About Batteries

Part 1: Aircraft batteries need TLC if you don't want to be left stranded

BY MIKE BUSCH

AIRCRAFT BATTERIES ARE THE Rodney Dangerfields of general aviation. They get no respect.

We let them sit unflown for weeks at a time, sometimes months. We deep-discharge them by forgetting to turn off the master switch. Then we jump-start the airplane with a ground power unit and go fly as our alternator fries them with excessive charging current. We fail to check our bus voltage regularly, resulting in long periods of undercharge or overcharge. If we're lucky, the electrolyte level gets checked once a year at annual inspection time.

Then we cuss them out when the airplane won't start on a cold Sunday morning in winter, and there's no mechanic or battery cart on the field.

NOT DIEHARDS

We probably learned these bad habits from our experience with automobiles. Car batteries are big, heavy, robust brutes that can tolerate this sort of abuse. Aircraft batteries aren't and can't. They're fragile and sensitive.

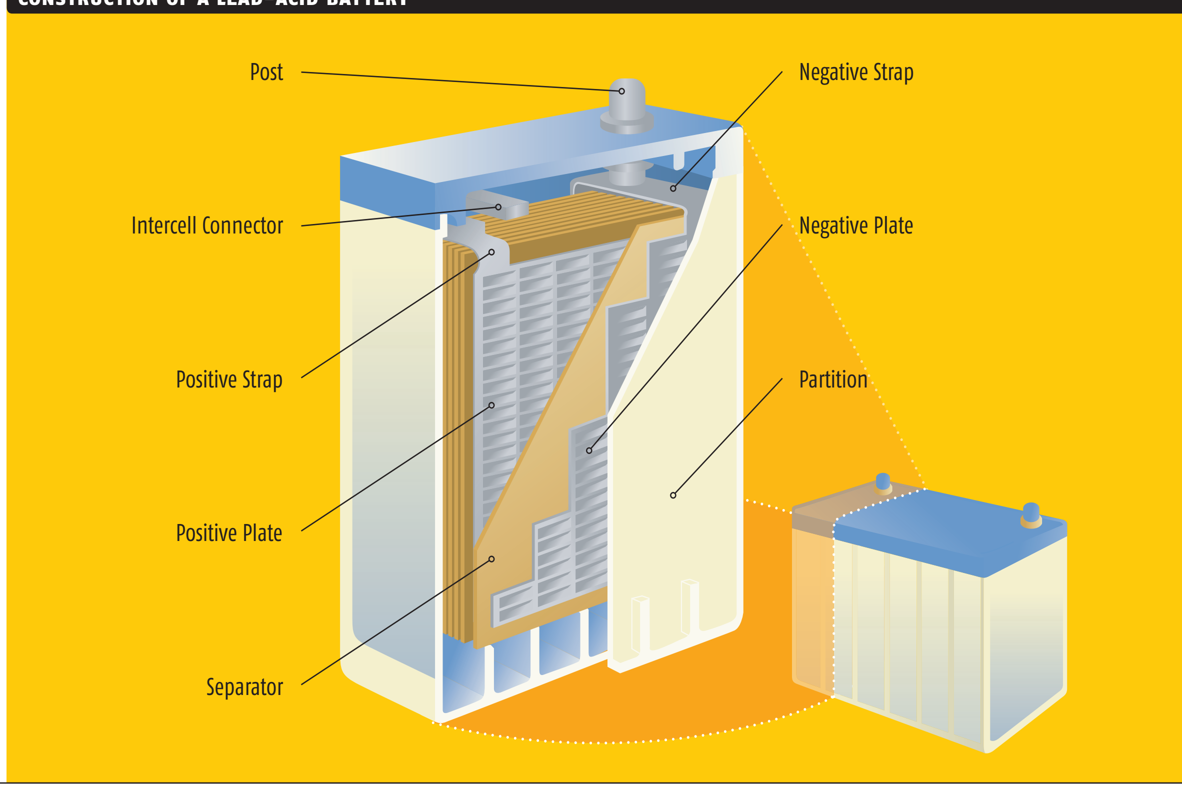
Aircraft batteries are built to be lightweight and compact. They have a small fraction of the capacity of our automotive batteries—typically 10-35 ampere-hours for an airplane battery compared to 100-200 ampere-hours for a car battery. Their lead plates are thin, fragile, and closely spaced. They can't handle much physical or electrical abuse.

CONSTRUCTION AND CHEMISTRY

Almost all primary (starting) batteries in piston GA aircraft are lead-acid batteries, the same kind we use in our cars. Transport jets use mostly nickel-cadmium (NiCd) batteries, while turbine GA use a mixture of NiCd and lead-acid.

There are two kinds of lead-acid batteries used in piston GA. One is the traditional "flooded-cell" battery that uses lead plates in a liquid sulfuric acid electrolyte bath. The other kind is the sealed battery known technically as

CONSTRUCTION OF A LEAD-ACID BATTERY



"valve-regulated lead-acid absorbed glass mat" or VRLA/AGM. These two kinds of batteries each have their pros and cons, and we'll be getting into that a bit later.

The chemistry of flooded-cell and sealed lead-acid batteries is identical. Each is constructed with multiple 2-volt cells connected in series—six cells for a 12-volt battery and 12 cells for a 24-volt battery. Each 2-volt cell contains an array of alternating plates known as "cathode" plates and "anode" plates. The cathode plates are connected to the cell's positive terminal, and the anode plates are connected to the cell's negative terminal.

The plates are not flat; they're intricately formed in a grid-like pattern to maximize their surface area. In fact, they're sometimes referred to as "grids."

When the cell is in a fully charged state, the cathode plates are elemental lead (Pb) and the anode plates are lead oxide (PbO_2). Both are immersed into an electrolyte consisting of dilute (about 33.5 percent) sulfuric acid (H_2SO_4). As the battery discharges, the

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sulfur and oxygen from the sulfuric acid electrolyte migrates to the plates, and both cathode and anode plates transform into lead sulfate ($PbSO_4$), and the electrolyte becomes increasingly dilute (i.e., mostly water).

As the battery is recharged, the sulfur and oxygen migrate from the plates back into the electrolyte, returning the cathode plates to Pb, the anode plates to PbO_2, and the electrolyte to 33.5 percent H_2SO_4.

OUTGASSING

As the cell charges, hydrogen and oxygen gas is liberated and gas bubbles form in the electrolyte. In conventional flooded-cell batteries, those gases are permitted to escape freely through the vented caps installed on each of the cells. The battery is positively ventilated when the aircraft is in flight to carry off these hydrogen and oxygen gases so that they don't form an explosive mixture. When the battery is charged on the ground, it should be done with the battery removed from the aircraft and well ventilated to prevent the risk of explosion.

In a sealed battery, the liberated gases are held inside each cell and not allowed to escape. Ultimately they recombine with the electrolyte (which is why these batteries are sometimes called "recombinant gas" or RG batteries). If a cell is overcharged and the gas pressure builds up to a dangerous value, a pressure relief valve will open to relieve the excessive gas pressure (hence "valve-regulated lead-acid" or VRLA), but this

ILLUSTRATION COURTESY OF **MIKE BUSCH**

Left: *A Gill flooded-cell battery.*

Center: *A Concorde sealed AGM battery.*

Right: *Cathode and anode plates in a lead-acid battery cell.*

permanently impairs the capacity of the cell. This doesn't happen under normal controlled charging conditions.

In sealed batteries, the sulfuric acid electrolyte is immobilized in one of two ways. A gelling agent can be added to the electrolyte to create a "gel cell" battery, or the electrolyte can be fully absorbed into a glass-fiber mat to create an AGM battery. Gel-cell batteries are frequently used in motorcycle and golf cart applications, and sometimes as backup aircraft batteries. Sealed aircraft starting batteries are always of the AGM variety.

AGM PROS AND CONS

The sealed AGM battery—originally developed by Concorde Battery Corporation in the mid-1980s—has a number of significant advantages over the traditional flooded-cell variety.

Because its plates are tightly sandwiched between layers of acid-saturated glass mat, the plates can be made thinner because they don't need to be self-supporting. This permits AGM batteries to squeeze more plates into a given volume, resulting in a higher energy density that can be as much as 1.5 times that of a comparably sized flooded-cell battery. The AGM construction also results in lower internal resistance, permitting the battery to accept faster charge and discharge rates without being damaged.

In addition, the AGM batteries have a significantly lower self-discharge rate (more about this later), are more resistant to freezing at extremely cold temperatures, and are more tolerant of vibration and physical shock. And of course, they're "maintenance-free" in the sense that they do not require (or permit) regular adjustment of the electrolyte level the way flooded-cell batteries do.

SO WHAT'S NOT TO LIKE?

Sealed AGM batteries do have a few disadvantages compared to the traditional flooded-cell battery.

Probably the biggest disadvantage is that AGM batteries are intolerant of deep discharging below about 50 percent of their fully charged capacity. By comparison, a flooded-cell battery can be discharged to 20 percent of capacity without injury. So if your aircraft uses an AGM battery, you really don't want to leave the master switch on. You also don't want to run your avionics for any significant time on battery power (say while updating software or databases) without plugging a ground power unit (GPU) into the aircraft. We've seen quite a few cases where AGM batteries died a sudden and untimely death right after a lengthy maintenance event (typically an annual inspection) where the shop did gear swings or avionics work running off the ship's battery without external power. That's a definite no-no with AGM batteries.

Also, the AGM batteries are less tolerant of overcharging than flooded-cell batteries. They will accept faster charge rates, but if you charge them too fast or too long and a pressure-relief valve opens to relieve excess pressure from outgassing, the cell capacity is permanently impaired because there's no way to add water to the

PHOTOGRAPHY COURTESY OF **MIKE BUSCH** electrolyte as there is with a conventional flooded-cell battery.

Finally, the AGM batteries are more expensive. As I'm writing this, a flooded-cell Gill G-243 battery with acid lists for $644.44 and can be purchased at Aircraft Spruce for $343.95. The comparable Concorde RG-24-15 AGM battery lists for $935.95 and sells at Spruce for $439.

Please note the *huge* markup on aircraft batteries! If you have your shop replace your battery, be warned that they're likely to charge you list price (this is standard industry practice). If you replace the battery yourself (which you are permitted to do under the FARs as preventive maintenance), you may save many hundreds of dollars.

WHAT TO BUY

Two companies make starting batteries for piston GA aircraft: Teledyne Battery Products (who sell them under the "Gill" trade name) and Concorde Battery Corporation. As I'm writing this, both sell both kinds of batteries: flooded-cell and sealed AGM.

However, Gill's sealed batteries do not have a good track record in my experience, so I would suggest steering clear of them. And although Concorde does sell flooded-cell batteries, it has announced that it will soon be discontinuing them and offering only the sealed AGM type that Concorde first pioneered 25 years ago.

Therefore, there are really only two viable choices: Gill flooded-cell batteries and Concorde sealed AGM batteries. I have always used the Gill batteries in my own airplane, and my firm generally recommends them to our managed maintenance clients, because they are relatively inexpensive, very reliable, and seem to give more warning before they fail. If you choose a flooded-cell battery, it is extremely important to check the electrolyte level regularly and add distilled water as necessary to avoid allowing the top of the plates to become uncovered.

Many owners prefer the "maintenance-free" sealed Concorde AGM batteries, particularly for aircraft based in hot climates where the lower self-discharge rate of the AGM battery offers a decisive advantage. The AGM batteries are great if you are careful not to let them discharge too far. Use of a GPU during maintenance is a must with these batteries, and use of a trickle charger during periods of disuse is highly recommended.

In Part 2 of this article in the next issue of *EAA Sport Aviation*, we'll discuss the care and feeding of aircraft batteries, including charging, conditioning, capacity testing, and how to decide when it's time to replace. *EAA*

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