

Utilization of Discarded Alkaline Batteries in LED Flashlights

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Abstract – The present usage of alkaline batteries in devices under-utilizes the potential charge. Used batteries still have some charge left in them that is ideal for driving LED flashlights.

I. INTRODUCTION

Many electronic devices and instruments that use alkaline batteries, only function properly when a certain threshold voltage is available. Empirically, the threshold value is about 1.35V for 1.5V cells and 7.5V for 9V cells. When the voltage from the batteries drops below this level, there still remains a fair amount of charge in the batteries, but they are discarded because they are of no use for the device. Also, it is the policy of some users of alkaline batteries in instruments to replace them every time they are about to be used in the field to avoid failure on site. This causes a number of batteries to be discarded with useful charge remaining. It would be desirable to recover this remaining charge from these batteries before they are discarded or sent for recycling.

II. DISCARDED BATTERY REMAINING CHARGE

Discarded (or depreciated) AA alkaline batteries, from various electronic instruments, were collected from a retail electronics store to get a sample of the population. The discarded batteries had their no-load voltage measured and they were sorted according to their remaining voltage. Below are the statistics:

No-Load Voltage	Number Found	Percentage of Population
Less than 1.0	22	14.3
1.0 to less than 1.2	21	13.6
1.2 to less than 1.3	18	11.7
1.3 to less than 1.4	27	17.5
1.4 to less than 1.5	29	18.8
1.5 or greater	37	24.0
ALL	154	100.0

Table 1. Sample Discarded AA Battery Statistics

Based on published material from battery manufacturers, it is estimated that, those batteries with voltages of 1.5V or more would, on average, have 75% of their full charge remaining. Based on that same information it is estimated that batteries with 1.3V to 1.5V would have, on average, 45% of their remaining charge available. Hence, the estimated recoverable charge remaining in this population is $(.240 \times 75) + (.363 \times 45) = 34.3\%$ of the total original available. If batteries are removed and preserved at the normal end of use, the expected voltage of the battery would be about 1.35V for AA cells. Batteries used in LED flashlights for devices incorporated with voltage inverters would allow the battery to be used down to 0.8V.

D, C, and AAA cells were collected and investigated. Similar distributions of voltage values were observed.

III. DISCARDED BATTERY UTILIZATION

A. LEDs and Used Batteries

The voltage required to operate an LED is about 2.6 to 3.7 volts. Therefore, three used AA batteries with voltages of 1.3V or higher are a viable power supply for operating an LED. This means that from the sample population of discarded AA alkaline batteries presented in the previous section, there is a large amount of useful energy going to waste, and that close to 60% of the population is needlessly being discarded.

B. LED Flashlights Using Used Batteries

The environmental impact of waste batteries is a large concern. Alkaline batteries are mostly sent directly to landfills as they are discarded in the general garbage. Recycling companies exist to take these batteries and recover the metals that they are constructed from, but the service is charged for. Therefore, any method of reducing the amount of batteries discarded should be of environmental interest, both for the waste

avoided and for the environmental cost to produce more batteries.

Lighting Sciences Canada has developed a number of simple LED flashlights that are designed to operate well with used alkaline batteries. These flashlights have been found to last hours, producing useful light, on batteries that have been considered dead for other devices. In fact, many flashlights were found to last for hundreds of hours before the light dropped below a useful level.



Picture 1. Dr. Frank Lin with Two LED Lights

LED flashlights using depreciated alkaline batteries could incorporate a resistor to limit the current down to 20 to 30 mA. Assuming 50 lumens/watt LEDs are used, flashlights using three 1.35V D cells would give out 5 lumens in the beginning and depreciate to a useful level after hundreds of hours.

C. 9-Volt Alkaline Batteries

Smoke detectors and many portable electronic test instruments use 9V alkaline batteries. Empirically, the replaced 9V battery will be measured to be generating around 7.5 volts. For this type of battery, a flashlight can be constructed using two LEDs (in series) and a current limiting resistor (about 150 ohms). Sixty lumen-hours can be produced using this type of battery.

D. Applications

LED flashlights using depreciated alkaline batteries generate a few lumens to a fraction of a lumen. They would be extremely useful for people who still use fuel-based lighting equipment. If all the used batteries were

collected and used in fuel-based lighting communities, it would easily reduce their fuel consumption by around 50%. This could equate to 20 billion dollars in fuel consumption savings.

For electrified communities, these lights would be useful as nightlights, blackout emergency lights, or lighting for those trapped in total blackout situations such as trapped miners or disabled submarines. For example, if these lights had been available, they would have been of great use to those in the Superdome after hurricane Katrina.

E. Suggested Discarded Battery Reuse Program

Since there is a viable use for presently discarded batteries, perhaps it would be of interest to develop some sort of program where these used batteries removed from devices can be reused in flashlights. When the charge is more fully utilized, commercial recyclers can then handle these batteries.

It is feasible for present cycling companies to involve themselves with re-use programs. It would involve adding extra handling of the batteries when they are received, but it is conceivable that automation could be developed to sort the batteries not only by size, but by remained charge level as well.

Because of today's increased concern over environmental and energy conservation issues, communities would readily accept and institute programs and policies to encourage the recycling of alkaline batteries. Companies that would provide this recycling service would benefit from the positive public relations. Additionally, such programs would reduce the amount of batteries being wasted directly into garbage collection and increase the amount of recycling from residential sources.

IV. CONCLUSION

Presently, batteries used in electronic devices are often discarded at time of replacement. The remaining charge is viable and useful in a simple LED flashlight. The environment would benefit from better utilization of alkaline batteries both in terms of waste reduction and manufacturing costs.