

AUX FUEL STRATEGIES

BY THOMAS P. TURNER, WICHITA, KANSAS

As the old saying goes, "The only time you can have too much fuel is when your airplane is on fire."

Since the early days of the Bonanza, owners have wanted additional fuel capacity to fly greater lengths, or to have more options if the weather closes in. There have been several auxiliary fuel designs over the years and each requires different fuel-management strategies.

You may develop your own strategy, which is fine so long as it is safe, does not violate aircraft limitations, and you use your strategy consistently. As pilot in command, you are ultimately responsible for the proper fuel management.

The dangers

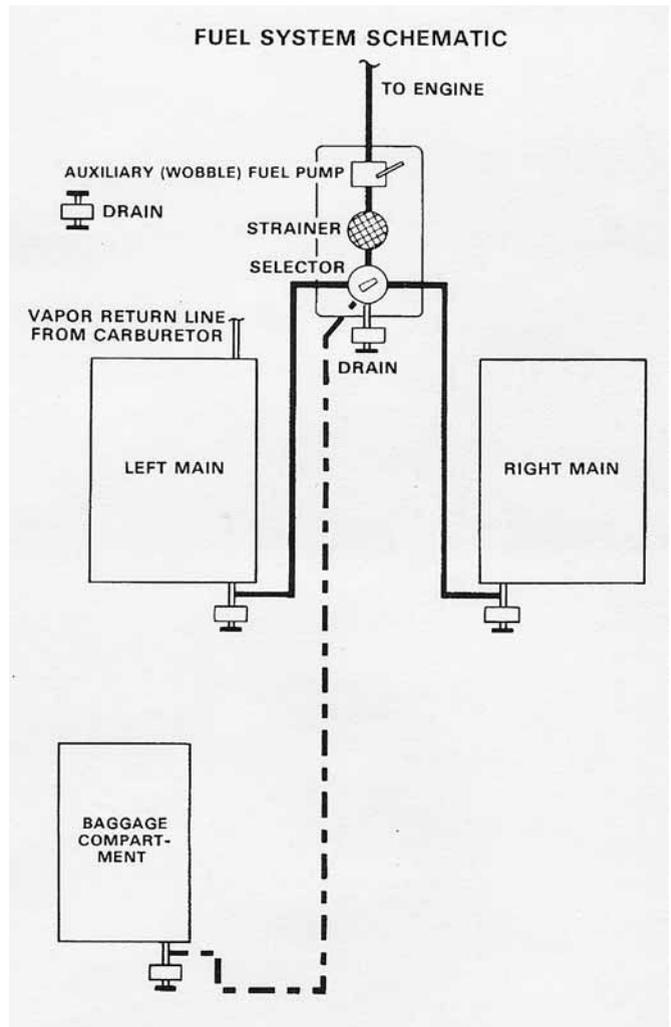
Every auxiliary fuel system I've ever seen carries a disclaimer: "Use in level flight only." Some are even placarded, "Straight and level flight only." Takeoff and landing checklists universally call for selecting a main fuel tank for takeoff and landing. Why is that?

- Auxiliary fuel systems often have long lines to the fuel selector. If an aux tank is run completely dry, the fuel pump will draw air into the lines. This can create a vapor lock that inhibits reintroducing fuel from another tank. The engine will quit and it may take some time to get the engine restarted, although some pilots cavalierly say, "I only lost a couple hundred feet before the engine restarted after switching tanks." That's unacceptable in my book, and there's no guarantee that the vapor lock will be broken at all before it's too late.

An exception is the aux tanks that feed into the mains. If a vapor lock forms in these lines, it will be relieved the next time you remove the tip tank fuel cap. It's OK to empty these tanks completely because the engine is always linked to the main tanks.

- It is possible to *unport* aux tanks if the fuel level is low and the airplane is out of rudder coordination, or if it is pitched up into a steep climb (go-around, missed approach, or initial climb).

Some people routinely run tanks dry to get maximum range out of the airplane. There is merit in a *controlled* experiment of running auxiliary tanks dry to determine their true usable capacity in level flight. But I recommend you do so at



a good altitude while circling directly above a low-traffic airport—just in case you can't get a restart.

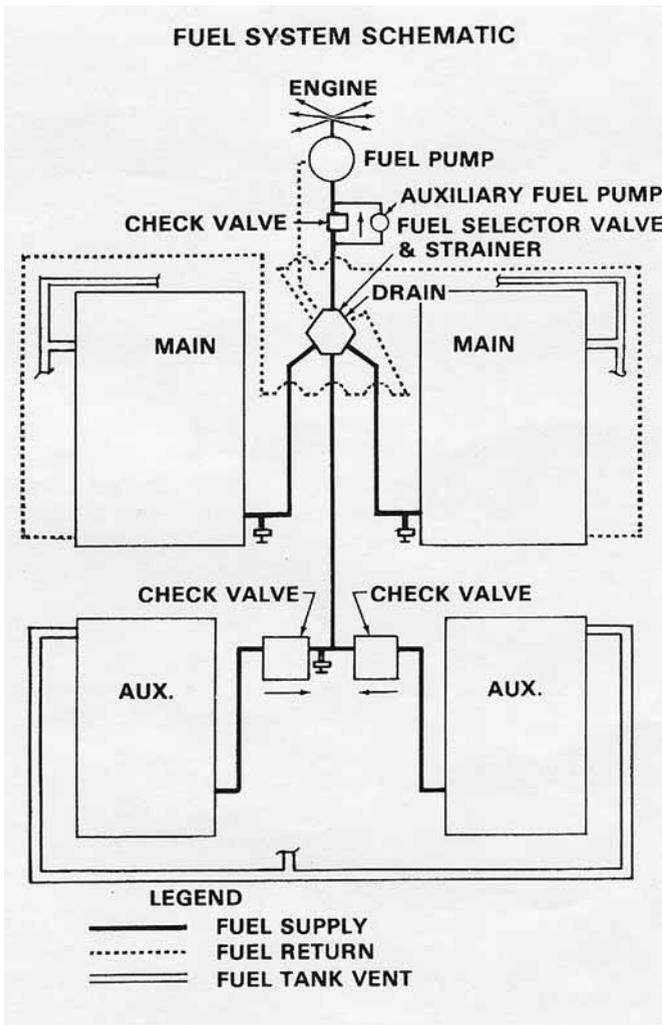
A few pilots report they can predict to the minute when a tank will run dry, and switch just as the flow begins to drop. I submit that if you can predict this accurately, you can predict when you are five minutes prior to a loss of pressure and switch then to avoid vapor lock. If five minutes' less endurance per tank makes your fuel state critical, then, in my opinion, you're cutting it way too short anyway.

Take a look at the fuel starvation mishaps reported at www.thomaspturner.net/fuel and you'll see that the hazard catches up with people all too often.

Aux system design

With the exemption of temporary ferry-tank arrangements for very-long-range and oceanic flying (which fall outside the scope of this discussion), auxiliary fuel tanks follow four basic designs:

- Fuselage-mounted tanks in the aft baggage area
- Wing-mounted, internal auxiliary fuel tanks
- Tip tanks that directly feed fuel to the engine
- Tip tanks that transfer fuel into the mains



Fuselage-mounted aux tank ("Straight" 35 through F35)

About halfway into the first year of Bonanza production in 1947, Beech began offering an optional 10- or 20-gallon fuel tank mounted in the aft baggage area. This became a popular addition to the airplane's standard 40-gallon (34 usable) system. According to the Pilots Operating Handbook (POH), all of the 10-gallon tank's fuel is considered usable, while 19 of the 20 gallons in each larger tank is "usable fuel." A switch on the pilot's subpanel permits reading the fuel level of the aux tank on the fuel quantity gauge.

NOTE: By Service Bulletin, Beech revised the unusable fuel quantities in some tank configurations. The numbers in this article are from current POHs.

The carbureted engine installed on these airplanes returns about 3 gph of excess fuel to the left main tank when the aux tank is in use. This is why these airplanes carry a recommendation to take off using the left fuel tank. If the left tank is full, return fuel will vent overboard through the tank's vents at the rate of about 3 gph.

The rate fuel is drawn from the aux tank is about 3 gph higher than indicated fuel flow in the cockpit. At 12 gph indi-

cated fuel flow, for instance, fuel is drawn from the aux tank at about 15 gph and a full 10-gallon tank will be empty after around 40 minutes. With the 20-gallon aux tank, it'll be time to switch to a main after about one hour 15 minutes, when you'll reach the aft tank's unusable fuel level.

Modify one of these airplanes with a fuel-injected engine and the return fuel flow will approximate 10 gph—at a 15 gph high cruise the 10-gallon tank will empty in 24 minutes, and the 20-gallon aux tank reaches unusable fuel in about 45 minutes. You'll still have that excess fuel on board (in the left main), but you have to make more room in the left main for return fuel *before* switching to the aux, and switch from the aux tank a lot sooner than fuel flow suggests so you can prevent a power interruption and the possibility of a fuel-line vapor lock.

A strategy for the fuselage-mounted aux fuel tank:

1. Confirm through all available means that the tank is serviced as expected prior to takeoff. Physically check with a calibrated dipstick if possible (less-than-full levels are not visible).
2. In cruise flight, ensure room for return fuel in the left main, switch to the auxiliary fuel tank and confirm fuel pressure continues. Switch the panel fuel gauge to the AUX position and start a timer.
3. Nearing anticipated time of tank depletion, based on observed flow rate plus return fuel rate and time, switch to a main fuel tank. Confirm pressure continues and set the panel fuel gauge to indicate the tank in use.

Wing-mounted (internal) aux tanks (F35 - M35; 35-33 - A33)

Beginning with the F35, the Bonanza offered wing-mounted auxiliary fuel cells placarded at 10 gallons capacity each with half a gallon unusable fuel per side, for a total of 19 gallons in addition to 34 gallons usable in the main tanks. Buyers could choose this or the fuselage aux tank system for one year only. Starting with the G35, the only option was internal wing tanks.

Two bladder-type fuel cells feed the selector. In the AUX position, fuel is drawn simultaneously from both auxiliary tanks. Including return fuel, the wing-mounted aux tanks empty in about one hour 15 minutes in carbureted Bonanzas and as little as 45 minutes in fuel-injected models. Return fuel from the aux tanks goes into the left main. If you upgrade to an IO-550 and use high cruise rich of peak EGT, the aux tanks will empty even quicker.

In a perfect world, you would be able to reach all the usable fuel (and maybe even the last "unusable" part). Owners report that often something less than 19 gallons is typically usable.

This configuration presents the best case to conduct a very careful test flight in clear skies above a low-traffic airport,

switching to full aux tanks in level flight and switching tanks again when fuel pressure begins to drop. After switching to a main tank and landing, refill the aux tanks. The amount you put back in is the approximate usable fuel you can expect with your individual airplane's system.

Fueling the airplane when it is sitting anything other than precisely level means one tank will get a little more fuel than the other when they appear "full." The precise location of fuel pickup lines from the tanks, or any misalignment or settling of one aux fuel bladder, may cause one tank to unport before the other.

Uncoordinated flight can cause one tank to empty or unport before the other. If one tank gets down to unusable fuel before the other, venting can stop fuel flow from both aux tanks. There's a good article about this in the November 2006 *ABS Magazine*, pg. 9891.

Fuel quantity indication in this configuration, especially as first introduced, is a human-factors nightmare. Sensors in each tank transmit the fuel level to a single gauge on the instrument panel. The pilot must move two switches: one to hook the gauge into the main or auxiliary tanks, the other to display either the left or right tank of that selection.

Beginning with the J35 and in Debonairs, a separate auxiliary fuel gauge simplified this somewhat, but the pilot must always be careful to set the switches to the indication he/she thinks it is reading.

A strategy for wing-mounted aux fuel tanks:

1. Confirm through all available means that the tanks are serviced as expected prior to takeoff.
2. In cruise, after ensuring room for return fuel in the left main, switch to the auxiliary fuel tanks and confirm fuel pressure continues. Start a timer. Pre-J35, switch the panel fuel gauge to the AUX position. Alternate between LEFT and RIGHT tank positions on the gauge selector to monitor fuel level.
3. When within five minutes of tank depletion, based on observed flow rate plus return fuel rate and time, switch to a main fuel tank. Confirm pressure continues and set fuel gauge switches to indicate MAIN and the tank in use.

And what about tip tanks?

Tip tanks for Beechcraft have been around in various forms for decades. They provide great improvement in range and healthy reserves for safety. And, like fuselage and internal wing auxiliary tanks, tip-tank strategy also requires some thought. But we'll leave that for another time.

Thomas P. Turner is manager of technical services for the American Bonanza Society. A certified Master Flight Instructor and holder of a masters degree in Aviation Safety, Tom once ran FlightSafety International's Bonanza pilot training program. He is widely published on topics of flying safely.

