

» **Checking for fuel contamination** as part of the preflight inspection.



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Fueling Errors: The Hidden Threats Lurking in Your Tanks

by Laurie Einstein Koszuta

Fuel problems in general aviation rarely announce themselves with drama; more often, the warning signs hide in plain sight. A cup of discolored avgas or a nozzle swapped in haste can set the stage for the same outcome: an engine starved of the fuel it was designed to burn.



Whether the threat comes from contaminated 100LL or a misfueling mistake on the ramp, the result is a preventable emergency that begins long before the aircraft leaves the ground. Understanding how these errors happen and how to catch them early is essential to keeping pilots and passengers safe.

How a Few Ounces of Fuel Can Reveal a Dangerous Problem: Fuel Contamination

Less than a minute after departure, climbing through only a few hundred feet, the engine in a late-model Cirrus SR22 sputtered and quit.

Moments earlier, the takeoff had been routine. Nothing seemed out of the ordinary. To the pilot, the sudden silence must have been unmistakably eerie and nerve-wracking.

In another incident, a Cirrus SR20 was forced to make an off-airport landing after the engine began running rough and losing power.

In both cases, the National Transportation Safety Board (NTSB) determined that water-contaminated fuel caused a total loss of engine power during the initial climb.

In an airplane equipped with a parachute, dual alternators, redundant electrical systems and some of the most sophisticated avionics in general aviation, such a chain of events can

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often be traced back to something far simpler: what wasn't drained from the fuel sump before departure.

According to Lex Crosett, a CSIP (Cirrus Standardized Instructor Pilot), COPA University instructor and a Designated Pilot Examiner (DPE), fuel-related accidents in modern aircraft are relatively rare. But that rarity can breed complacency and is dangerously misleading.

“Pilots tell themselves there are a lot of filters between the fuel farm and the fuel truck and the truck itself has filters,” noted Crosett. “Then they think, how bad could it be if I take on 50 gallons and skip draining the sump? The airplane has been in the hangar since the last time I flew it.”

Unfortunately, that assumption is exactly how a routine flight can begin with a perfectly normal run-up and end in trouble shortly after takeoff.

The Normalization of Deviance

“Skipping a step begins with rationalization,” Crosett said. “It's windy. It's cold. The airplane has been sitting in a clean hangar. You don't feel like kneeling on a dirty ramp to drain the sumps. You are in a hurry. You just fueled. Besides, any contamination seems unlikely since water takes time to settle through the fuel.”

There are a host of reasons pilots use to justify why it probably won't matter this time.

Crosett called this the normalization of deviance. It is how small departures from procedure gradually become acceptable because nothing bad happened the last time.

Until one day it does ... even for experienced pilots.

How Water Actually Gets Into The Tanks

Many pilots assume contamination comes from the fuel truck. In reality, that's one of the least likely sources. “Most fueling operations are extremely careful about contamination,” Crosett says. “It has happened and it will happen again, but it's relatively rare.”

A far more common source is the aircraft. “Fuel caps are not perfectly sealed,” said Paul New, a pilot, presenter on aircraft ownership at COPA Pilot Proficiency Program (CPPP) events and an accomplished Airframe and Powerplant (A&P) mechanic. “Caps can loosen, seals can wear and even a small leak can allow moisture to enter the tank during rain or overnight exposure to humid air.”

However, caps sit in a shallow recess that acts like a small bowl. Rainwater can collect there and if the O-ring seal is worn or improperly seated, that water can slowly seep into the tank. Fuel cap design can be a contributing factor, although wet-wing aircraft like the Cirrus rarely have such issues.

Crosett explained: “Temperature swings can also introduce moisture. When an aircraft is rolled out of a warm hangar into cold air, condensation can form, sometimes even producing frost on the wings above the fuel tanks. If humid air is present inside a partially filled tank, water vapor can condense or freeze into tiny ice crystals. That is one reason many pilots keep their tanks full whenever weight and mission allow, minimizing the amount of moist air inside the tank, much like boat owners who keep fuel tanks full to reduce moisture buildup.”

What Happens When Water Enters the System

Another commonly misunderstood factor is how long water takes to settle through fuel.

Widely cited guidelines say that it takes approximately 15 minutes per foot of fuel depth for water droplets to settle to the lowest point of the tank.

New explained that when water enters a fuel tank, it breaks into small droplets suspended in the fuel. Internal structures in the tank can temporarily trap that water. As fuel burns off during flight and the level drops, the surface tension of the avgas can release those beads from the sidewall and allow those droplets to flow downward toward the drains.

“Before reaching the engine, fuel passes through a component known as the gascolator, which acts as the final filter and water separator,” New emphasized. “The gascolator can hold roughly

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Fuel sample with suspended and separated water layer indicating contamination.

3 ounces of water before becoming overwhelmed. If more water enters the system than it can contain, the separator can no longer prevent contaminated fuel from reaching the engine.”

Crosett added, “That’s why water can sometimes appear during a later sump check, even if an earlier sample looked clean.”

This settling process depends on several factors, including the depth of the fuel in the tank, the degree of turbulence during fueling and the size of the droplets. Furthermore, cold fuel increases the viscosity, slowing the settling process and any movement of the aircraft can remix the water. “Pilots may sump the tanks, see no water, fly a trip and then find water afterward,” New said. “It doesn’t mean anything tragic; it just took time to make its way down to the drains.”

Best Practice

“The guidance is to refuel first, then go to the restroom or whatever you need to do and finish by completing the rest of the preflight inspection,” said New. “By the time you return to the sump drains, typically 10 to 20 minutes later, any water present has had time to collect at the low points. If you sump immediately after fueling, you’re probably not going to see any contamination.”

Pilots should always follow a few basic practices:

- Sump the tanks before the first flight of the day.
- Know every sump location on the aircraft.
- Visually inspect every fuel sample.

“That includes checking all five sump points on the Cirrus including the main wing tanks, header or slosh tanks and the gascolator itself,” said New. “Missing one can allow contamination to remain in the system. You’d be surprised how many pilots are unaware of how many sump points their Cirrus has.”

Looking for the Right Clues

Even when pilots do sump the tanks, contamination can still go unnoticed if the sample isn’t examined carefully. “Remarkably,” New said, “many pilots cannot clearly describe what water in fuel actually looks like.”

Crosett agreed. “Understanding safety and emphasizing best practices is important,” he said. “Most of the pilots who come to CPPP events are experienced pilots and yet they show up because they know they don’t know everything and realize they need to continue learning.”

Water in avgas typically appears as clear beads or bubbles that separate and settle to the bottom of the sampler. Sediment may appear as small particles or discoloration. The sample should also match the correct color of the fuel grade.

“Some pilots drain a quick sample and dump it without really looking,” New added.

Crosett emphasized that proper technique matters as well. “Pilot operating handbooks (POH) usually recommend draining several ounces at each sump point,” he said, “enough to clear the lowest part of the fuel system where water or debris may collect. The fuel strainer typically includes a filtration screen so the sample can be safely poured back into the tank if it’s clean. Regardless of any reason you can think of, you can’t just sump for a second or two. Take the time to follow the manufacturer’s recommendation.”

When in Doubt ...

Both Crosett and New said that when in doubt, keep draining. The general rule is simple: Drain the sump until the sample runs clear. Crosett goes one step further: When in doubt, chicken out.

If multiple samples continue to show water or debris, the aircraft may have a larger contamination problem that requires maintenance attention. However, the opposite mistake – assuming the problem is gone after one quick sample – can be equally dangerous.

A proper sump check takes less than a minute. Recovering from an engine failure after takeoff takes far longer.

“Pilots should also be aware that some aircraft have additional drain points unrelated to the fuel system,” noted Crosett. “Aircraft equipped with TKS anti-icing systems have separate drains under the wings, often marked in red. These drain glycol-based TKS fluid, not fuel and can occasionally confuse pilots unfamiliar with the system.”

Water and debris contamination in fuel is not new in aviation. The procedure to detect it has not changed in decades. A few ounces of fuel in a sampler can reveal a problem that might otherwise appear only after the wheels leave the ground.

In an age of sophisticated avionics and advanced aircraft systems, one of the most important safety checks in aviation still comes down to a simple habit: a careful preflight and a quick look at the fuel in the cup.



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New also noted that some pilots have dangerous misconceptions, such as the belief that piston engines won't start, taxi, complete a run-up or even take off normally if misfueled with Jet A instead of avgas. That isn't true. Residual avgas remaining in the fuel lines can temporarily allow the engine to run before the jet fuel reaches the cylinders and detonation begins.

Another misconception is that Jet A nozzles will not fit into avgas filler ports because of their larger duckbill shape. While this safety feature helps, it isn't foolproof. If an inexperienced LST encounters resistance, they may try to force the nozzle into the opening and inadvertently introduce the wrong fuel. "In some cases," said New, "the problem isn't even the technician – the fuel truck itself may contain the wrong fuel, contaminated fuel or avgas that was not fitted with the correct nozzle. It's rare, but it happens."

Detecting Contaminated Fuel

According to a July 2021 AOPA Pilot article by A&P/IA Mike Busch, it is impossible to distinguish pure avgas from a mixture of avgas (blue) and Jet A (straw-colored) by color alone.

Busch, who once experienced a misfueling event that was fortunately detected before engine start, noted that there is no visible difference in color or clarity between 100LL and a 50/50 mix of avgas and Jet A.

He also noted that he was taught that since Jet A is significantly heavier than avgas, Jet A and 100LL will separate just like oil and water, with Jet A at the bottom and 100LL at the top. That's true, he said, but only if the contaminated fuel is allowed to sit undisturbed for hours. In reality, 100LL and Jet A mix quite well and the mixture can take a surprisingly long time to separate.

Busch explained that there are at least two reliable ways to distinguish pure 100LL from Jet A-contaminated fuel. The first is by odor. "Jet A has a distinctive kerosene smell that can be detected even in small concentrations. The other and probably the best method is the paper towel test," Busch said. "Pour a sample on a white paper towel and allow it to evaporate. If it leaves an oily, golden-colored ring, jet fuel is present."

Busch noted that the greatest danger occurs when a piston engine runs on a mixture of 100LL and Jet A. A large amount of Jet A mixed with a small amount of avgas might be detectable during run-up. However, a 50/50 mixture might not begin detonating until full power is applied. The engine could fail catastrophically 30 seconds or three minutes after takeoff.

"Always visually confirm the fueling process when possible."

Even a small amount of Jet A contamination may produce only a moderate detonation. Over time, that detonation can crack sparkplug nose core insulators or cause internal engine damage that may not be immediately noticeable. "In those cases, the engines are basically melting because of the detonation," said New. "But it is very preventable. Communicating exactly the type of fuel, the number of gallons you require and which tanks should be filled is the first step."

How to Prevent Disaster

Several simple practices can significantly reduce the risk:

- Always visually confirm the fueling process when possible.
- Verify the fuel type at three points: the aircraft placard, the fuel order receipt and the fuel truck or pump labeling.
- Never rely solely on color or smell.
- Make sure your aircraft fuel placard is present and legible. If it is missing or faded, the line technician has no clear reference point to determine the correct fuel.
- Strict adherence to nozzle and port incompatibility standards is critical. Jet A "duckbill" nozzles should never be replaced with round nozzles that could fit avgas filler necks.

"If a misfuelling event occurs," New explained, "an A&P mechanic must drain the entire fuel system and flush it according to the service manual. It's a time-consuming process and very expensive. But that inconvenience pales in comparison to what can happen if the mistake isn't discovered until after takeoff."

Clear communication, careful observation and a few verification steps are best practices that can prevent tragedy. In aviation, the smallest details matter. Fuel is one of the most important. ⊕