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WHAT'S YOUR FUEL FLOW AT TAKEOFF?

One of the biggest reasons cylinders fail to go the distance is insufficient fuel flow at takeoff. Is yours set high enough?

by Mike Busch

Premature cylinder problems are epidemic. Hardly a day goes by that I don't hear or read about a Cirrus owner having to pull one or several cylinders at annual due to poor compression with leakage past the exhaust valve. The cause of this epidemic seems to be the confluence of several contributing factors.

TCM seems to have had some manufacturing problems during the late 1990s and early 2000s that resulted in less-than-perfect valve-to-seat concentricity. (I think they've fixed this problem in current production, although it's hard to be sure yet.)

Also, maintenance shops and mechanics have been slow to adopt the guidance TCM issued in SB03-3 urging mechanics not to pull cylinders due to low compression without performing a borescope inspection and identifying the cause of the low compression. Although it's been six years since TCM issued that service bulletin, we're still finding that the majority of shops that work on piston-powered GA aircraft still are not performing regular borescope inspections. As a result, we're still seeing a lot of cylinders pulled unnecessarily.

But I think **one of the biggest factors contributing to early cylinder demise is inadequate fuel flow at takeoff.** These engines require a very, very rich mixture to avoid excessive combustion temperatures and pressures at full takeoff power. If the mixture isn't rich enough, the cylinder assemblies will suffer... particularly the exhaust valves.

How Much Fuel Flow Is Enough?

If you ask most pilots, "How much fuel flow is enough at takeoff?" most would make reference to the POH or the top-of-the-green on the fuel flow gauge. In fact, I've seen many pilots actually adjust the mixture control on takeoff to reduce fuel flow because the fuel flow needle was flirting with the red line.

This is *not* a good idea. **Fuel flow at takeoff is like tire pressure: Too much is better than too little.** A little excess fuel flow on takeoff might reduce takeoff power by a couple of percent, but a little shortfall can overstress the engine and fry the exhaust valves in short order. I'd much rather see takeoff fuel flow a tad over red-line than significantly below it.

The "gold standard" for adjusting fuel flow on fuel-injected TCM engines is a 39-page service bulletin called SID97-3E. It's one that every Cirrus owner should be familiar with. You can download your own personal copy of this important document from the TCM website at http://www.tcmlink.com/pdf2/SID97-3E.pdf.

If you look at the preamble of SID97-3E (see Figure 1), you'll see that TCM recommends adjusting the fuel system at initial engine installation, at every annual or 100-hour inspection, any time a fuel system component is replaced, and any time fuel flow seems to have drifted off-spec. Hardly any shops

TELEDYNE CONTINENTAL® AIRCRAFT ENGINE

CATEGORY 4

SERVICE INFORMATION DIRECTIVE

SID97-3E

Compliance Will Enhance Safety, Maintenance or Economy Of Operation

Technical Portions
FAA APPROVED
SUPERSEDES M73-22, M89-10, M92-17, SID98-10A, SID97-3, SID97-3A, SID97-3B, SID97-3C and SID97-3D,

SUBJECT: PROCEDURES AND SPECIFICATIONS FOR ADJUSTMENT OF TELEDYNE CONTINENTAL MOTORS (TCM) CONTINUOUS FLOW FUEL INJECTION SYSTEMS.

PURPOSE: Provide procedures and specifications for the adjustment of Teledyne Continental Motors (TCM) fuel injection systems.

COMPLIANCE: At Engine Installation, 100 hour/Annual Inspection, fuel system component replacement or as required if operation is not within specifications.

MODELS AFFECTED: All TCM continuous flow fuel injected engine models except IO-240-B w/ Bypass Fuel System; L/TSIO-360-RB; TSIO-520-L, LB, WB; GTSIO-520-F, K, N and GIO-550-A Engine Models.

FIGURE 1: *SID97-3E is the bible for setting up fuel flows on TCM fuel-injected engines.*

TABLE 3. Fuel Sytsem Adjustment Values (cont'd.)

IDLE AND FULL POWER FUEL PRESSURES AND FLOWS					
ENGINE SEE NOTE 7	Prop. RPM & (MAP)	Unmetered Pump PSI (NOTE 3)	Metered Nozzle PSI (NOTE 4)	Fuel lbs/hr (NOTE 5)	Fuel gal/hr (NOTE 6)
IO-550-N	600	8 - 10		-	-
	2700	28 - 32	19 - 21.3	150 - 160	25.6 - 27.3

FIGURE 2: *Here are the SID97-3E fuel-flow specs for the IO-550-N engine used in the Cirrus SR 22. The system should be adjusted to achieve the red-boxed values. (The SID provides a similar table entry for the SR20 engine.)*

actually do this routinely at annual inspection, but that's TCM's recommendation.

About half of SID97-3E's 39 pages are devoted to tables of fuel flow specifications for every model of fuel-injected TCM engine. I've extracted the specifications for the IO-550-N used in the Cirrus SR22 (see Figure 2).

For an IO-550-N engine, the table calls for full-power fuel flow (standard day, sea level, 2,700 RPM) to be 25.6 to 27.3 GPH, or equivalently 150 to 160 PPH. It also calls for unmetered fuel pressure at idle (600 RPM) to be 8 to 10 psi.

Read the Fine Print

Many A&Ps interpret this to mean that any fuel flow value within that range is okay, but in fact that's not quite right. If you read the fine print of SID97-3E, you'll find a couple of very important notes that mechanics often miss. Here's one:

NOTE:

> ***To ensure optimum cooling during FULL POWER operations, the FULL POWER fuel flow should be set to the maximum specification limit.***

In other words, the fuel system should be set up to produce 27.3 GPH or 160 PPH at takeoff, and anything less will compromise cooling and cylinder longevity. That typically translates to a fuel flow indication right at red line on the fuel flow gauge. (In my experience, it's not a bad idea to adjust the system 0.5 GPH or 6 PPH higher, just for a bit of extra cushion.)

Here's another important note that's often missed:

NOTE:

> ***Maximum part-throttle full-rich fuel flow will be achieved by setting the idle RPM (low) unmetered fuel pump pressure to the minimum value specified.***

So not only is it important to adjust full-power fuel flow to the *maximum* limit, but it's also important to adjust idle-power fuel flow to the *minimum* limit (8 psi in the case of the IO-550-N). Only by adjusting the system this way can you be sure of getting sufficient fuel flow at part-throttle settings.

Aftermarket Alterations

Finally, there's the sticky issue of how to adjust fuel flow for engines that have been modified with after-market alterations like GAMIjectors and turbonormalizers. Here's what SID97-3E has to say on that subject:

The setup procedures contained in this bulletin are only for use on engines that have not been modified from their original configuration as shipped from the factory by Teledyne Continental Motors. Engines which have been modified by the installation of aftermarket components such as turbo-normalizing systems, turbocharging systems, intercoolers, after-coolers, fuel nozzles, etc., whether by STC or field approval, must use the instructions provided by the STC holder or installer. TCM will not accept any responsibility or liability for any modified engine set up in accordance with procedures contained in this Service Information Directive.

In other words, TCM says "follow the STC-holder's instructions." So if you have a turbo Cirrus, or use non-TCM cylinders (Superior Millennium or ECi Titan), SID97-3E technically does not apply to your engine. It turns out that Superior Millennium cylinders "breathe" a bit better than TCM factory jugs - they have a bit higher "volumetric efficiency" - so they actually need a bit higher fuel flow on takeoff than what SID97-3E specifies to obtain adequate cooling on takeoff.

A Quick Sanity Check

If you don't have your copy of SID97-3E handy, here's a quick rule-of-thumb you can use:

> *For a normally aspirated fuel-injected engine designed to run on 100-octane fuel (8.5-to-1 compression ratio), takeoff power fuel flow in GPH should be roughly 9% of the engine's maximum rated horsepower. (For example, an IO-550-N rated at 310 horsepower should flow about 28 GPH.)*

This rule-of-thumb yields a slightly higher number than SID97-3E, but it'll at least make sure you're in the ballpark. (And there are some, including me, who think a little higher takeoff fuel flow is better.)

After reading this column, if you have even the slightest doubt about whether your takeoff fuel flow is adequate, go get it adjusted - and make sure you tell your mechanic that you'd like it to be on the high side. The life you save may be your own ... cylinders!

About the Author

Mike Busch - honored by the FAA as its "National Aviation Maintenance Technician of the Year" for 2008 - has been a pilot for more than 44 years and 7,000 hours, and an aircraft owner and CFI for more than 40 years. He became increasingly interested in the maintenance aspects of aircraft ownership about 20 years ago, and ultimately earned his A&P/ IA. Mike is also a prolific aviation writer, with hundreds of technical articles published in *American Bonanza Society Magazine, Aviation Safety, AVweb, Cessna Pilots Association Magazine, IFR, Light Plane Maintenance,* and *The Aviation Consumer*. He co-founded AVweb in 1995 and served as its editor-in-chief for more than seven years. Mike conducts weekend "Savvy Owner Seminars" at which aircraft owners learn how to obtain better aircraft maintenance while spending a lot less money (http://www.savvyaviator.com/). He is founder and CEO of Savvy Aircraft Maintenance Management (http://www.savvymx.com/) that professionally manages the maintenance of owner-flown aircraft including Cirrus SR20s and SR22s. Any questions for Mike may be emailed to mike.busch@savvyaviator.com.