LISA TURNER
COMMENTARY / AIRWORTHY

The Top Three Fuel System Problems

And how to avoid them

BY LISA TURNER

WHEN WAS THE LAST TIME your car stopped running because of the fuel supply? Did you answer "never" or "a really long time ago"? It's inconvenient but generally not life-threatening. You just coast over to the side of the road and feel embarrassed as you wonder who you are going to call.

Fear, rather than embarrassment, is the first feeling we have if we have a fuel problem in our airplane. It's serious. Especially when flying over a mountain range or flying at night. Airplanes aren't cars, and it's not as simple as saying, "Fuel management errors are pilot error." (See sidebar — Safety Stats.) While the majority of the accidents could have been easily avoided through better preflights and pilot judgment, many of the accidents in experimental aircraft are a result of other things, such as fuel system design, assembly, and maintenance.

Here are the top three fuel system problems in homebuilts, and how to avoid them. If you're flying a certified aircraft, the principles are the same, but you may not have as many opportunities for error in the design and maintenance areas.

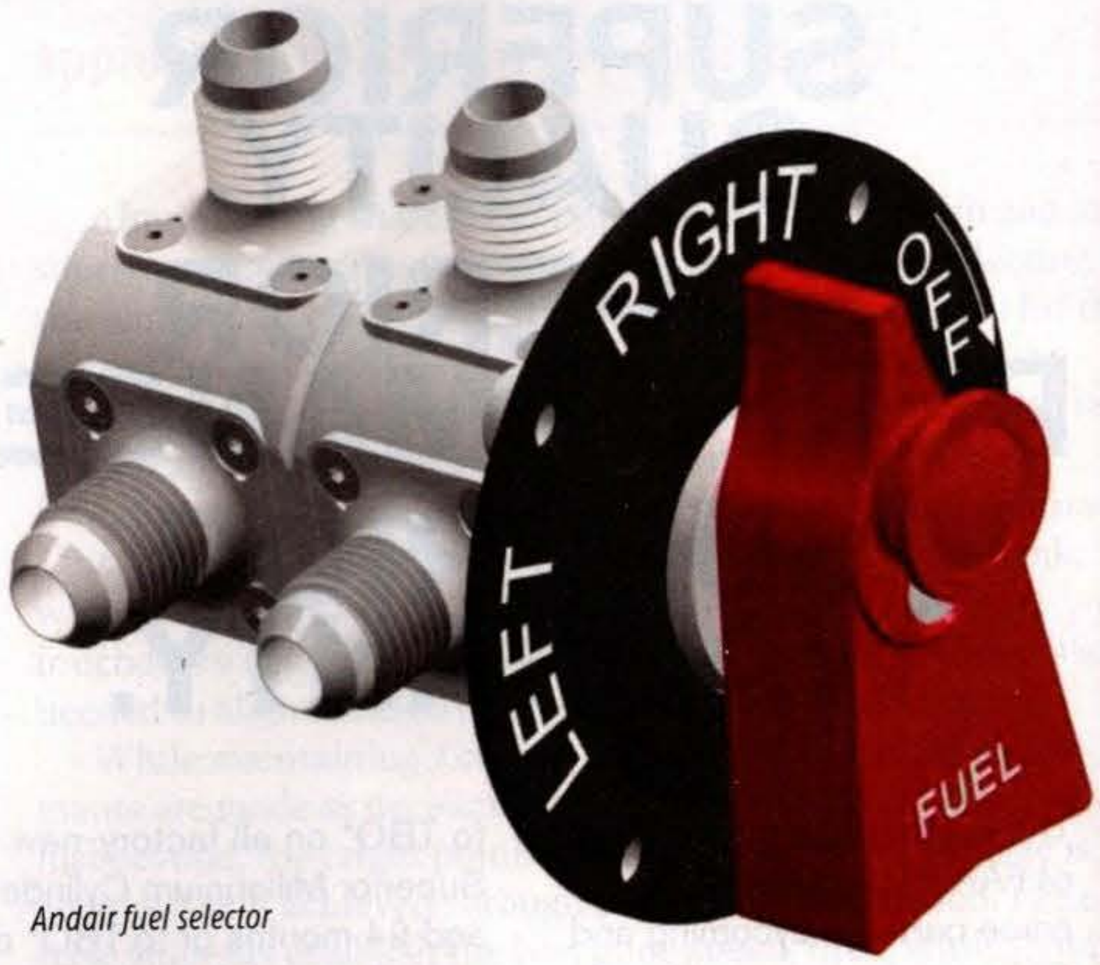
1

MISSING PIECES OR TOO MANY PIECES (DESIGN)

The most opportunities for error will be found in an original experimental design. As with all of the other critical systems, a thorough and informed fuel delivery design is paramount. At the other end of the spectrum are the quick-build kits where the fuel system design is already built in. You should still review the opportunities for error, even if you are the owner of a flying secondhand homebuilt airplane.

- **Fuel valve selector.** Managing fuel while in flight should be simple and straightforward. However, on many of the aircraft I've inspected, it's confusing and complex. There should be only one fuel selector in a single-engine aircraft. It should be in a visible, easy to reach place for the pilot when they are fully belted in. The selector markings should be clear. On one installation I was inspecting, I couldn't tell which end of the selector handle to read. In an emergency, any confusion or hesitation is a bad thing. There should be a detent at each position that you can feel, and operation should be smooth.

  A classic example of these rules being broken was the 1997 fatal crash of John Denver in his newly acquired secondhand Long-EZ. It had an unmarked and balky fuel selector behind the pilot's left shoulder. Denver lost control of the aircraft while unbuckling and turning in the seat to access the handle. The plans called for the selector to be at the front of the pilot seat within easy reach.



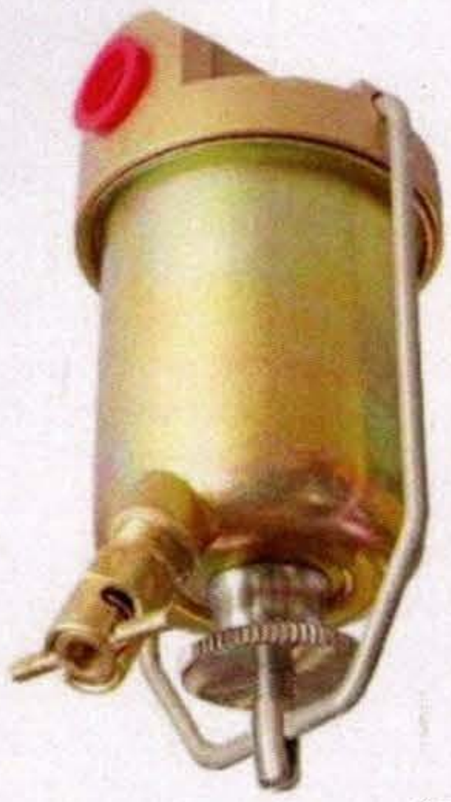
Andair fuel selector

The fuel selector handle should not pass through OFF to change tanks. On a high-wing aircraft with gravity feed and two tanks, L-BOTH-R works well, and on a low-wing, L-R works well. I don't recommend feeding from both tanks on a low-wing airplane with a fuel pump. One tank can unport (suck air) as the fuel level lowers, and this will stop the flow.

PHOTOGRAPHY COURTESY OF **LISA TURNER**

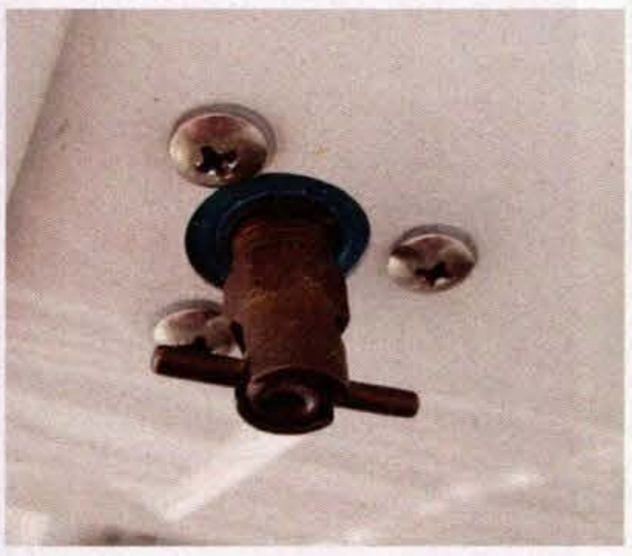
- **Fuel filters (non-fuel-injected systems).** Some builders decide that the more filters they have, the better. I saw five lawn tractor-type inline filters in one installation. More filters mean more opportunity for fuel starvation (clogging the supply). What recommendation has the designer provided? Often this detail is missing from the documentation, so it's important to research it. I've seen plenty of cheap plastic and paper filters, as well as very fine mesh filters, used in kit aircraft. I strongly recommend not using these filters. I've seen them crack and leak, especially at the fittings. Any moisture in the gas will swell a paper element and stop the flow. Fine mesh will clog quickly. Ditch the lawn tractor filters and use a gascolator. Check with the kit manufacturer for advice if it's not in your documentation.

- **Gascolator.** As handy as the gascolator is, it doesn't replace having sump drains at the lowest points in the system. The gascolator does not have to be at the lowest point as long as you have sump drains at the lowest points.



Gascolator

- **Fuel vents.** Sometimes seen as an afterthought by builders, fuel tank venting is critical. Using a vented fuel cap without tank vents may not provide the air exchange needed to keep fuel flowing from a tank. As the fuel level in your tank lowers, it must be filled with something or it creates a vacuum. Even a partial vacuum can stop fuel from flowing. On your preflight, check the vent openings. Insects love nesting in them, especially wasps.



Low points should have drains.

I've seen some strange up-down-around routings for vent lines, one even ending up in the cockpit. Oops. What is that fuel smell? Make sure your vents don't have any traps or places where the fuel can sit in a low spot. Vents should be located in an area of slight positive pressure. Make sure wing tanks vent outboard.

An ideal tank vent is a standpipe style tube attached to the fuel cap and pointed into the wind a few inches above the cap. It's obviously not popular with the low-wing flush-cap crowd, but it works really well.

SAFETY STATS

50

About 50 general aviation accidents a year could be prevented if pilots were better at fuel management, according to the NTSB.

56%

In Safety Alert 067 (August 2017), the NTSB stated fuel mismanagement was the sixth leading cause of GA accidents in the United States. An analysis of GA accidents from 2011 through 2015 found that fuel exhaustion (in which an aircraft runs out of fuel) accounted for 56 percent of fuel-related accidents, and fuel starvation (in which fuel is in the aircraft's tanks but does not reach the engine) accounted for 35 percent.

95%

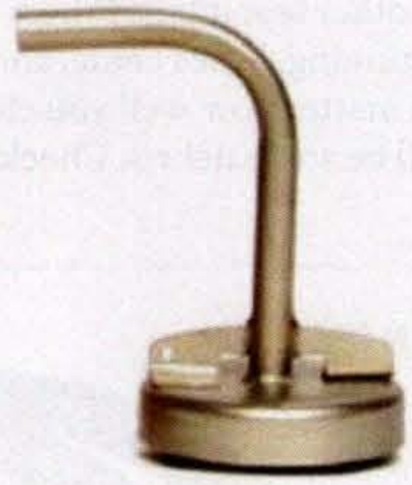
Ninety-five percent of all fuel-management-related accidents were associated with pilot error, while equipment issues contributed to the remaining 5 percent, according to the NTSB.

50%

Data showed GA pilots with private pilot or sport pilot certificates were involved in half of the fuel-related accidents, those with commercial or air transport pilot certificates were involved in 48 percent of fuel-related accidents, and student pilots were involved in 2 percent of fuel-related accidents.

From: Flight Safety Foundation, September 11, 2017.

If you want additional tanks in your aircraft, the complexity and risk go up. Don't decide to design a special fuel system for your homebuilt unless you're an expert. On design issues, check with the aircraft designer and/or the manufacturer for the kit you are building. If there is a builders group, its members can provide additional real-world experience. My advice is to never, ever modify the kit manufacturer's design without consulting the manufacturer first. Modifications to fuel systems can be dangerous without proper engineering and design work.



Standpipe type vented fuel cap

LISA TURNER

2 MAINTENANCE AND MATERIAL FAILURES

Once we've tested and flown our homebuilt, our excitement level is high, and we switch from "build-examine-inspect" mode to "let's fly" mode. When this happens, we assume that everything is going to keep working, just as it does in our cars and trucks. Here are potential problems.

- **Inspection items not on the list**. When builders are getting ready for the first flight, I like to go over the preflight checklist and make sure everything is on it. Fuel system details are often missing. Extra critical is adequate fuel sampling from the sumps, which will tell you a lot about the condition of the fuel.

- **Using automotive parts.** If you're building an aircraft, I recommend that you use aircraft grade fuel lines. I've seen builders use a variety of plastic and rubber hoses that were just waiting to crack and spring a leak. Both rubber and plastic are very time-limited materials. Rubber deteriorates quickly, and plastic cracks and splits. When you've spent all of your time building the airplane of your dreams, you don't want your fuel hose to be the weakest link in the maintenance chain. Don't skimp on this component. Aeroquip and Parker make excellent lines that will last a long time.

- **Inadequate flight testing and inspections in the first 100 hours.** Don't forget about the fuel system after you've run your fuel flow tests and are working on other test items. Filters clog unusually fast at the beginning, hoses chafe, and fittings loosen and leak. No matter how well you cleaned your tanks, there will be some debris. Check and recheck them.

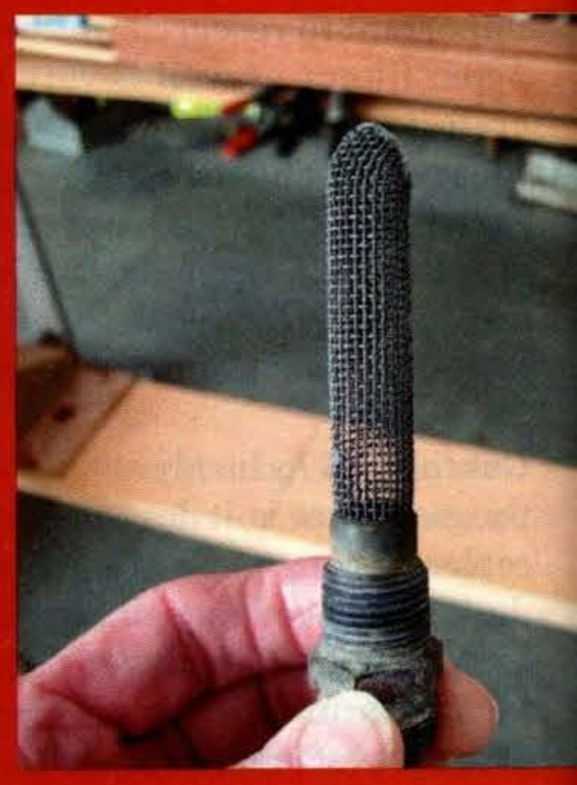
Below: *Grounding line built into the gas caddy.*

FUELING SAFETY

Many of us fuel our airplanes ourselves. Don't forget that fueling anything – from a weed eater to an aircraft – has risk associated with it. From accidental spills on a hot exhaust to a static electricity surprise, there are enough serious accidents every year to prompt heeding the following recommendations.

STATIC ELECTRICITY

Walk across the carpet in the winter and then pet the cat – ouch! In a fueling situation, an electrostatic charge is generated as fuel flows through pipes, hoses, pumps, and filters. The strength of the charge depends on how fast the liquid is flowing and the difference in charge from one material to another. The airport fuel truck uses a grounding strap when it fuels your airplane to prevent the charge from building up and creating a spark that can ignite the fuel vapor. Because the fuel flow is high in the hose, there is more potential charge. When filling from airport pumps, always use a grounding strap.



Finger screen

Identify a good ground point on your aircraft. It will vary depending on what your airplane is made of so check with the manufacturer or the builders' group. Filler necks and finger screens should be part of the grounded system.

Many of us use the typical 5-gallon red plastic containers to fuel our airplane. We believe this is perfectly safe because we've refueled all of our lawn equipment through the years without incident. Although the flow rate with these cans is low, there is still a risk. Here's what you can do.

Ground all containers before opening and dispensing fuel. You can reduce static charge between plastic can contents and your airplane by doing the following:

- Physically touch the outside of containers and ground lines to bleed excess charges off your body.
- Use a lightly dampened (water) rag to wipe the plastic can down. This reduces static charge (it raises the humidity).
- When filling the can from a station pump, place the can on the ground.
- Touch the outside of metal and plastic containers with the fill nozzle before and as you fill a can, and touch the siphon hose or can spout to the filler opening on the airplane when filling.
- Pour slowly. I know it's time-consuming. Or you can use a pump or siphon
- Make sure any screen or funnel you are using is similarly touching, or grounded, to everything else.
- When de-fueling, be just as careful. Use all of the same precautions that you use to refuel.

I really like the gas caddies for fueling. They range from $180 to more than $600. With the high-end models, you get a built-in grounding strap, a high-efficiency hand-crank pump, a fire screen, a gauge, and a drain valve.

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13 HUMAN FACTORS (ERRORS AND MISTAKES)

We don't decide to develop a fuel problem. However, like other preludes to disaster, multiple mistakes can add up to an off-airport landing — or worse.

- **Lack of system familiarity or understanding**. If you don't understand how a system works while building your aircraft, study it or ask for help in understanding why it goes together the way it does. I've seen some builders deliberately leave components off the airplane because they didn't understand why the parts were there, or add things they didn't need, like extra fuel selectors and filters.

- **Assumptions.** As humans, once we mentally decide something is one way or the other, it's hard to switch to another point of view, like first impressions. If we think we are correct, then we will persist, even in the face of contradictory facts. From "The weather looks fine here" to "I know I can stretch it a little longer," it's not hard to understand why good judgment goes astray. We need to be as humble as possible and maintain open minds as we conduct our inspections and do our planning.

- **Inadequate preflights and flight planning.** Similar to assumptions, just because we did an inspection yesterday and everything was fine doesn't mean we should not do a thorough inspection before we fly today. We also tend to shortcut the flight-planning process when we are excited about going somewhere. Clear your mind for a moment in the excitement and let logic guide you in a careful preflight and adequate time on your checklists and planning.

Yes, we sometimes wish that our airplanes were jump in and go, as simple to operate and as reliable as our cars. When was the last time you preflighted your car or truck? Most of us don't even take a walk around it before we get in and turn the key. One day this may also be the case with our flying machines, but for now, some attention, thoughtfulness, and planning will deliver the happiness and freedom that being in the sky produces. *EAA*

Lisa Turner, EAA 509911, is a manufacturing engineer, A&P, technical counselor, flight advisor, and former DAR. She built and flew a Pulsar XP and Kolb Mark III, and is currently restoring a Waco UPF-7 with her husband. Lisa is a member of the EAA Homebuilt Aircraft Council and Women in Aviation International.

FUEL SYSTEM CHECKLIST

GENERAL

- [x] How much fuel is really in your tank(s), and is it the right fuel for your airplane?
- [ ] Do you know how much unusable fuel you have?
- [ ] Can you expect a center of gravity change as fuel is consumed? How does this affect loading and flying?
- [ ] Can you use all of the fuel in every fuel tank if you have an electrical system failure?
- [ ] Are all placards installed and correct?
- [ ] Did you clean the tanks before assembling the system?
- [ ] Can you identify water in a fuel sample?
- [ ] Can you identify what the right fuel is by the color?
- [ ] Have you calibrated your fuel flow on your engine monitor if you have one?
- [ ] Have you calibrated and labeled your fuel sight tube if you have one?
- [ ] Did you make up a fuel system schematic if you built the airplane?
- [ ] Gas caps — condition — cracked or missing gaskets?
- [ ] Consider carrying an extra fuel cap in the airplane with a standpipe vent. If your tank vent becomes clogged on a trip, you'll have an alternate until you can clear it.

SELECTOR

- [ ] Clearly marked? Easy to move with a detent at each position?
- [ ] Easy to see and operate from your seated and belted position?

FILTERS

- [ ] Recommended type by the manufacturer? Filter material other than paper? Mesh size passes 150 percent fuel flow test?
- [ ] Easily accessible for change-outs?
- [ ] If the engine is fuel injected, do you have the recommended fuel pump and filter combination along with a bypass and cockpit indicator?

TANKS & LINES

- [ ] Sump drains at low points in the system?
- [ ] Make sure you sample from every sump. Wait 10 minutes after filling a tank before checking to let contaminants settle.
- [ ] Check sumps first, then the gascolator.
- [ ] No traps in vent lines?
- [ ] Venting for each tank?
- [ ] Preflight check for vent clogs or insects?
- [ ] Fuel hose material checked for length of service and condition?
- [ ] Clamps and connections tight and not abrading the material?
- [ ] Fire sleeve protection in hot areas?
- [ ] No chafing, and protection through firewall and bulkheads?
- [ ] Connections: DO NOT use Teflon tape on fittings. PST sealant is okay.

Add your own items here!