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6<sup>th</sup> Grade Science

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## **Which Battery Is Better?**

### **Abstract**

Advertisers are always touting more powerful and longer lasting batteries, but which batteries really do last longer, and is battery life impacted by the speed of the current drain? This project looks at which AA battery maintains its voltage for the longest period of time in low, medium, and high current drain devices. The batteries were tested in a CD player (low drain device), a flashlight (medium drain device), and a camera flash (high drain device) by measuring the battery voltage (dependent variable) at different time intervals (independent variable) for each of the battery types in each of the devices. My hypothesis was that Energizer would last the longest in all of the devices tested. The experimental results supported my hypothesis by showing that the Energizer performs with increasing superiority, the higher the current drain of the device. The experiment also showed that the heavy-duty non-alkaline batteries do not maintain their voltage as long as either alkaline battery at any level of current drain.

### **Question**

Which AA battery maintains its voltage for the longest period of time in low, medium, and high current drain devices?

### **Variables**

Independent Variable: Time, how long each battery operates.

Dependent Variable: Voltage.

Table 1

Variables

<b>Experimental Group</b>	<b>Controlled Variables for Each Group</b>
Low current drain	Same portable CD player Play the same music track Play at the same volume level
Medium current drain	Identical flashlight Identical light bulb
High current drain	Same camera flash
All groups	Battery size (AA) Constant temperature (A battery works better at a warm temperature.)

### **Hypothesis**

As I test for increasingly long periods of time, the Energizer AA battery will maintain a higher voltage than other batteries.

### **Background Research**

Batteries come in many shapes and sizes. Some are no larger than a pill while others are too heavy to lift, but most batteries have one thing in common—they store chemical energy and change it into electrical energy. The cell is the basic unit that produces electricity. A battery has 2 or more cells, but people often use the word battery when talking about a single cell, too, like a dry cell. A dime-sized battery in a watch is a cell. Cells act like pumps to force electrons to flow along conductors (DK Science 150).

“The electrical force of a cell or battery is called its electromotive force (emf). This force, which makes electrons flow around a circuit, is measured in units called volts (v.). Each kind of cell has a particular emf. A dry cell, for example, has an emf of 1.5 volts” (DK Science 150).

Another way to measure a battery is by how much current it can provide. Current measures how many electrons flow through the cell. The unit used to measure current is amps.

A common cell has several important parts: the positive terminal and electrode, the negative terminal and electrode, and the electrolyte, which is between the two electrodes. The positive electrode is made out of a carbon rod. Powdered carbon and manganese oxide prevents hydrogen from forming on the carbon rod, which would stop the cell from working normally. The negative electrode is made out of zinc, which serves, as a case for the cell. Electrons flow from the negative terminal through a wire in the device the battery is powering into the positive terminal (Learning Center).

The most common cell is the dry cell and different types have different types of electrolytes. The dry cell works like the cell invented by the French engineer Georges Leclanche in 1865. His cell had a liquid electrolyte, but in the modern version the electrolyte is ammonium chloride paste (DK Science 150). Ordinary dry cells are used in most flashlight batteries. These dry cells use ammonium chloride as the electrolyte. "Cells needed to supply heavier currents use zinc chloride. Alkaline cells, which last longer and can supply even heavier currents, use the alkali potassium hydroxide" (DK Science 150).

Most flashlights take two or more dry cells. Cells are connected in series one after another. Large powerful flashlights may take four or more cells. The size of a cell has no effect on its emf. The chemicals in the cell determine its emf, but large cells last longer than small cells of the same basic type.

How long a battery lasts also depends on how it's used. Two batteries may last the same length overall but one might maintain higher voltage over more of its lifetime, in a sense providing better quality. A high powered device such as a motorized toy running constantly takes more current than a less power hungry device such as a personal stereo that alternately runs and rests. Batteries also don't perform as well at low temperatures (Best Batteries 71).

As you use a battery, its emf drops. You can consider an alkaline battery dead at 0.9 volts. The paper you are reading is posted as an example on the Science Buddies website.

In order to work well in high drain devices you need to make the shell of the battery thinner so it can hold more electrons and deliver more current (Booth 127).

Companies have made improvements in their batteries so they are better in high drain devices. A high drain device is a thing that takes a lot of current. Low drain devices would include CD and cassette players and related devices. "Eveready meanwhile quantifies the power requirements as 400 to 800 mA for halogen lamps; 400-1000 mA for cellular phones; and 500-900 mA for camcorders. Digital cameras are in the 800-1200 mA range, while photoflash units are the thirstiest of all-1000 to 2000 mA according to Eveready" (Booth 127).

### **Materials List**

- CD player & a CD (low drain device)
- Three identical flashlights (medium drain device)
- Camera flash (high drain device)
- AA size Duracell and Energizer batteries
- AA size of a "heavy-duty" (non-alkaline) battery (I used Panasonic)
- Voltmeter & a AA battery holder
- Kitchen timer

**Experimental Procedure**

1. Number each battery so you can tell them apart.
2. Measure each battery's voltage by using the voltmeter.
3. Put the same battery into one of the devices and turn it on.
4. Let the device run for thirty minutes before measuring its voltage again. (Record the voltage in a table every time it is measured.)
5. Repeat #4 until the battery is at 0.9 volts or until the device stops.
6. Do steps 1-5 again, three trials for each brand of battery in each experimental group.
7. For the camera flash push the flash button every 30 seconds and measure the voltage every 5 minutes.
8. For the flashlights rotate each battery brand so each one has a turn in each flashlight.
9. For the CD player repeat the same song at the same volume throughout the tests.

## Data Analysis and Discussion

Table 2

Flashlights: Energizer Batteries

Battery #	3	4		19	20		31	32		
Time (hrs)	Voltage (v)	Voltage (v)	Dead?	Voltage (v)	Voltage (v)	Dead?	Voltage (v)	Voltage (v)	Dead?	Avg Voltage (v)
0.0	1.605	1.610		1.607	1.609		1.604	1.605		1.607
0.5				1.396	1.402		1.400	1.412		1.403
1.0	1.356	1.363		1.343	1.351		1.354	1.360		1.355
1.5				1.307	1.314		1.318	1.327		1.317
2.0	1.295	1.295		1.280	1.288		1.304	1.311		1.296
2.5	1.273	1.280		1.267	1.284		1.268	1.278		1.275
3.0	1.260	1.265		1.255	1.262		1.261	1.267		1.262
3.5	1.249	1.256		1.245	1.247		1.247	1.252		1.249
4.0				1.226	1.232		1.230	1.238		1.232
4.5	1.221	1.226		1.206	1.216		1.212	1.224		1.218
5.0				1.197	1.204		1.196	1.210		1.202
5.5	1.160	1.186		1.170	1.178		1.177	1.190		1.177
6.0				1.128	1.150		1.174	1.184		1.159
6.5	1.108	1.135		1.085	1.117		1.132	1.144		1.120
7.0	0.630	1.120	Yes	1.012	1.063		1.125	1.137		1.015
7.5				0.515	0.586	Yes	1.063	1.095		0.815
8.0							0.609	0.900	Yes	0.755

[Note: This table is only one of many completed for this project.]

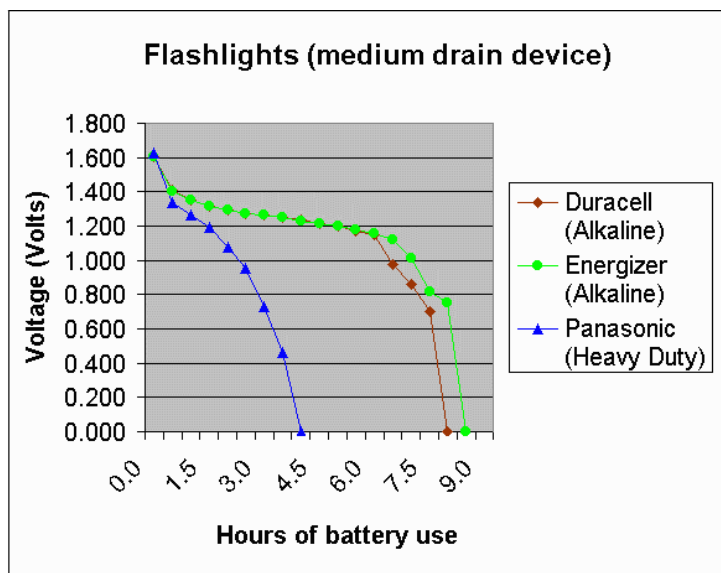


Fig. 1. Graph of voltage vs. hours of battery use in flashlights for three brands of batteries.

[Note: This graph is one of three that the student prepared.]

According to my experiments, the Energizer maintained its voltage (dependent variable) for approximately a 3% longer period of time (independent variable) than Duracell in a low current drain device. For a medium drain device, the Energizer maintained its voltage for approximately 10% longer than Duracell. For a high drain device, the Energizer maintained its voltage for approximately 29% longer than Duracell. Basically, the Energizer performs with increasing superiority, the higher the current drain of the device.

The heavy-duty non-alkaline batteries do not maintain their voltage as long as either alkaline battery at any level of current drain.

### **Conclusions**

My hypothesis was that Energizer would last the longest in all of the devices tested. My results do support my hypothesis.

I think the tests I did went smoothly and I had no problems, except for the fact that the batteries recover some of their voltage if they are not running in something. Therefore, I had to take the measurements quickly.

An interesting future study might involve testing the batteries at different temperatures to simulate actual usage in very cold or very hot conditions.

### **Acknowledgements**

I would like to thank my teacher Mrs. Garmon, and my father who let me take over his workshop while I worked on my experiment.

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