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Li-Ion Taming

Keeping the Powerpacks Under Control

There was a time when "batteries not included" was the standard delivery configuration for new devices, and the go-to powerpack consisted of heavy cylindrical alkaline batteries in sizes from AAA to D. There are still plenty of alkaline-battery-powered devices out there. However, today's tablets, mobile phones, laptops, and other such items owe their sleek, featherweight design to better battery technology, such as rechargeable lithium ion (Li-Ion) and non-rechargeable lithium metal batteries.

Chances are good that the unseen powerpack sealed into your favorite portable device is a lithium ion (Li-Ion) rechargeable battery. That's because Li-Ion batteries provide an almost unbeatable combination of light weight, high capacity, and none of the "memory effect" that plagues nickel cadmium (Ni-Cad) batteries. So what's not to like?

The downside to lithium batteries, both lithium metal and Li-Ion, is that mishandling, misuse, or malfunction (e.g., internal short-circuit failures) can result in a roaring fire. Like all battery types, Li-Ion batteries operate through a controlled chemical reaction that generates electrical energy (current) and transmits power through terminals made of conductive metal. This process inevitably generates some degree of heat. The danger arises when problems lead to an uncontrollable, rapid increase in temperature and pressure within the battery cells. This condition could result in a battery fire and, due to the construction of Li-Ion batteries, failure in a single battery cell could initiate fire in adjacent battery cells. For this reason, Li-Ion battery fires are particularly difficult to suppress or extinguish. As a 2010 FAA Safety Alert for Operators (SAFO) states,

> *Our test results have also demonstrated that lithium-ion cells are flammable and capable of self-ignition. Self-ignition of lithium-ion batteries can occur when a battery short circuits, is overcharged, is heated to extreme temperatures, is mishandled, or is otherwise defective. Like lithium metal batteries, lithium-ion batteries can be subject to thermal runaway. A battery in thermal runaway can reach temperatures above 1,100 degrees F, which exceeds the ignition temperature of most Class A materials, including paper and cardboard. These temperatures are also very close to the melting point of aluminum (1,220 degrees F).*

Keeping the Li-Ion Caged

The FAA and other organizations such as the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA), continue to research these issues, as well as develop possible new safety rules and guidance for both flight crews and passengers. Though the tips below were developed for airline crews and passengers, GA pilots and their passengers can also benefit from following this advice:

- Keep batteries installed in portable electronic devices. Leaving batteries in battery-powered devices is an effective means of insulating the terminals and protecting against short-circuiting.
- When replacing with a spare battery during flight, handle batteries with care.
- Pack spare batteries in baggage that is accessible during flight — you certainly do not want a Li-Ion battery fire to start and propagate in a baggage compartment you can't reach.
- Keep spare batteries in the original retail packaging. Because it is designed for the transport of those batteries, this packaging prevents unintentional activation and short-circuiting by effectively isolating the batteries from contact with each other and other objects.
- If original packaging is not available, place each battery individually in its own protective case, plastic bag, or package. A sturdy, re-sealable plastic bag (e.g., a freezer bag) is suitable for this purpose. Covering the battery terminals with insulating tape, such as electrical tape, is another effective method.

What If …?

If, despite all precautions, you do find yourself facing a hungry Li-Ion fire, testing by the Fire Safety Branch of the FAA's William J. Hughes Technical Center has resulted in the following tips for fighting lithium-type-battery fires. These procedures consist of two phases: (1) extinguishing the fire, and (2) cooling the remaining cells to stop thermal runaway.

To extinguish the blaze, use a Halon, Halon replacement, or water extinguisher to douse the fire and prevent its spread to additional flammable materials.

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One area in which humans have always been the weaker species in is vision and specifically *night* vision. While many other animals developed better night vision or evolved their other senses to compensate, for the last 100,000 years or so, our only technological recourse was to carry light (e.g., fire) with us. This all changed in World War II. Since then we've been rapidly closing the gap between us and other animals.

Lighting the Way

There are two basic kinds of technology that comprise our night vision arsenal: light amplification and alternate wavelength. These two technologies have very different operating principles and implementations. With these differences come varying advantages and disadvantages.

The most prominent example of light amplification technology is the night vision goggle system (NVG). They work by doing exactly what the name says: they amplify the ambient light by as much as 50,000 times, according to some reports. That's quite an improvement from the Vietnam era Generation I systems that required at least some moonlight to function, and even early Generation 0 systems that required a separate infrared lighting source. The current Generation III requires virtually no light to function and can make an apparently pitch black environment light up like a sunny day.

Alternate wavelength technology works by using sensors that can "see" in other wavelengths of energy. The most common example would be infrared (IR). IR allows you to see heat energy, or more specifically, *differences* in heat energy. IR technology tends to be aircraft-mounted due to the size and power demands of the sensor. Earlier sensors had to be cooled to very low temperatures in order to work. This meant larger, more complicated installations on the aircraft and also tended to require wait times to cool the sensor to operating temperature. Not only do these IR sensors help shed light on the darkness, they also can improve visibility through some common visual obstructions such as fog, snow, or rain.

Another example of alternate wavelength technology is millimeter wavelength radar. Millimeter wave radar is one of the technologies specifically allowed by rule, but it is largely out of reach for the GA world. For the purposes of this article, therefore, our use of the term "IR technology" is intended to represent the group of alternate wavelength technologies.

At Home in the Dark

Night vision imaging systems (NVIS) falls into the category of light amplification technology. The advantages with this technology are significant, but it is not without its limitations. One issue is depth perception as some designs only use single tubes in order to save on costs. This practice essentially turns the user into a bit of a Cyclops, thereby eliminating depth perception completely. Another issue is dramatically reduced peripheral vision. Most people are accustomed to about 190° of peripheral vision, but many NVGs offer only around 40°. The Department of Defense is working with advanced NVG designs that feature four tubes, instead of the more conventional one or two, to improve peripheral vision. Still, that change only boosts peripheral vision to a reported 95°. Lastly, there are concerns that the extra weight of the systems — which are head mounted — can cause increased fatigue and eye strain. NVGs also require significant modifications to be made to the aircraft, like the addition of filters to lights and switches to prevent the illumination from upsetting the NVGs.

For these reasons, the FAA places restrictions on the use of NVGs by pilots. In addition, there are also hardware certification requirements. Many of the prerequisite requirements for NVG use are found in 14 CFR part 61, specifically 61.1 (b)(12) and (13), 61.31(k), 61.51(k),61.57(f) and (g), and 61.195(k). There are also instrument and equipment requirements listed in part 91.205(h). Part 61.31(k) is critical

Photo Courtesy of Rockwell Collins

A HUD display of information from a Rockwell Collins EVS-3000 Enhanced Vision system.