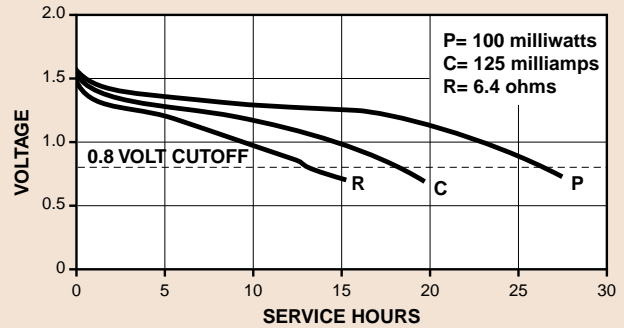
3. Constant Power (“P”): In this mode, the current during the discharge increases as the battery voltage decreases, thus discharging the battery at a constant power level. (Power = Current x Voltage)

The discharge profiles of a battery under the three different modes are plotted in **Figures 5, 6 and 7**. **Figure 5** shows the voltage profile; **Figure 6**, the current profile; and **Figure 7**, the power profile during the discharge of the battery.

Electrical devices require a minimum input power to operate at their specified performance level. The data in **Figures 5, 6 and 7** are based on the discharge of a “AA” size alkaline-manganese dioxide battery (MN1500). At the end of the discharge when the battery reaches its end-of-life, the power output is the same for all of the discharge modes and is at the level required for acceptable equipment performance. In the example shown, the minimum power level is 100 milliwatts and the battery end-of-life or cutoff voltage is 0.8 volts. During the discharge, the power output equals or exceeds the power required by the equipment until the battery reaches its end-of-life.

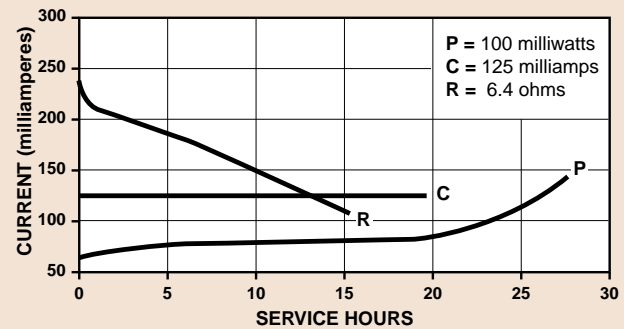
In the constant resistance discharge mode, the current during the discharge (**Figure 6**) follows the drop in the battery voltage (**Figure 5**). The power, $I \times V$ or V^2/R , drops even more rapidly, following the square of the battery voltage (**Figure 7**). Under this mode of discharge, to assure that the required power is available at the end-of-battery-life, the current at 0.8 volts is 125 milliamperes. As a result, the levels of current and power during the discharge are in excess of the minimum

Figure 5



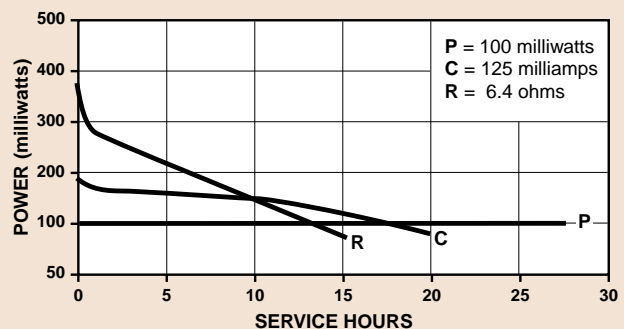
Voltage profile under different modes of discharge

Figure 6



Current profile under different modes of discharge

Figure 7



Power profile under different modes of discharge

Performance Characteristics (cont.)

required. The battery discharges at a high current, draining its ampere-hour capacity rapidly and excessively, resulting in a short service life.

In the constant current mode, the current is maintained at a level (125 milliamperes) such that the power output at the end of the discharge is 100 milliwatts, the level required for acceptable equipment performance. Thus, both the current and power throughout the discharge are lower than that for the constant resistance mode. The average current drain on the battery is lower and the discharge time, or service life, to the end-of-battery-life is longer.

In the constant power mode the current is lowest at the beginning of the discharge and increases as the battery voltage drops to maintain a constant power output at the level required by the equipment (100 milliwatts). This discharge mode requires the lowest average current drain and, hence, delivers the longest service time.

Under the constant power mode, the battery can also be discharged below its end voltage. With suitable power regulator circuitry, the current can be increased at these lower battery voltages, maintaining the required power output. The constant power mode provides the most uniform equipment performance throughout the life of the battery and makes for the most efficient use of the battery's energy.

It should be noted that the advantage of the constant power discharge mode over the other modes of discharge is greatest with batteries that have a sloping discharge, such as the alkaline-manganese dioxide cell, as compared with those having a flat discharge characteristic.

5.4 Effect of Temperature

The alkaline-manganese dioxide system is best suited for use over a temperature range of -4°F to 130°F (-20°C to 54°C). At lighter loads, some output can be obtained at temperatures as low as -20°F (-30°C). Actual service depends on cell size and current drain. For most cells, up to 75 percent of the rated capacity at room temperature can be delivered at 32°F (0°C).

The graph in **Figure 8** illustrates how cell size and current drain affect performance over a range of temperatures. As current drain increases, temperature impact becomes more dramatic. Low temperature

Figure 8

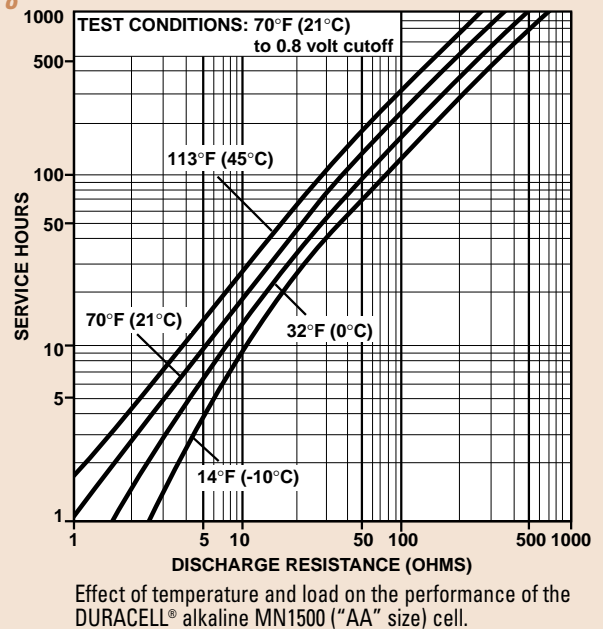


Figure 9

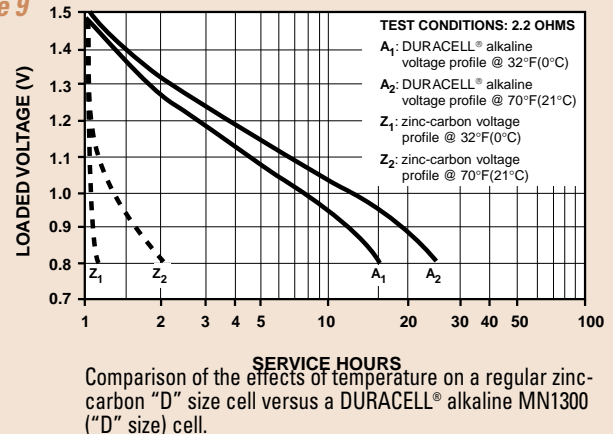
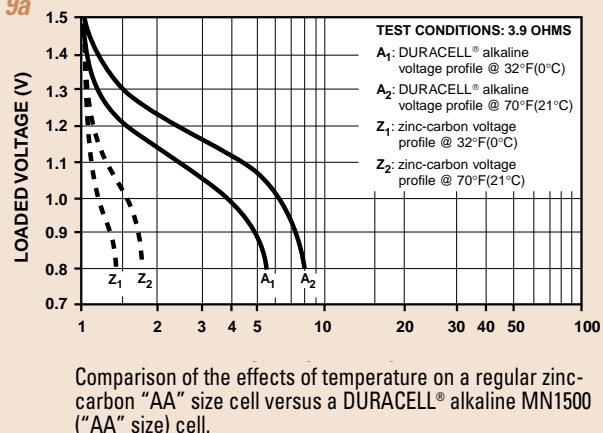


Figure 9a



Performance Characteristics (cont.)

performance of alkaline and regular zinc-carbon cells is compared in **Figure 9**, showing the “D” size cell at 70°F (21°C) and 32°F (0°C). **Figure 9a** shows “AA” cell performance under the same conditions. The alka-

line cell will maintain a higher voltage for considerably longer than the regular zinc-carbon cell, resulting in a service life at lower temperatures which is up to ten times that of the regular zinc-carbon cell.

5.5 Internal Resistance

Alkaline cells, because of their compact construction and highly conductive electrolyte, have low internal resistance, usually less than 1 ohm. The low internal resistance characteristic is a benefit in applications

involving high current pulses. Unlike regular zinc-carbon cells, alkaline cells do not require rest periods between pulses and maintain their low internal resistance, increasing only at the very end of useful life.

5.6 Energy Density

Energy density is a measure of available energy in terms of weight and volume. It is the ratio of a cell's capacity to either its volume or weight and can be used to evaluate a cell's performance.

Table 1 is a summary of the major alkaline product types comparing both volumetric energy density and gravimetric energy density. Volumetric energy density

is an important factor where battery size is the primary design consideration. Gravimetric energy density becomes important where weight of the battery is critical, such as in portable computers and cellular phones. The values shown in this table are typical for each cell size. Actual energy output will vary, dependent mostly on drain rates applied.

PRODUCT NUMBER	SIZE	NOMINAL VOLTAGE	RATED CAPACITY*	LOAD	WEIGHT		VOLUME		TYPICAL GRAVIMETRIC ENERGY DENSITY**		TYPICAL VOLUMETRIC ENERGY DENSITY	
		volts	ampere-hours	ohms	pounds	kilograms	cubic inches	liters	watt-hours per pound	watt-hours per kilogram	watt hours per cubic inch	watt hours per liter
MN1300	D	1.5	15.000	10	0.304	0.138	3.440	0.056	59.2	130	5.2	322
MN1400	C	1.5	7.800	20	0.143	0.065	1.640	0.027	65.5	144	5.7	347
MN1500	AA	1.5	2.850	43	0.052	0.024	0.510	0.008	65.8	143	6.7	428
MN2400	AAA	1.5	1.150	75	0.024	0.011	0.230	0.004	57.5	126	6.0	345
MN9100	N	1.5	0.800	100	0.021	0.010	0.210	0.003	45.7	96	4.6	320
7K67	J	6.0	0.580	340	0.075	0.034	0.960	0.016	37.2	82	2.9	174
MN908	Lantern	6.0	11.500	15	1.349	0.612	30.620	0.502	40.9	90	1.8	110
MN918	Lantern	6.0	24.000	9	2.800	1.270	75.880	1.243	41.1	91	1.5	93
MN1604	9V	9.0	0.580	620	0.101	0.046	1.390	0.023	41.4	91	3.0	182

* TO 0.8V per cell at 21°C (70°F).

** Based on 1.2 volt average operating voltage per cell at 21°C (70°F).

Table 1. Comparison of typical energy densities of major DURACELL® alkaline cells/batteries.

To determine the practical energy density of a cell under specific conditions of load and temperature, multiply the ampere-hour capacity that the cell delivers under those conditions by the average discharge voltage, and divide by cell volume or weight.

Gravimetric Energy Density:

$$\frac{(\text{Drain in Amperes} \times \text{Service Hours}) \times \text{Average Discharge Voltage}}{\text{Weight of cell in Pounds or Kilograms}} = \frac{\text{Watt-Hours}}{\text{Pound or Kilogram}}$$

Volumetric Energy Density:

$$\frac{(\text{Drain in Amperes} \times \text{Service Hours}) \times \text{Average Discharge Voltage}}{\text{Volume of cell in Cubic Inches or Liters}} = \frac{\text{Watt-Hours}}{\text{cubic Inch or Liter}}$$

Performance Characteristics (cont.)

Using the MN1300 data from **Table 1** the previous equations can be used to determine energy density for this cell.

Gravimetric Energy Density:

$$\frac{15.00 \text{ Ampere-Hours} \times 1.2 \text{ Volts}}{0.304 \text{ Pounds (0.138 Kilograms)}} = \frac{59.2 \text{ Watt-Hours}}{\text{Pound}} \text{ or } \frac{130.4 \text{ Watt-Hours}}{\text{Kilogram}}$$

Volumetric Energy Density:

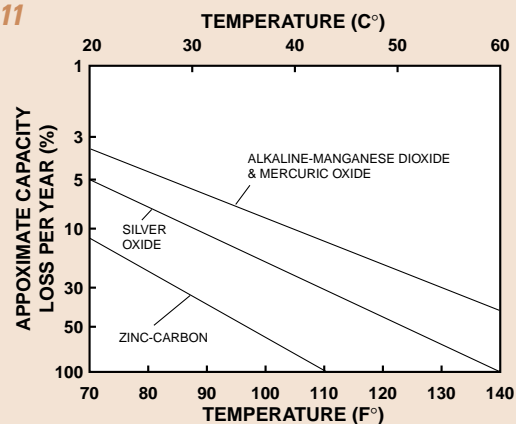
$$\frac{15.00 \text{ Ampere-Hours} \times 1.2 \text{ Volts}}{3.44 \text{ Cubic Inches (0.563 Liters)}} = \frac{5.23 \text{ Watt-Hours}}{\text{Cubic Inch}} \text{ or } \frac{320 \text{ Watt-Hours}}{\text{Liter}}$$

5.7 Shelf Life

Alkaline cells have long shelf storage life. After one year of storage at room temperature, cells will provide 93 to 96 percent of initial capacity. When stored for four years at 70°F (21°C), service of about 85 percent is still attainable. Storage at high temperatures and high humidity will accelerate degradation of chemical cells. At low temperature storage, the chemical activity is retarded and capacity is not greatly affected. Recommended storage conditions are 50°F (10°C) to 77°F (25°C) with no more than 65 percent relative humidity.

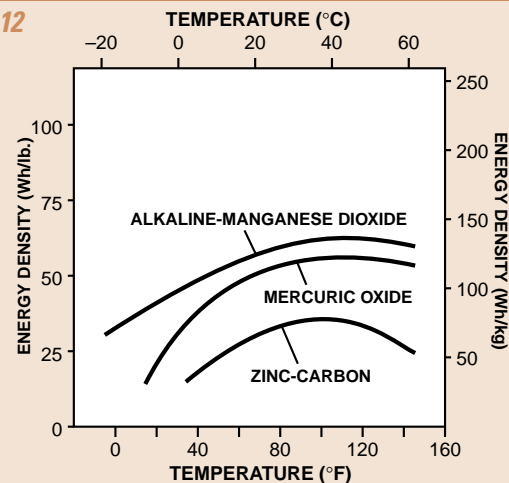
Figure 11 compares various DURACELL® zinc anode systems and the effect of temperature on capacity retention. At room temperature, the alkaline system loses approximately 5 percent capacity after one year of storage. Subsequent capacity loss is approximately 2 percent per year. By comparison, zinc-carbon cells lose nearly 15 percent capacity per year at room temperature. As the temperature elevates, capacity losses increase. At temperatures above 113°F (45°C), the regular zinc-carbon cells will be completely discharged within one year, whereas the alkaline system will still retain approximately 80 percent of its original capacity.

Figure 11



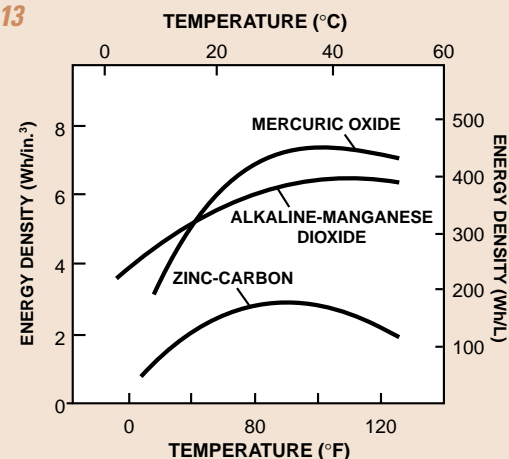
Effect of temperature on capacity retention for various DURACELL® zinc anode systems

Figure 12



Gravimetric energy density comparison of zinc anode systems.

Figure 13



Volumetric energy density comparison of zinc anode systems.

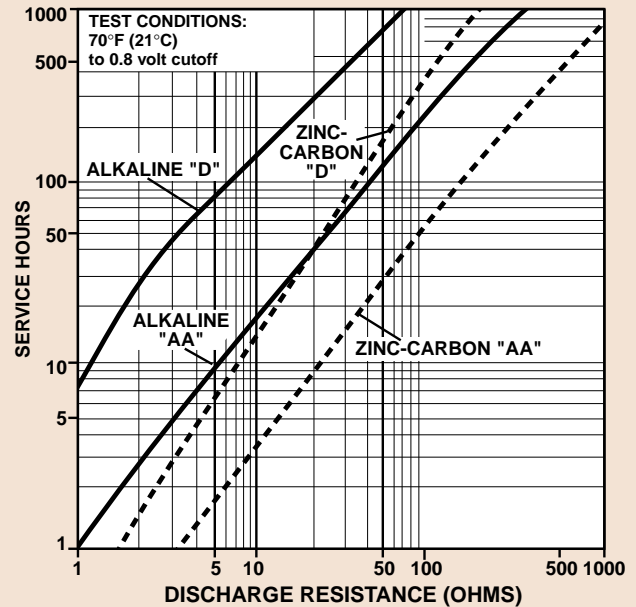
Performance Characteristics (cont.)

5.8 Comparison of Zinc-Carbon and Zinc-Alkaline

In **Figures 12 and 13**, comparisons are made between the DURACELL® alkaline-manganese dioxide system and several other zinc anode systems, showing the effect of temperature on both gravimetric energy density and volumetric energy density.

Another comparison, showing the effect of discharge load on the cell's capacity and how this can influence the selection of a battery for an application, is illustrated in **Figure 14**. The regular zinc-carbon cell performs efficiently under light discharge loads, but its performance falls off sharply with increasing discharge rates. The alkaline system has a higher energy density at light loads and does not drop off as rapidly with increasing discharge loads. For low-power applications, the service ratio of alkaline compared to regular zinc-carbon is in the order of 2:1. At heavier loads, such as those required for toys, motor-driven applications, and pulse discharges, the ratio can widen to 8:1 or greater. At these heavy loads, alkaline batteries are preferred on both a performance and cost basis.

Figure 14



Comparison of the typical discharge characteristics of regular zinc-carbon "D" and "AA" size cells versus DURACELL® alkaline "D" (MN1300) and "AA" (MN1500) size cells.

5.9 Cost Effectiveness

The impact of the discharge rate and duty cycle on the cost of battery operation is shown in **Table 2** which compares the service life and cost-per-hour of service of regular zinc-carbon cylindrical cells with alkaline-

manganese dioxide cells under various loads. The relative cost-per-service-hour column shows the cost savings resulting from the use of alkaline-manganese dioxide batteries versus zinc-carbon batteries in each application.

BATTERY TYPE	TEST*	ACTUAL SERVICE HOURS		RELATIVE COST PER SERVICE HOUR	
		ZINC-CARBON	ALKALINE	ZINC-CARBON	ALKALINE
D	Flashlight: 2.2 ohms	3.7	20.5	1	.56
C	Toy: 3.9 ohms	2.2	20.8	1	.33
AA	Flashlight: 3.9 ohms	1.1	6.2	1	.41
AA	Tape Player: 10 ohms	3.5	17.4	1	.47
Relative Cost Ratios		0.35	1.0		

* Test conditions: D - Flashlight - 2.2 ohms, 4 minutes/hour to 0.9 volts.
AA - Flashlight - 3.9 ohms, 4 minutes/hour to 0.9 volts.

C - Toy - 3.9 ohms, 1 hour/day to 0.8 volts.
AA - Tape Player - 10 ohms, 1 hour/day to 0.9 volts.

Table 2. Impact of discharge rate and duty cycle on the cost of battery operation.

6 Applications

DURACELL[®] alkaline batteries—with their superior drain rate characteristics, good shelf storage life, low internal resistance, and wide operating temperature range—are a popular choice for many portable power applications. The most common uses are found in the consumer market, in applications such as photographic equipment, remote control devices, toys, electronic games, flashlights, tape recorders, home health care devices, radios, shavers, clocks, calculators, and computers.

Alkaline cells also have significant application presence in the industrial and government sectors. Some industrial applications include portable medical and

industrial instrumentation, portable and emergency lighting products, communications equipment, and portable electrical measurement devices. Military applications include a variety of communication devices and general instrumentation.

Duracell is actively involved in the development of battery products that can power applications currently utilizing rechargeable batteries or AC power, such as notebook computers, handheld cellular phones, camcorders, power tools, and more. The goal of this development program is to provide customers with a primary battery option where needed.

7 Battery Care

7.1 Storage Conditions

Batteries should be stored at temperatures between 50°F (10°C) and 77°F (25°C), with relative humidity not exceeding 65 percent. Refrigeration of alkaline batteries is not necessary because of their very

good capacity retention. Excessive temperature cycling and storage at temperatures greater than 77°F (25°C) should be avoided to maximize shelf life.

7.2 Proper Usage and Handling

Discharged batteries should be removed from equipment to prevent possible damage. Batteries should be removed from a device when it is not expected to be in use for several months. Batteries should also be removed from equipment while it is being powered by household (AC) current. Always replace all batteries at the same time since batteries in series, in different states of discharge, may eventually drive the weakest battery into voltage reversal with progressive risk of leak age or rupture. Mixing battery systems, such as

alkaline with zinc-carbon, may also result in voltage reversal and should be avoided.

Always replace the battery or batteries in your equipment with the size and type of battery specified by the equipment manufacturer.

Keep batteries away from small children. If swallowed, consult a physician at once. (For information on treatment, telephone the National Capital Poison Center, Washington, D.C., at 202-625-3333 collect.)

7.3 Charging

All batteries listed in this bulletin are of the primary type and are not designed to be recharged. Attempts to recharge an alkaline battery may cause an

imbalance within the cell, leading to gassing and possibly explosion on either charge or discharge cycles.



8.1 Disposal Procedures for Alkaline-Manganese Dioxide Cells and Batteries

The disposal of waste products in the United States is regulated by the U.S. Environmental Protection Agency. The EPA Regulations are listed in the “Code of Federal Regulations”, CFR40, entitled “Protection of Environment.” Individual states and local communities also may establish regulations covering the disposal of waste products. These may be more stringent than the federal regulations and cover the disposal of household waste, which is not included in federal regulations. Thus, state and local agencies should be contacted for their disposal guidelines.

The U.S. EPA has not provided any specific regulations or guidelines for the disposal of alkaline-manganese dioxide cells and batteries. As a result, a number of state and local governments recently have passed or are considering legislation which may require separation, collection or other special procedures for the disposal of batteries, particularly for those that contain heavy metals. Internationally, procedures vary from country to country.

In the absence of specific regulations or guidelines, the following is recommended for the disposal of DURACELL® alkaline-manganese dioxide cells and batteries.

A. Batteries in Household Use:

Individual alkaline-manganese dioxide cells and batteries can be disposed of with other household waste.

B. Commercial Quantities:

The recommended procedure for disposal of alkaline-manganese dioxide cells and batteries is in a hazardous waste landfill. Since these cells are not classified as a “hazardous waste”, they can be shipped to the hazardous waste facility as a “non-hazardous” waste. Local regulations, which may specify other methods for the disposal of these batteries, supercede these recommendations.

Waste management companies can provide assistance in the disposal of these batteries.

8.2 Collection and Handling

Commercial or bulk quantities of alkaline-manganese dioxide cells and batteries should be collected and transported in a manner to prevent short circuit, compacting or mutilation, or any other abusive physical or electrical handling that would destroy their physical

integrity. They should not be exposed to fire or high temperatures. Exposure of these cells to high temperatures or fire can cause the cells to leak, vent and/or explode.

8.3 Storage

Alkaline-manganese dioxide batteries should be stored in a well-ventilated, covered area, preferably

using relatively small, heat-resistant plastic containers. Containers should not be hermetically sealed.

8.4 Shipment

DOT and EPA do not provide guidelines for the shipment of alkaline-manganese dioxide cells and batteries to a disposal site. Your state and/or local regulatory agency should be contacted as they may have established such guidelines or regulations.

Note: Guidelines for the disposal of alkaline-manganese dioxide cells and batteries are continually under review. Duracell can be contacted if additional guidance is required.