MIKE BUSCH
HANDS ON / SAVVY AVIATOR

If a one-cycle engine can perform well while using a quart of oil an hour, surely an aircraft engine with 50 times the displacement can, too.

Is Your Engine Airworthy?

A common-sense approach

HOW DO WE DETERMINE whether a piston aircraft engine is airworthy? Compression tests and oil consumption are only part of the story—a smaller part than most owners and mechanics think.

My friend Bob Moseley is far too humble to call himself a guru, but he knows as much about piston aircraft engines as anyone I've met. The man has been rebuilding Continental and Lycoming engines for four decades, so there's not much about these engines he hasn't seen, done, and learned.

From 1993 through 1998, "Mose" worked for TCM as a field technical representative covering several states and portions of Canada. These days, Mose and his wife, Rita, operate a small shop called SkyTEK Inc. (*www.SkyTEKonline.com*) in Fulton, Missouri. The company offers a wide variety of engine-related services including custom overhauls, prop strike inspections, cylinder work, accessory repairs, fuel-injection system setup, and all manner of troubleshooting and repair. Bob is an airframe and powerplant mechanic with inspection authorization (A&P/IA) and an FAA designated airworthiness representative.

Mose is also generous when it comes to sharing his accumulated powerplant expertise with others. For years, he's been an active participant on various type club forums. I often refer owners to him when they need an expert second opinion on some engine-related subject. He also helps educate mechanics by participating in FAA-approved IA renewal seminars.

WHICH ENGINE IS AIRWORTHY?

During his IA renewal seminars, Mose often challenges hundreds of A&P/IA mechanics with this hypothetical scenario:

"Imagine you are doing annual inspections on two similar airplanes—let's say they're Bonanzas with like-type engines—the TCM IO-550s.

"Bonanza A's engine is a brand new Platinum engine that the owner installed just 40 hours ago. As you'd expect, all cylinders exhibit near-perfect compression of 77/80 or better. The owner is complaining that since the new engine was installed, the oil consumption has been high—a quart every three hours or so. He also claims that the aircraft seems sluggish in cruise, the takeoff roll somewhat longer, and the climb rate slower than what he considers normal for a Bonanza. He takes you up on a brief test flight, and sure enough, the plane strikes you as being a bit of a dog. The owner swears that it performed better before the new engine was installed.

PHOTOGRAPHY BY **MARK PHELPS**

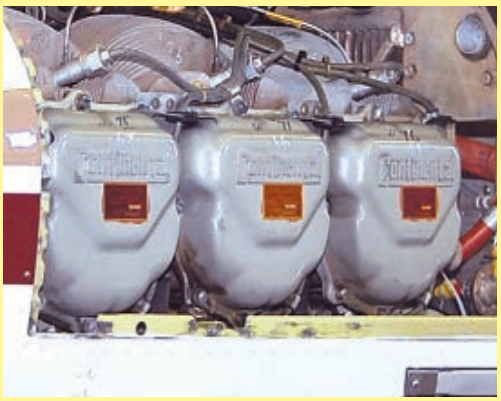
WHAT IS A COMPRESSION CHECK?

Four-stroke piston engines work by:

1. Sucking in a mixture of air and fuel vapor through the intake valve as the piston rides downward on its first stroke;
2. Squeezing that mixture into a smaller space as the piston pushes upward in the cylinder;
3. Banging the piston back down in the "power" stroke with an explosion set off by a spark plug firing, then;
4. Blowing the unburned gases out the exhaust valve with another upward stroke of the piston.

The health of an engine is, in part, measured by how much pressure, or compression, it can generate within each cylinder. Some leakage is inevitable—around the flexible metal rings that surround each piston to hug the cylinder walls; through worn or contaminated intake or exhaust valves; or worst of all, through a crack in the cylinder itself or the cylinder head. Mechanics test compression during the annual inspection by pumping 80 pounds per square inch (PSI) of air into each cylinder, then measuring how much of that pressure stays inside.

—Mark Phelps



On this big Continental six-banger, mechanics have made note of the compression readings of each cylinder over the years—showing as low as 50/80 pounds at one time. The most recent readings, noted in fresh Sharpie ink, are all in the healthy 70s.

"Bonanza B's engine has 1,500 hours since field overhaul by some shop you've never heard of. This engine is also using a quart of oil every three hours. You check the compressions and find that they're marginal, all in the low 50s and high 40s, just barely squeaking by the compression test criteria set forth in TCM Service Bulletin SB03-3. The owner is not happy with the high oil consumption and all the oil on the belly, but claims that the airplane seems to be performing okay.

MIKE BUSCH

"You're the IA, so you have to make the call. Which engine is airworthy?" Mose will ask.

The correct answer is that Bonanza B's engine is airworthy, and Bonanza A's is unairworthy.

Bonanza B's engine meets TCM's SB03-3 minimum compression specs (even if just barely), and oil consumption of a quart every three hours is high but still well within specified limits. In contrast, Bonanza A's engine may have superb compression readings, but it's clearly unairworthy because it's not making full rated power—and that's far and away the most important airworthiness criterion for any engine.

What's wrong with Bonanza A's engine? Many things can cause an engine with near-perfect compression readings to not make full-rated power: improperly timed ignition, misadjusted fuel-injection system, collapsed lifters, incorrect pushrod length, bad cam, or incorrect pistons (just to name a few).

In this case, Mose says that the combination of high compression readings and high oil consumption suggests that the problem is most likely glazed cylinder walls due to improper break-in procedure. It's possible that flying the engine at high power for a few hours might cure the problem; if that doesn't do the trick, the cylinders may have to come off for honing and then the break-in repeated using the proper procedure.

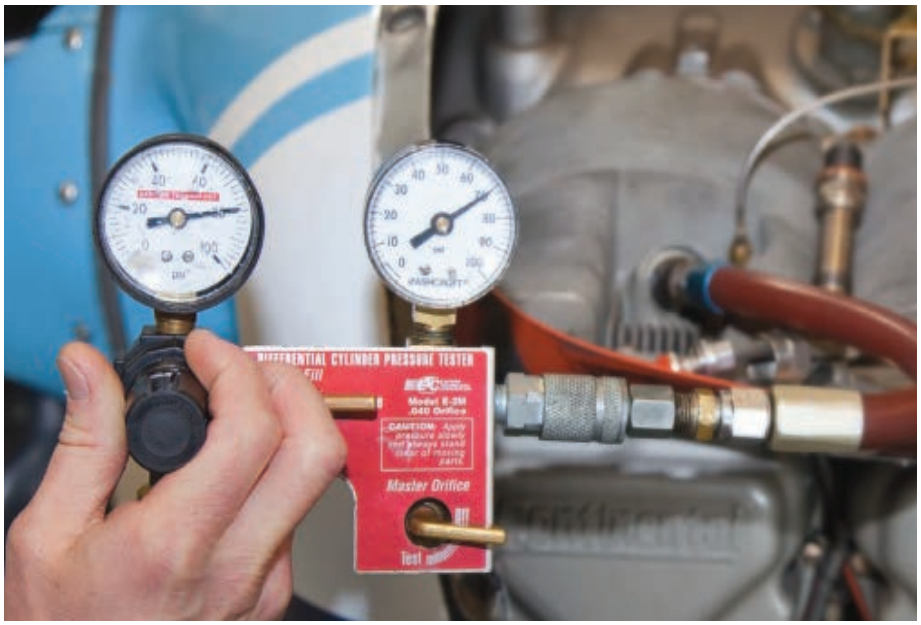
WHO HAS THE BEST ENGINE?

Now, just to make things more interesting, Mose presents the roomful of IAs with another hypothetical scenario.

"Four good-looking fellows, coincidentally all named Bob, are hanging out at the airport. Remarkably enough, all four Bobs own identical Bonanzas, all with TCM IO-550 engines. Even more remarkably, all four engines have identical calendar times and operating hours.

"The four Bobs start comparing notes. Bob One brags that his engine uses only one quart of oil between 50-hour oil changes, and his compressions are all 75/80 or better. Bob Two says his engine uses a quart every 18 hours, and his compressions are in the low 60s. Bob Three says his engine uses a quart every eight hours, and his compressions are in the high 50s. Bob Four says his compressions are in the low 50s, and he adds a quart every four hours.

"Who has the best engine? And why?"



Many aircraft owners and mechanics have placed too much emphasis on compression test readings as a measure of engine airworthiness. The truth is that an engine can have relatively low compression readings while continuing to run smoothly and reliably and make full-rated power all the way to TBO and beyond.

PHOTOGRAPHY BY JIM KOEPNICK

MANUFACTURER'S GUIDANCE

What do engine manufacturers say about the importance of compression test results and oil consumption? If you fly behind an engine built by Teledyne Continental Motors (TCM), the manufacturer's guidance is remarkably consistent with Bob Moseley's.

COMPRESSION TEST RESULTS

The bible for compression testing of TCM cylinders is TCM Service Bulletin SB03-3. In it, TCM throws the old 60/80 standard right out the window, and establishes a variable go/no-go compression limit based on what your mechanic's compression test gauges read when hooked up to a calibrated standard known as a "master orifice tool." For most compression testers, the no-go compression limit is somewhere in the low 40s. Thus, according to TCM, a cylinder that measures 50/80 is every bit as airworthy as one that measures 75/80.

SB03-3 goes even further, saying that even if a cylinder measures below the no-go limit (say 35/80), it should not be removed from the engine unless a borescope inspection of the cylinder reveals some obvious reason for the low compression (like a burned exhaust valve or excessive barrel wear). If the low-compression cylinder looks okay under the borescope, TCM says the engine should be returned to service, flown for a while, and then the compression retested. Only if the cylinder flunks the compression test a second time should it be pulled for repair.

OIL CONSUMPTION

How much oil consumption is too much? TCM has two things to say on this subject. In the type certificate data sheet (TCDS) for most of its engines, TCM establishes a maximum acceptable oil consumption rate by means of a formula based on engine horsepower. For a 300-hp engine, that number is about 1.5 quarts per hour! (For lower-power engines, it is proportionally less.)

TCM also has a service bulletin that suggests that oil consumption greater than 1 quart per three hours is "cause for concern" and warrants further investigation to determine the cause.

This guidance from TCM is astonishingly liberal. It's clear that TCM—like Moseley—does not consider low compression or elevated oil consumption to be major airworthiness issues. If your TCM engine has compressions in the low 50s and is burning a quart of oil every four hours, TCM says "nothing to worry about."

—Mike Busch

This scenario always provokes a vigorous discussion among the IAs. One faction typically thinks that Bob One's engine is best and Bob Four's is worst. Another usually opines that Bobs Two and Three have the best engines, and that the ultra-low oil consumption of Bob One's engine is indicative of insufficient upper cylinder lubrication and a likely precursor to premature cylinder wear.

Mose takes the position that with nothing more than the given information about compression readings and oil consumption, he considers all four engines equally airworthy. While many people think that ultra-low oil consumption may correlate with accelerated cylinder wear, TCM's research doesn't bear this out, and Mose knows of some engines that went to time between overhauls (TBO) with very low oil consumption all the way to the end.

While the low compressions and high oil consumption of Bob Four's engine might suggest impending cylinder problems, Mose says that in his experience, engines that exhibit a drop in compression and increase in oil consumption after several hundred hours may still make TBO without cylinder replacement. "There's a Twin Bonanza that I take care of, and one of its engines lost compression within the first 300 hours after overhaul," Mose relates. "The engine is now at 900 hours, and the best cylinder measures around 48/80. But the powerplant is running smooth, making full-rated power, no leaks, and showing all indications of being a happy engine. It has never had a cylinder off, and I see no reason it shouldn't make TBO."

LAWN MOWER LESSONS

To put these issues of compression and oil consumption in perspective, Mose likes to tell the story of an engine that was not from Continental or Lycoming but from Briggs & Stratton:

"Years ago, I had a Snapper lawn mower with an 8-hp Briggs on it. I purchased it used, so I didn't know anything about its prior history. But it ran good, and I used and abused it for about four years, mowing three acres of hilly, rough ground every summer.

"The fifth year I owned this mower, the engine started using oil. By the end of the summer, it was using about a half quart in two hours of mowing. If I wasn't careful, I could run out of oil before I ran out of gas, because the sump only held about a quart when full. The engine still ran great, mowed like new, although it did smoke a little each time I started it.

"The sixth year, things got progressively worse. By the end of the summer, it was obvious that this engine was getting tired. It still ran okay and would mow at

Oil consumption is an even less important factor than compression when assessing if an engine is airworthy. Lycoming and TCM publish maximum acceptable oil consumption values, usually something like 0.15 pounds/hour/horsepower; for a 300-hp engine that works out to a whopping 1.5 quarts/hour!

the same speed if the grass wasn't too tall. But it got to the point that it was using a quart of oil every hour, and was becoming quite difficult to start. The compression during start was so low (essentially nil) that sometimes I had to spray ether into the carb to get the engine to start. It also started leaking combustion gases around the head bolts, and would blow bubbles if I sprayed soapy water on the head while it was running. In fact, the mower became somewhat useful as a fogger for controlling mosquitoes. But it still made power and would only foul its spark plug a couple of times during the season when things got really bad.

"Now keep in mind that this engine was rated at just 8 hp and had just one cylinder with displacement roughly the size of a coffee cup, was using one quart of oil per hour, and had zilch compression. Compare that to an IO-550 with six cylinders, each with a 5.25-inch bore. Do you suppose that oil consumption of one quart per hour or compression of 40/80 would have any measurable effect on an IO-550's power output or reliability—in other words, its airworthiness? Not likely."

COMMON SENSE

I really like Bob Moseley's common-sense approach to aircraft engines. Whether we're owners or mechanics (or both), we would do well to avoid getting preoccupied with arbitrary measurements—such as compression readings and oil consumption—that have relatively little correlation with true airworthiness. Instead, we should focus on the stuff that's really important: Is the engine "making metal"? Are there cracks in the cylinder heads or crankcase? Are there exhaust leaks, fuel leaks, or serious oil leaks? Most importantly, does the engine seem to be running rough or falling short of making full-rated power?

If the answer to all of these questions is no, then we can be reasonably sure that our engine is airworthy and we can fly behind it with well-deserved confidence. EAA

Mike Busch, 2008 National Aviation Maintenance Technician of the Year, has been a pilot for 44 years, logging more than 7,000 hours. He's a certificated flight instructor and an airframe and powerplant mechanic with inspection authorization. E-mail questions to Mike at *mike.busch@savvyaviator.com*.

PHOTOGRAPHY BY **JIM KOEPNICK**