BATTERY OF OPTIONS

Pick your main-ship battery power from a wide range of options

STORY BY DAVE HIGDON

True Blue Power's TB17 lithium-ion battery

Not too many years ago, aircraft owners and operators enjoyed a variety of battery options similar to the paint-color variety Henry Ford offered Model T customers.

Mr. Ford offered "any color you want – as long as it's black." No rainbow-of-color options for the venerable Model T.

Somewhat similarly, aircraft owners enjoyed a similar variety of choices for their aircraft's battery: Any type they chose – as long as it employed wet-cell lead-acid battery chemistry.

That was it.

Now operators faced no shortage of suppliers offering the dominant wet-cell lead-acid batteries; an array of manufacturers produced them.

They still do.

In truth, no other option delivered the cost-effectiveness of the lead-acid wet-

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cell chemistry. So battery makers focused their product-development efforts on improving the technology – by squeezing out the most cranking amps and longest lifespans possible from the technology.

And as it was, the lead-acid chemistry represented a step up from the battery chemistry and construction employed for the first widespread use of battery power: the 19th century telegraph network.

Wet-cell batteries provided the juice to power the earliest telegraph networks going back to 1837. Instead of lead and zinc plates with an acid electrolyte, the telegraph batteries used copper, zinc and an electrolyte called blue vitriol.

The batteries weren't rechargeable. But as the battery's output dropped, users could replenish each cell with fresh water and additional blue vitriol.

Then in 1859, French physicist Gaston Planté developed the first lead-acid battery – also the first rechargeable battery for commercial use.

More than 150 years later, wet-cell lead-acid batteries remain in widespread use. The technology's longevity stems from a variety of reasons: Lead acid is as dependable as it is familiar.

It's also inexpensive on a cost-per-watt basis. Few other battery technologies deliver bulk power as inexpensively as lead acid.

You can find the wet-cell lead-acid battery in everything from automobiles to electric golf cars, forklifts and marine engines. The cost-effectiveness even keeps the technology viable in uninterruptible power supplies providing standby power for millions of computer networks.

The commonality with automobile and truck batteries brought another benefit to the lack of options for aviation batteries: that familiarity.

The auto batteries in general share the strengths and weaknesses of aircraft batteries.

People knew and understood the care and feeding as well as they knew the weaknesses of the wet-cell lead-acid battery: Their tendency to lose their charge if left connected but unused; their reduced cranking power in cold weather; and the need to periodically check and replenish the electrolyte level in each individual cell.

The landscape began to change, first with the development of nickel-cadmium batteries, then again with sealed wet-cell lead-acid batteries using recombinant-gas technology or absorbent glass mat technology, both of which effectively eliminated most maintenance, particularly the need to add electrolyte in the sealed valve-regulated models.

And most recently – within the past decade – another step in battery evolution finally came to aviation: lithium-ion batteries, measurably the most power-dense option yet.

Each technology remains in use today, and each brings its own strengths and weaknesses to their roles, be it main-ship battery or standby battery used to provide power backing up to aircraft electrical systems.

Consider these alternatives to the straight flooded-cell lead-acid battery the next time a client or customer seeks input on improving their aircraft's electrical system.

The budget king

Since the 1970s, the straight-up flooded-cell lead-acid battery faced several challenges to its primacy, all of them from derivative chemistry and construction.

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The first sealed, or maintenance-free, lead-acid models to market emerged in the mid-1970s. To control venting during stressful charge and rapid discharge, engineers added valves that release gases if pressure builds up.

These valve-regulated lead-acid batteries are sometimes called sealed lead-acid, gel cell, or maintenance free batteries.

Rather than submerging the plates in a liquid, the electrolyte is impregnated into a moistened separator, a design that resembles nickel- and lithium-based systems. This enables operating the battery in any physical orientation without leakage.

The sealed battery contains less electrolyte than the flooded type, hence the term "acid-starved" – and a factor in their lighter weight.

Their distinct construction, with the gel and absorbent glass mat types of VRLA can be mounted in any orientation – and they require no routine maintenance.

Perhaps the most significant advantage of sealed lead acid is the ability to combine oxygen and hydrogen to create water and prevent dry-out during cycling. The recombination occurs at a moderate pressure of 0.14 bar (2 psi). The valve serves as a safety vent if the gas buildup rises.

Repeated venting should be avoided as this will lead to an eventual dry-out. According to RWTH, a research university located in Aachen, North Rhine-Westphalia, Germany, the cost of VRLA is about $260 per kilowatt hour in 2018 dollars.

Several types of sealed lead acid have emerged, among them the most common so-called gel cell battery, also known as valve-regulated lead acid, and absorbent glass mat. The gel cell contains a silica type gel that suspends the electrolyte in a paste.

Smaller packs with capacities of up to 30 amp hours are often called SLA, or sealed lead acid. Packaged in a plastic container, these batteries are used for small UPS, emergency lighting and wheelchairs.

Because of low price, dependable service and low maintenance, the SLA remains the preferred choice for health care in hospitals and retirement homes. The larger VRLA is used as power backup for cellular repeater towers, internet hubs, banks, hospitals, airports and more.

Lead-acid dreams: the cost champions

Among the various incarnations of wet-cell lead-acid batteries that aircraft owners choose from, all share their relatively superior costs per kilowatt hour and relatively long life spans.

Models to fit most 14-volt aircraft start at about $250 and rise from there to nearly $3,000 for larger aircraft.

Some of the newer options in wet-cell lead-acid batteries deliver lighter weight and higher power output to make the newer technology even more cost efficient than the older construction batteries.

And with maintenance virtually eliminated between annual inspections, those higher-priced maintenance-free batteries still produce lower life cycle costs – a welcome addition to their lighter weight and higher cranking amperage.

Nickel

Most Part 23 light aircraft use those lead-acid batteries examined above, including piston singles and twins, both 14 volt and 28 volt.

For most commercial and corporate aircraft, generally turbine-powered aircraft, the preferred battery technology has for years been the nickel-cadmium battery.

NiCads use electrodes made of nickel hydroxide, metallic cadmium and an alkaline electrolyte of potassium hydroxide.

The keys to the kingdom in aviation tend to belong to the products with discernibly lower life cycle costs, and NiCad manufacturers long have claimed that their products deliver a longer service life, longer shelf life, and are more easily maintained.

Conversely, makers of the sealed lead-acid batteries say their products don't have to be maintained, cost a fraction of what Ni-Cads cost, while delivering performance on par or better than the Ni-Cads.

Of course, each side backs up its perspective with valid research, and each uses solid logic to explain their opinions on the subject.

Sadly, the use of different specifications and testing parameters muddies the waters and gives pause to claims of superior performance, costs and life span.

There's little question that the Ni-Cad batteries perform better at starting turbine engines – turbojets, turboprops and turboshafts. The higher power demanded of turbine engines in start cycles and the greater length of the starting cycles make the NiCads more suitable for the turbine powerplants.

Ditto for the recovery from a deep, long starting cycle exhibited by the NiCad batteries.

In fact, so demanding are some turbine engines' start cycles that those aircraft often fly with two main-ship NiCad batteries. Their total costs may run more, but their power density and cranking power are critical to the turbine-aircraft missions they fly.

Electrochemistry

During a charging cycle, the active material – cadmium hydroxide – of the negative plate is converted to pure cadmium.

Nickel hydroxide in the positive plate is converted to nickelic oxyhydroxides. The electrolyte is not directly involved in the charge/discharge process but serves as a medium for ionic transfer.

Specific gravity of the potassium hydroxide/water solution remains virtually unchanged during these processes.

These batteries have high cranking power and low recovery times to recharge to the point of enabling a second engine start.

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 fully charged.

Operations: Nickel-cadmium aircraft batteries

During constant current discharge, a NCAB will provide an almost flat curve, with a slight downward slope. When most, if not all, of the active materials convert, as discussed in the electro-chemistry section, the voltage then begins to drop off rapidly. The electrolyte remains a solution of potassium hydroxide and water.

During recharge, a significant voltage rise is observed, followed by a slow continuous rise to a transition voltage. At this point, the negative plate is fully charged and begins to generate hydrogen gas. As the over-charge continues, a rapid voltage increase is observed due to the increased impedance of the cell.

Shortly thereafter, oxygen begins to evolve at the positive plate. Little or no recombination actually takes place.

This results in the water of the electrolyte being broken down by hydrolysis. The act of reversing current flow, or charging as it is commonly known, in an electro-chemical couple is endothermic by nature.

Charging cools up to the point of gas generation/recombination. At the onset of gassing, the reaction changes from endothermic to exothermic. In other words, the cell/battery begins to generate heat.

Whenever gassing occurs, the temperature increases, presenting the potential for thermal runaway regardless of electro-chemistry. The higher the recombination rates, the greater the potential for thermal runaway during charge.

NiCad batteries cost more, deliver more power and better fulfill the engine-starting role they play in our aircraft, but have shorter life spans and require more attentiveness when in use.

New battery on the block

During the past five years, Mid-Continent Instrument Co.'s True Blue Power division successfully introduced a new battery option for 24-volt aircraft, both piston and turbine.

It's an option that saves weight. It's also an option with higher power density, greater cranking power, less sensitivity to cold, and reduced maintenance requirements. And it's an option boasting lower overall life cycle costs, capping the benefits to owners and operators.

The True Blue Power lithium-ion batteries are certificated and STC'd for a growing list of Part 23 and Part 25 aircraft.

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Today, True Blue Power offers an STC kit to equip late-model Beech A36 Bonanzas with the TB17 Advanced Lithium-ion Battery, along with an installation kit, an MD41-1817 ACU to monitor battery health and charging, and the manuals for the system.

True Blue Power offers STC'd packages for the Cessna 208 and 208B Caravan turboprop, de Havilland's DHC-8 Dash 8, and Robinson Helicopters' R44. True Blue Power batteries are also on a number of new-production aircraft, among them the Cirrus SF50 single-engine jet, Robinson Helicopters' R66 turbine-powered ship, and others.

The company also makes maritime batteries using the same technologies. Learn more about this AEA member company's products at truebluepowerusa.com. ❑