Cell Science:

Modern Batteries for Modern Airplanes

STORY BY DAVE HIGDON

Mid-Continent Instruments' MD835 is the first emergency power supply featuring lithium nanophosphate technology. This alternative cell chemistry offers distinct advantages over standard lead-acid designs, including weight, maintenance costs and life expectancy.

Out of sight, out of mind.

The phrase is one of scores of highly human rationalizations. It allows a line of thinking that questions whether, if something's not in view, does it really matter?

For any and all areas of life where one might consider this a relatively innocuous truism, we seldom embrace such cavalier thinking anywhere in aviation. Where flying machinery is concerned, pretty much everything matters all the time; otherwise, why would aircraft designers bother?

If it exists as part of a flying machine, it matters; no matter the flying conveyance, nothing exists without a reason — even when you can't see it.

Batteries easily fall into this crack — the unseen, unheralded little box of chemical energy storage. While an essential item serving multiple purposes in the aircraft, batteries can fall into neglect because — yes, you got it — they're out of sight and, until they fail, generally out of mind.

All those flying machines needing electric starters, ones with lights, electronics and electrically powered instruments, fall only one small step below the powerplant in importance.

A battery is at the heart of every electrical system.

Beyond the electrical system, batteries specifically provide backup power to electronic flight-instrument systems, backup batteries for individual components and as standby, standalone power sources are proliferating.

Credit for this proliferation belongs to an ongoing evolution in battery technologies that is influencing a wide swath of our lives.

Many Needs, Many Types

Electrical storage devices use chemical compounds to generate a reaction that produces direct current electricity — the stuff we need to run starter motors, power lights, radios and blower motors.

The name "battery" overlooks one key aspect of these devices: a battery really is an assembly of individual power sources — cells — assembled to maximize either their cumulative voltage or their collective amperage.

You can see the cells in traditional lead-acid batteries with six or 12 caps for adding electrolyte to each of the individual series-connected cells — cells that add up to 14 or 28 volts.

We use individual cells — increasingly rechargeable nickel metal hydride AAA, AA or D cells, for example — in our flashlights, portable radios and hand-held GPS navigators.

Lead acid, NiCad; Li-ion and RG all employ different chemical technologies to produce their power.

Why so many types? Because of the many different applications for which they're needed — and because no single type suits all applications. Each holds out distinct advantages for its role.

Lead-acid batteries, for example, are at the low end of the power-density scale — a measure of the wattage available from a volume of battery, usually expressed in watts per liter. They are stable over long periods without use. They can sustain high peaks and long discharge rates, recover quickly from the drain, and be recharged again and again. They work excellently as our electrical system's ballasts.

Nickel cadmium, or NiCad batteries, the first real breakthrough in rechargeable cells after lead acid, moved into the lead-acid role for some turbine aircraft, predominantly because they required less maintenance, delivered higher power and suffered less from cold temperature. Unfortunately, NiCads suffer from their own shortcomings — short life spans, limited recharge life and a nasty habit of developing a charge "memory," which would signal to a charging controller the battery was recharged to capacity while it was still well below the limit.

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Nickel-metal hydrides, which began replacing NiCads in many uses, exhibited less of a memory problem, but still needed regular conditioning. They do perform slightly better as power sources.

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Li-ion — lithium ion — batteries are excellent at powering low-demand devices, such as portable phones, portable GPS units, iPads and iPods, and as backup power sources for aircraft.

They can produce steady power for long periods of time, and they recharge almost as fast as they discharge — a distinct benefit for portable applications.

The newer Li-ion technologies show no "memory" problems, have excellent use profiles and a high number of recharge potential. And one of them — lithium nanophosphate — improves on the high-load use without overheating.

Mid-Continent Instruments tapped the lithium nanophosphate technology for its latest instrument backup battery.

The Electrical Buddy System

The lead-acid battery common to most airplanes works as part of the electrical system.

Supplying sufficient electrical power for an aircraft's components falls to the alternator, starter/generator or old-fashioned generator, which runs off the engine. The jobs of absorbing power fluctuations, serving as an electrical-system backup and providing engine-starting power all fall to the battery.

But you can't have one without the other, and it helps everyone and everything concerned if the electrical-generation capacity exceeds the load the aircraft can demand — with a right-sized battery sufficient in power to turn the engine to start it and absorb spikes in the output of the generating source, but as compact and low-maintenance as possible.

Ideally, the partners both work seamlessly and pretty much invisibly — out of sight — as they do when everything works properly, keeping them out of mind as well.

While they sit quietly working away back in the dark hollows of an airframe, batteries absorb considerable abuse in their largely unsung lives.

They store their energy for an instant of high demand, then convert their chemical potential energy into enough electrical kinetic energy to spin an engine — and make the delivery at the speed of light.

The main battery suffers the strains of battery drain for the duration of the start cycle. Like humans, batteries tend to work a little slower when the temperature drops.

Meanwhile, the battery needs to convert electrical power back into the chemical energy potential that existed before engine start, a recharge process generally controlled and monitored by a regulator in the system. This process makes batteries warm.

Regulators should match the system and the battery because overcharging is unwise, as is charging so quickly that the battery struggles to accept the load and overheats; the electrolyte could boil or the heat could damage the battery.

In most airplanes, the main battery also must be ever ready and eager to work as a standby electrical supply in the event the generating source fails. The larger the battery's storage capacity, the longer it can supply standby power — but you don't want it to be too large lest it eat up payload and space needed for other things.

And the lowly battery has to do these things while enduring extreme, rapid changes in altitude, temperature and atmospheric pressure.

Matching Battery to System

Technology aside, your aircraft's electrical system needs two things: a supply source capable of meeting the needs of the airplane when everything is turned on, and a battery and regulator matched to the system.

This supply source — alternator, generator and starter generator — should be able to meet the demand when you turn on all the lights, all the radios, all the electronics and all the portable stuff you plug into the old cigarette-lighter socket.

If the source can't meet the full demand, every time you impose this demand the regulator will start making up the difference by tapping power off the battery. The battery must be matched to the charging system, so the regulator doesn't try to charge it too much, too little or too quickly. Plus, it should be powerful enough to give you time to use it as the sole source of electrical power in the event of a generating-source failure. Forty minutes of power is a good minimum to consider.

Avionics shops should be able to help customers if they question whether or not their regulator matches up with their needs and the airplane's charging system.

Choosing a Battery: It's Not So simple

Technology advances — sometimes only temporarily.

Consider the lead-acid units still dominant today. Readily available, right sized, reasonably priced and familiar. It should be no surprise they remain popular. Thanks to a major advance in lead-acid battery technology, expect them to stay popular for a long time to come.

In a way, this development, the hottest thing in lead-acid battery technology today at first blush seems like a step backward — back to lead-acid from the once-cutting-edge nickel cadmium battery in many aircraft applications. However, the old dog returned to the pack significantly improved and with benefits over older lead-acid technology and the newer NiCad that displaced old lead acid in many applications.

It's called recombinant gas technology, or RG. Yes, it's been around for a while, so actually, it's not brand new. The RG battery offers aircraft owners some distinct advantages.

For one, RG neutralizes most maintenance issues while improving performance. As such, it is trickling ever farther into the aircraft arena, with RG batteries sized for virtually every application — standby systems included.

The biggest issues with lead acid have long been maintenance and service. In exchange for the pure cranking power and long-term stability, owners are cursed with the regular need to replenish the sulfuric-acid-based electrolyte. During use, the electrolyte converts to hydrogen gas and sulfate ions; the gas vents off, then the sulfur deposits itself on the lead-oxide plates and goes back into solution when the battery is recharged.

Over time, the water evaporates, meaning less sulfuric-acid production on recharge; exposed plates get damaged, their output deteriorates and, finally, the battery fails.

Building on the technologies employed in successfully designing NiCads, engineers reinvented the liquid-electrolyte, lead-acid battery — in the process, solving some of the issues that pushed them out of favor.

And this paved the way for the recombinant gas lead-acid battery, or RG.

Sealed Against Worry

Sealed, valve-regulated lead-acid recombinant gas batteries are, as the name attests, sealed. There are no caps to remove for refilling individual cells in a battery; there is no refilling possible — and it's not necessary.

Using an internal design that intersperses a thin fiberglass mount between plates, the RG battery also

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uses a slightly different electrolyte mixture and two different plate materials: one is lead peroxide, the other pure spongy lead.

Without taxing any memories of our chemistry classes, the simplest explanation for the "recombinant gas" aspect of the battery stems from the thin mats, the thin electrolyte layer between plates and mats, and the materials in the plates.

Instead of the battery giving off hydrogen, the electrolyte gases off oxygen — and keeps the oxygen in close proximity to recombine with the sponge lead plate on the negative anode and maintain the same electrolyte chemistry. A valve system regulates pressures internally.

The resulting plate designs RG technology made possible and the enclosed matting delivers a higher power density than the typical lead-acid battery. The batteries tend to last longer as well, offsetting the higher costs they might initially command.

Over the lifespan of the battery, the costs tend to equalize.

As replacements for NiCad units, RG batteries cost less and generally provide a longer service life, adding further to their value equation.

The RG batteries don't suffer from the so-called "memory effect" that robs NiCads of their capacity over time. Special conditioners helped restore the capacity of NiCads, and the conditioning cycle needed to be run regularly to maintain peak battery performance.

RG batteries need no such conditioning for capacity retention, although many manufacturers recommend using a battery conditioner to extend the lifespan of both convention and RG lead-acid batteries.

As a choice for an individual aircraft, you might find customers initially cautious about spending more on a battery that seems to have lower numbers — but produces equally good cranking power for engine start — and will last longer over time.

If customers understand the longer-life/lower-maintenance equation, a higher price should dissolve in the face of a higher value equation.

Other Battery Needs

If you've taken the smart step to install a new-generation 406 MHz ELT in your aircraft, you likely have one of these already working away for you.

If you have any of the Aspen Avionics Evolution series of glass-panel hardware, or you've recently opted for a new backup battery for your panel, like the new units from Mid-Continent Instruments, you've got a lithium-ion battery at work for you.

Li-ion batteries deliver a high-power density — lots of wattage per liter of volume — and generally perform without worries like developing a charge-level "memory" or a steadily declining output level.

Li-Ion batteries deliver power at a steady level, until they fall off quickly at the end of their capacity.

As with other batteries, they should meet the power needs of their installation and, if attached to the charging system — as some standby units might be — they should be compatible with the regulator's output.

Finally, most batteries only require periodic checking. ❑