Homeland Security

Science and Technology

TechNote

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions. Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts unbiased operational tests on commercial equipment and systems and provides those results along with other relevant equipment information to the emergency response community in an operationally useful form. SAVER provides information on equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL).

Information provided by the SAVER Program will be shared nationally with the responder community providing life- and cost-saving assets to federal, state, and local responders.

The SAVER Program is supported by a network of technical agents who perform assessment and validation activities. Further, SAVER focuses primarily on two main questions for the emergency responder community: “What equipment is available?” and “How does it perform?”

For more information on this and other technologies, please see the SAVER Web site or contact the SAVER Program Support Office.

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Single-Use Batteries

Emergency responders rely heavily on battery-powered equipment to accomplish their job. To ensure that potentially life-saving equipment is ready to use when needed, it is important for responders to keep the right batteries for their equipment on hand.

Batteries convert stored chemical energy to electrical energy when the battery is used within a device. Single-use batteries will need to be replaced when the stored energy is expended.

Single-use batteries are available in many standard sizes, including AAA, AA, C, D, N, 9 volt (V), and lantern. The capacity of a battery is its ability to maintain a usable voltage, at a set current, for a period of time and is given in amp hours (Ah) or milliamp hours (mAh). Shelf-life is the length of time, under specified conditions, that a battery can be stored and still retain a useable amount of capacity.

Single-Use Battery Types and Applications

The performance of a rechargeable battery is largely determined by its *runtime* and *cycle life*. Runtime refers to the length of time a battery will power a device, is an indication of capacity, and varies based on the device it is used in. Cycle life refers to the number of times a rechargeable battery can be discharged and recharged and still deliver at least 50 percent of its rated capacity. A sign that a rechargeable battery is at the end of its cycle life is decreased runtime, which limits the device’s use.

Over time, all rechargeable batteries experience *capacity fade*—a permanent loss of capacity that limits runtime and cycle life. Capacity fade results from damage that occurs with normal use during the charge and discharge cycles. The rate of capacity fade accelerates when batteries are charged more often than necessary, overcharged, undercharged, or stored in elevated temperatures.

Battery capacity is also affected by *self-discharge*—a temporary, inevitable loss of capacity that occurs over time in all batteries, whether they are used or not. Rechargeable batteries have higher self-discharge rates than single-use batteries. However, unlike single-use batteries, self-discharge is not permanent in rechargeable batteries and charging them will restore capacity. Warmer storage temperatures will speed up the rate of self-discharge, so batteries should be stored in a cool, dry place.

Table 1 – Single-Use Battery Characteristics

Battery Type	Nominal Cell Voltage (V)	Operating Temperature Range (^oF)	Shelf-life at 75°F (years)	Suggested Applications
Standard carbon	~1.5	23 to 115	< 2	Penlights; small AM/FM radios; low-drain devices
Alkaline	~1.5	23 to 140	4 – 7	PASS devices; finger pulse oximeters; large or mid-sized flashlights; mid to high-drain devices
Lithium	~1.5	-40 to 140	5 – 8	Digital cameras; gas leak devices; high-drain devices

Standard carbon batteries typically have the lowest capacity, shortest shelf-life, and lowest cost of the three battery types in Table 1. The efficiency of standard carbon batteries decreases as energy demands increase. Economical applications include use in low-drain devices, such as penlights and small AM/FM radios.

Alkaline batteries are usually more expensive than standard carbon batteries, but they have higher capacity and a longer shelf-life. They also operate at higher temperatures. In low-drain devices, alkaline batteries will last as long as standard carbon batteries; however, in higher drain devices, they may last four to nine times longer. Alkaline batteries are an economical choice for use in devices that will draw a small current for a long time or a higher current for only a brief time, such as Personal Alert Safety System (PASS) devices and finger pulse oximeters.

Lithium batteries are lighter, more expensive, and have higher capacity and a longer shelf-life than alkaline batteries. They last as long as alkaline batteries when used in low-drain devices; however, they last longer than alkaline batteries when used in high-drain devices, such as digital cameras and gas leak detectors.

Application Considerations

Device specifications should be checked to determine what types of batteries are safe to use, since using the incorrect battery may lead to equipment damage or failure. Some manufacturers suggest specific battery types to maximize device performance. In general, however, devices that accept standard-size batteries allow for flexibility amid a selection of battery types that are appropriate for a device.

Due to their low self-discharge rates and long shelf-lives, single-use batteries are dependable and well suited for equipment that may sit for moderate periods of time between uses. Alternatively, rechargeable batteries may be a more economical choice in devices used daily. Device power requirements should also be considered when choosing batteries. For example, using lithium batteries in high-drain devices is more economical than using standard carbon batteries. Although lithium batteries cost more, they will last longer, driving their cost per use below that of standard carbon batteries.

Single-use battery performance is largely determined by capacity, which is reduced by ordinary use, self-discharge, and exposure to extreme storage or operating temperatures. Self-discharge is an inevitable loss that occurs over time in all batteries, and the rate of discharge varies with the chemical composition of the battery. Warmer storage temperatures will speed up the rate of self-discharge, while cooler temperatures will slow it down. Operating temperatures affect capacity differently. For example, a battery used in freezing temperatures will not last as long as the same battery used in a controlled environment. Heat has both a positive and negative influence on capacity—batteries can usually deliver more current at slightly elevated temperatures. However, higher temperatures may cause permanent damage to the battery and reduce battery capacity.

Optimizing Battery Performance

Measures can be taken to optimize battery performance and preserve capacity. Batteries should be inspected for leakage or other damage and replaced if necessary, especially in seldom used equipment. Batteries should be stored in a cool, dry place to minimize the effects of self-discharge. Users should consult battery specifications prior to using batteries in extreme climates.

In devices that require several batteries, battery replacement must be done in complete sets, using batteries of the same brand and type. If changed individually, batteries with differing properties will adversely affect the total voltage and/or capacity available to power the device. Newer or more powerful batteries may also attempt to charge weaker ones. In extreme cases, this can result in smoke or fire as batteries overheat.

Battery Disposal

Federal regulations require the chemical composition to be marked on batteries, since they can contain heavy metals such as cadmium in NiCd batteries, and improper disposal may contaminate the environment. Disposal should be in accordance with federal, state, and local environmental regulations. Some states regulate battery recycling due to environmental concerns. There are a growing number of recycling companies and battery retailers that will accept used rechargeable batteries. When government regulations cannot be confirmed, battery manufacturers are a good source of information on proper disposal.

Emerging Battery Technology

To keep up with the increasing power requirements of advanced electronic devices, battery research is focused on developing batteries with increased capacity in smaller packages. Improvements are also focused on creating batteries that are less vulnerable to capacity deterioration caused by self-discharge and extreme storage or operating temperatures.