FLYING LESSONS for December 17, 2020

FLYING LESSONS uses recent mishap reports to consider what *might* have contributed to accidents, so you can make better decisions if you face similar circumstances. In almost all cases design characteristics of a specific airplane have little direct bearing on the possible causes of aircraft accidents—but knowing how your airplane's systems respond can make the difference as a scenario unfolds. So apply these *FLYING LESSONS* to the specific airplane you fly. Verify all technical information before applying it to your aircraft or operation, with manufacturers' data and recommendations taking precedence. **You are pilot in command, and are ultimately responsible for the decisions you make.**

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This week's LESSONS:

Many readers wrote about last week's *LESSONS* on the need for accurate fuel gauges, both for safety as a crosscheck to other means of determining fuel load and to comply with the unequivocal regulatory requirement that fuel gauges ready accurately in flight. Some objected, primarily on the basis of what it would cost to repair or replace their faulty gauges. Others reported trying without success with existing systems that they could not fix. More readers cancelled their (free) subscription to *FLYING LESSONS Weekly* in the past week than I've seen cancel in a single week in a very long time—I don't know *why* they chose to stop reading; I can't say it's causal, but it certainly correlates to this unpopular topic. ***Was it something I said?*** Probably.

See https://www.mastery-flight-training.com/20201210-flying-lessons.pdf

That said, I also received many positive comments, and eventually enough new subscribers to balance the cancellations with an additional four new readers for the week. ***Was it something I said?*** I hope so.

As I wrote last week,

> Believing that float type fuel gauges are inherently inaccurate, accepting a lack of verifiable fuel quantity information (that compensates for leaks and other losses not detectable by digital flow monitors), and denying fuel indicators the maintenance and repair attention they require, is a great example of the Normalization of Deviance. I believe this owner/pilot complacency regarding fuel quantity indicator accuracy is a major factor in the high rate of fuel starvation and fuel exhaustion accidents.

See https://en.wikibooks.org/wiki/Professionalism/Diane_Vaughan_and_the_normalization_of_deviance

AOPA's research reveals that "about two-thirds" of all engine failures in general aviation aircraft that result in an NTSB report are the result of fuel starvation or fuel exhaustion. "An average of more than three accidents per week result from fuel exhaustion, starvation or contamination," AOPA warns about "these easily preventable accidents" that are in turn the direct result of the pilot's fuel management and dramatically impacted by the accuracy of fuel quantity indicators.

A 2017 article in *Flight Safety Australia*, the Civil Aviation Safety Authority (CASA) periodical, defines the Normalisation of Deviance as:

> The lack of bad outcomes can reinforce the "rightness" of trusting past practices instead of objectively assessing the risk, resulting in a cultural drift in which circumstances classified as "not okay slowly come to be reclassified as "okay."

See:

https://www.aopa.org/news-and-media/all-news/2018/august/flight-training-magazine/accident-report-fuel-management
https://www.aopa.org/training-and-safety/air-safety-institute/safety-centers/fuel-management
https://www.flightsafetyaustralia.com/2017/05/safety-in-mind-normalisation-of-deviance/

Ultimately what I hope readers get out of last week's *LESSONS*: that ***accepting fuel gauge inaccuracy is example of the Normalization of Deviance may be a causal factor in the majority of reported inflight engine failures.***

I hope you stay with me. Read on for comments and insights from fellow *FLYING LESSONS* readers.

Questions? Comments? Experiences to relate? Send them to mastery.flight.training@cox.net.

Debrief: Readers write about recent *FLYING LESSONS:*

Reader and avionics/panel devices expert John Collins writes about the fuel gauges *LESSONS*:

> I liked your analysis of requirements for keeping fuel gages calibrated. I offer one common failure mode in the Bonanza [and similar airplanes] with its rubber bladder tanking system. The tank gets air to replace the fuel volume as it is consumed. The design of the tank is that the bladder is attached to the top inside surface of the wing, usually the leading edge. Snap fasteners are used to attach the top of the tank to the wing and the tank itself sits on the lower inside wing surface without any attachments. The fuel senders are attached to the top of tank with a float that swivels upwards when full and rests on the bottom surface when empty. Vent air enters the tank at the top at the highest point in the bladder. If bugs crawl up into the vent lines providing the air to the tank, they may block all air going to the tank. This causes the tank bladder to collapse upward as fuel is consumed, lifting the sender floats as well. So as fuel gets close to actual empty, the cockpit indication can go to nearly full. I tell pilots if they open their fuel cap and hear a whoosh, that is a sign the tank is not getting good venting. Also, one will often see the bottom of the tank bladder curled up close to the area around the fuel cap.

I've seen this failure mode myself and teach it in type-specific training courses. But even in this scenario it's valuable to have accurate and trusted fuel quantity indicators. In such a case you'll see the indicated fuel level *rise* in the affected tank, or at least fail to decrease if that tank is in use. This **erroneously *high* fuel level** may be your first indication that fuel is leaking or venting overboard, or that an obstructed vent will prevent you from accessing fuel from that tank—events that would not register as anything abnormal on fuel totalizers. Thank you, John.

Australian reader Dave Laughton writes:

> I've owned a [Piper] Malibu Matrix for the past 10 years during which time I've also been a member of MMOPA, and from first-hand experience backed up by very many postings on that forum I unhappily report that it seems, despite three previous attempts by Piper to supply a working system, the fuel gauges in combustion engines PA46 aircraft have been a very substantial failure since inception back in the mid 80's, and at no point did it appear that Piper were compelled or committed to resolving it.
>
> Happy to report that their fourth, very expensive (again), attempt at providing a reliable gauge is successful, at least I hope so as I've just spent about $AU11,000 installing them.
>
> As for placarded calibration in Australia your comments seem to be true for analogue gauges, but not for the glass panels. Mine has been so erratic to date as to be unable to be reliably calibrated, and therefore next to totally useless. No repair has been available, a source of great amazement, frustration and concern for the reasons you so correctly describe.

Senior leadership of Piper Aircraft and leaders of MMOPA read *FLYING LESSONS*, Dave, so I'm sure they're happy to see you now have a workable (albeit costly) solution for analog gauges. A solution for the interface with aftermarket avionics would be the avionics manufacturer's responsibility aided at times by the ingenuity of the installation shop. We had issues with my employer's A36 Bonanza getting a then-new Garmin G500 TXi Engine Indicating System (EIS) to accurately read the Beech factory fuel senders. Given that we'd removed the original gauges and were counting on the EIS to serve as primary indicators, I was concerned. But the manufacturer and our installer were able to get them to work properly and accurately with only minor adjustments. It sounds as though you've retained your original analog gauges in your Matrix, but I hope you'll find a solution for your glass panel as well. Thank you, Dave.

See https://mmopa.com/

Reader Henry Fiorentini adds his thoughts on fuel gauge accuracy:

> Perhaps obvious, but accuracy is less important than consistency. If the gauge is consistently off by a certain amount, then it can be calibrated to the correct amount – even if only by a 'correction factor' like your Australian friends. And virtually by definition, that amount will be extremely accurate, so long as the gauges are consistent.
>
> One nice thing about electronic fuel gauges (like my JPI, or the EIs or any such) is that such calibration can be done internally. The tech (or you!) can fill and drain the tanks to 1/2 or 1/4 full and tell the electronics to peg "Whatever voltage reading you are getting now is to be shown as 1/4 tank (or maybe just "x" gallons). The calibration/offset is done internally, not on an external, paper placard. On my beloved JPI 930 with fuel totalizer, this "theoretical remaining fuel" has never been off by more than 2 gallons total, even when I've refueled when I'm below 1/ 4 total fuel, which also corresponds to the actual/float fuel gauges to within 1-2 gallons. And such theoretical/incremental measurements can be re-calibrated by the pilot, and I have mine to read a wee bit MORE than actual, so in reality I have just a gallon or two more than my JPI totalizer says, just to be on the safe side.
>
> And regrettably, I agree that many pilots just look for any excuse to abdicate responsibility, like "That never works anyway!" To paraphrase a TV show parody, "Sure it's easy to blame ourselves. But it's even EASIER to blame something else." To the extent that there is no reason to keep flying with less than about an hour of fuel (about 14 of 74 Gallons in my F33A), I find very little excuse for fuel exhaustion.

You've been essentially doing voluntarily what CASA (and likely other regulators) make mandatory in their jurisdictions.

I'll also pass along a joke Henry sent, just to lighten the mood:

> Pilot to ATC: Mayday/mayday! Emergency! November 1234 is low on fuel, low on fuel!!!
>
> ATC: Roger, I have an airport at 3 miles, bearing 20 degrees to your left.
>
> Pilot: THANK YOU. THANK YOU THANK YOU…
>
> (20 minutes later)
>
> Pilot: Mayday/mayday! Emergency! November 1234 is low on fuel, low on fuel!!!
>
> ATC: Didn't I just direct you to an airport?
>
> Pilot: Yeah, but their prices were too high!

Thanks, Henry.

Reader, longtime aviation journalist and self-described "seasoned instrument pilot" Dave Higdon (who at one point considered buying the "flying restoration project" Cessna 120 I was selling in the early '90s) adds:

> Excellent info in your discussion about fuel starvation and pilots' attitudes toward gauges. Count me among those pilots with a distrust of their fuel-indication systems. Ultimately, my solution was to install an excellent fuel-flow/totalizer system digitally linked to my aircraft's GPS navigator; more and better info was the result -- and highly accurate, it turned out.
>
> Prior to that totalizer upgrade, however, my habit with a new plane was to fully fill the tanks -- two tanks in the case of the two Pipers we once owned -- and with one absolutely full to fly on the other tank until the engine died from, yep! Starvation. Land on the full tank (of course) and fill that empty tank to the same point

> and get a true read on its capacity and to calculate the hourly fuel burn at the lean-of-peak fuel flow at cruise altitude and speed.
>
> On a repeat of this process I could observe the gauge needles and at 15-minute intervals make note of the needle's position, and pretty accurately calculate fuel remaining by the needle and note what the totalizer showed as fuel remaining at each 15-minute period.
>
> By the time this process was repeated twice with each tank my trust in the indications increased substantially, and it also let me tweak the "K Factor" for the totalizer to the point that I knew it ran fast to the tune of one-tenth of a gallon per hour....helped my trust in the totalizer, as well...
>
> Pilot friends told me I was gambling with my life to run a tank try, because "what if the engine didn't restart?" after dying from starvation....but the instant the fuel pressure started wavering I switched on the boost pump, changed tanks and with the prop windmilling still, the engine always -- always -- restarted in a couple of seconds. And these exercises always began with *plenty* of altitude....Piece of cake -- and helped me increase my knowledge of -- and confidence in -- my aircraft.

I'm not a fan of running a tank completely dry either, Dave, but from your note it sounds like you usually predict when the tank is *about* to run dry, and then closely monitor the fuel flow to switch before the engine actually starves. That's a workable solution as long as you have the command of your aircraft your note describes, you're accurate with your calculations, fast with the tank switch, and know how much fuel is exactly in each tank using some independent means that permits you to make accurate inputs into the totalizer. It also requires you to avoid other distractions and defer other tasks (a frequency change, etc.) that might creep in just as the need to switch tanks arises.

Some airplane types also have more of an issue with vapor lock when a tank is run dry, especially if feeding from an auxiliary fuel tank. So this is not a one-size-fits-all technique.

If I knew the fuel tank was going to run dry in a minute or so (and assuming I want to take it that low, and not leave a little reserve in case I have problems with the other tank), I'd switch tanks *then* instead of waiting for the pressure drop. That extra minute or two of fuel won't make the difference between reaching your destination or not (at least it *shouldn't* make a difference!), and it avoids the possibility of not getting a rapid restart in a pilot-induced engine failure, even for just a couple of seconds. Yours is a commonly cited technique, Dave. Thanks for including all the details that go into using it.

Reader Robert Guzak writes:

> I am the owner of a 2000 Cessna 182S. I have never left the ground without first dipping the tanks to confirm fuel content even though I find my gauges to be very accurate. That is a step I never miss. I then put that number into my engine monitor which is very accurate in calculating fuel burn. This process has become a regular routine for me and I never have a fear of running out of fuel. Checking for water in the tanks is also a necessity. I have never found water in the tanks but you never know after a fill if there was any water in the fuel you just put into the tanks. I usually fill after a flight and although hangared all the time and out of the elements, check before the next flight to make sure water has not settled out from the last fuel up.

Great technique, Robert. Dipping the tanks, that is, inserting a calibrate stick or test tube directly into the tank to physically read the fuel level, is a "must" in airplanes for which this technique works—generally, high-wing airplanes with little to no wing dihedral. Regardless of airplane type, use all available means of detecting fuel level—dipping, visual inspection of fuel level (another thing less "usable" in some airplane types when fuel level is less than nearly full), totalizer input since the last top-off, a written log of airplane time since last fueling and the amount of fuel added, and of course the fuel quantity indicators. If any one fuel measurement noticeably differs from the others investigate and remedy the discrepancy, adding fuel as necessary for a positive confirmation of fuel level before flight.

Reader Lilly Spirkovska adds:

> Great article. I've heard that myth before ("correct only when empty") and it never made sense to me. Glad to see that the FAA isn't that silly and actually wrote a reasonable FAR. It's not too useful to be flying along fat, dumb, and happy only to have the fuel light come on, and unlike in cars, you don't even get that extra 5 miles before you run out of fuel! Thanks for setting me (and the rest of us) straight. Thank you for all you do to improve aviation safety! Happy Holidays!

I believed the "only accurate when empty" myth myself for a long time before I got curious, actually looked up the certification regulations and learned the real requirements. Curiosity and research beats chatter on the internet any day (he said, writing on the internet). Thank you, Lilly, and Happy Holidays to you as well.

Reader Bill Moore wraps it up this week:

> My own Beech Bonanza (V35B) has what I consider to be not always reliable accurate gauges. After reading so many stories and presentations about this being a cause in so many accidents and sadly fatalities. I spoke to Curtis Boulware (owner of Baker Aviation in Florida) and at the next annual I am replacing my factory sending units with the new and reported highly accurate digital units. It will not be cheap, but it is that important to know exactly how much fuel is on board and in which tank. Until next May, I refuel anytime I can tell by visual inspection that I am below 45 to 50 gallons out of 80 total.
>
> I have been teaching in a B36TC with the sight gauges in each wing and factory gauges in the panel. That airplane also has at least one tank that is not as accurate as it should be. Thankfully it arrived at Baker Aviation this past Sunday which those squawks on the list to fix.
>
> In my own flying and instruction f**uel management is as important as the weather and other key decisions before flight is commenced**. You have mentioned fuel management many times and as pilots **it is time for us to own this area of flight management**.
>
> My two cents - and thank you for your never ending efforts to keep us safe.

That's' the response I hoped to get…refusing to make deviance normal, and as you said owning the opportunity (and requirement) to avoid the cause of about two-thirds of all inflight engine failures. Thank you, Bill.

Questions? Comments? Send them to mastery.flight.training@cox.net.

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If you're flying for the holiday, fly with mastery and assume command of your flight. Plan for contingencies before you depart, and get your passengers and those awaiting your arrival to buy into your options in case a delay or cancellation is warranted. Take your time, make good use of the fantastic resource that is personal aviation…and have fun doing it!

Share safer skies. Forward *FLYING LESSONS* to a friend

Pursue *Mastery of Flight.*

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