

## **AIRCRAFT OIL USAGE**

*JIM EYRE*

Most oil knowledge is something that someone told someone who heard it from somebody. But, as they say on *X-Files*, “The truth is out there.”

Almost all general aviation piston engines have a wet sump, a built-in oil reservoir, instead of an external oil tank. How can you determine by looking at the oil dipstick of a wet-sump engine the minimum oil quantity with which the engine can be operated safely? It is one-half of the maximum indication etched on the dipstick. If the engine holds 12 quarts, for example, it can be operated with a minimum of six. (Refer to Federal Aviation Regulation 33.39).

Low-time pilots who sidle up to longtime fliers are often surprised when the graybeards scoff at their practice of completely filling their airplane’s oil reservoir. “It’s going to blow out all over the belly if you fill it up,” the old-timers say. They’re correct. Here’s the lowdown on engine oil capacities.

Way back in the early days of aviation, the rule makers had gathered their experience from the radial engine Transport Category airplane world. So they worded the regulation related to engine oil capacity to read, *“The usable oil tank capacity shall not be less than the product of the endurance of the airplane under critical operating conditions and the maximum oil consumption of the engine under the same conditions, plus a suitable margin to assure adequate system circulation and cooling.”* The oil capacity of an engine is predicated on the endurance of the airplane! What does this mean to us “ordinary” pilots?

When an engine is being designed the company wants its new offering to be favorably looked on by as many airframe manufacturers as possible for as many of their airplanes as possible. Following the mandates governing tank capacity, it follows that the engine manufacturers did not want the oil capacity of their engines to limit their market, so they built in extra capacity.

Civil Aeronautics Administration Manual No. 107 (January 1949), titled *Aircraft Power Plant Handbook*, adds oil-tank capacity guidelines when it says, *“The customary ratio is*

*one gallon of oil for every 25 gallons of fuel, but not less than one gallon for every 75 maximum continuous horsepower of the engine involved for non-Transport category airplanes.”* Is it any wonder that engines have overly large oil capacities?

T-Craft Cessna 182s have a 230-horsepower O-470(R, L, U) engine. The oil capacity of this engine is 12 quarts, yet it is quite safe to fly a four-hour flight with only 8 or 9 quarts in the sump. Experience has shown that oil added above the nine-quart level is quickly “blown out” the crankcase breather tube, which exits the engine compartment at the right cowl flap. This “blowing out” results in a very oily belly (those members that clean the belly’s at plane wash can attest to this). Safety is not enhanced when the sump is full of oil. However it is expensive (@\$4.59/quart).

The newest regulations governing the standards of aircraft engines are found in Part 33 of the FARs, particularly Part 33.39 which says that oil systems must be designed and constructed to ensure proper operation in all flight attitudes and conditions. For airplanes with wet sump systems (T-Craft fleet) *“this requirement must be met when only one-half of the maximum lubricant supply is in the engine.”*

How much is not enough? John Frank, at Cessna Pilot Association, says, *“There are two oil levels – enough and not enough. The not-enough level will be signaled by a rise in oil temperature and a decrease in oil pressure – as long as the temperature is stable you have enough oil.”*

So for regulatory reasons airplane engine sumps are generous in relation to the needs of the engine, and somewhere between very full and half-full is the “sweet spot” identifiable by stable oil temperatures and stable oil consumption.

The best time to get an accurate dipstick reading is just prior to the first flight of the day. If you check the oil level shortly after the engine has been run for a while, the dipstick reading will be noticeably lower because a significant quantity of oil remains adhered to various engine components. Another reading taken 24 hours later will often show an oil level that is 1/2 to 1 quart higher.

Oil consumption is a very important trend to monitor in an engine; therefore we try and keep track of how many quarts of make-up oil are added between oil changes by having T-Craft Members record on the sign-out sheet if they add any oil. Usually we find that less oil is consumed soon after oil change and more added as time progresses (oil’s time in service increases).

Experience has shown us that 4-6 quarts for the 152, 6-8 quarts for the 172s and 8-10 quarts for the 182s is quite sufficient. If you feel you need to “top it off” according to dipstick markings than please show at next plane wash and volunteer to clean the under carriages.

***The following contributed to this article: Cessna Pilot Association; AOPA Pilot; Aviation Maintenance Bulletin; Sport Flying Magazine; Textron Lycoming “Flyer” Newsletter, and our faithful local mechanics.***

## CHECKING THE DIPSTICK

NOVEMBER 15, 2016 / MIKE BUSCH / 10 COMMENTS



*There's a lot more to checking the dipstick than just noting the oil level. The appearance of the oil is at least as important as its quantity.*

We've been doing it since our earliest days as student pilots. Now that we're aircraft owners, we still do it as part of our standard preflight ritual. But are we doing it right? It turns out that there's a lot more to checking the engine's oil dipstick properly than just making sure that the oil level is above the minimum-for-flight level listed in the POH. If we really pay attention, we can learn a lot about the condition of our oil and of our engine.

### HOW MUCH OIL IS NEEDED?

The engines on my Cessna 310 have 12-quart sumps—13 quarts if you include the quart in the spin-on oil filter. When I first acquired the airplane, my mechanic would fill the sump to its maximum capacity at each oil change. It didn't take me long to discover that the engines didn't like that, and promptly tossed several quarts out the engine breathers.

My POH states that the "minimum for flight" oil level is 9 quarts. So I asked my mechanic to service the sump to 10 quarts (instead of 12), and I'd add a quart of make-up oil when the level got down to 9 quarts. That worked better, but I was still seeing a fair amount of oil on the underside of the engine nacelles and the outer gear doors.

After I became a mechanic myself and learned about such things, I checked the Type Certificate Data Sheet (TCDS) for my Continental TSIO-520-BB engines, and found that an oil level of 6 quarts was sufficient to make good oil pressure in all flight attitudes from 23° nose-up to 17° nose-down. Armed with this information, I decided to experiment with lower oil levels.

What I discovered was that oil consumption (and the oily mess on the airframe) was drastically reduced if I maintained the oil level at around 8 quarts on the dipstick.

Since then, I've avoided filling the sump to more than 9 quarts, and I normally do not add make-up oil until the dipstick reads about 7½ quarts. (This still gives me a 1½-quart "cushion" above what the engine needs to operate reliably in all flight attitudes.) You might wonder why Continental put a 12-quart sump on an engine that requires only 6 quarts. The answer is that FAA certification requirements demand that the engine be designed to hold twice as much oil as it actually needs:

*FAR §33.39 Lubrication system.*

*(a) The lubrication system of the engine must be designed and constructed so that it will function properly in all flight attitudes and atmospheric conditions in which the airplane is expected to operate. In wet sump engines, this requirement must be met when only one-half of the maximum lubricant supply is in the engine.*

The TCDS for my TSIO-520-BB engines states that maximum acceptable oil consumption is about one quart per hour. If my engines actually used that much oil, then I'd need to fill the sumps nearly to their maximum capacity to ensure that I had enough oil to make a 5-hour flight without risking oil starvation. But since I know from long experience that my engines use more like 0.1 quart per hour, there's no reason for me to carry anywhere near that much oil.

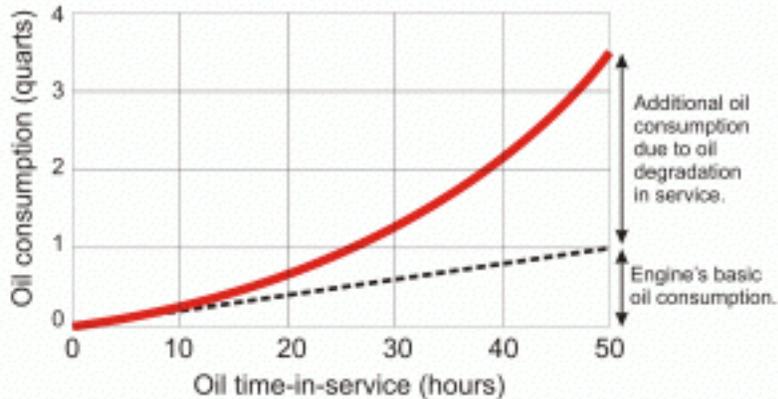
Every aircraft engine installation has an optimum oil level at which oil consumption is minimized and the engine is happiest. I would encourage you to experiment to determine what oil level works best for your airplane. Your engine will operate properly at 50% of its maximum oil capacity—guaranteed. As long as you keep the oil level a quart or two above the 50% point, your engine will be happy.

The best time to get an accurate dipstick reading is just prior to the first flight of the day. If you check the oil level shortly after the engine has been run for awhile, the dipstick reading will be noticeably lower because a significant quantity of oil remains adhered to various engine components. Another reading taken 24 hours later will often show an oil level that is ½ to 1 quart higher.

## OIL CONSUMPTION?

Having assured yourself that there's enough oil in the engine, your next task is to make note of how much oil your engine is using. Keeping track of oil consumption—particularly any significant increase in oil consumption rate—is an important tool for monitoring engine condition.

The most common method of measuring oil consumption is to record how many quarts of make-up oil are added between oil changes, and to divide the total by the number of hours in the oil-change interval. (For example, if the oil is changed after 50 hours and 6 quarts of make-up oil were added during that time, the average oil consumption rate is 50/6 or 8.3 hours per quart.)



*Oil consumption isn't linear—it accelerates as the oil deteriorates over time. The rate of consumption during the first 10 hours after an oil change is a good indication of engine condition.*

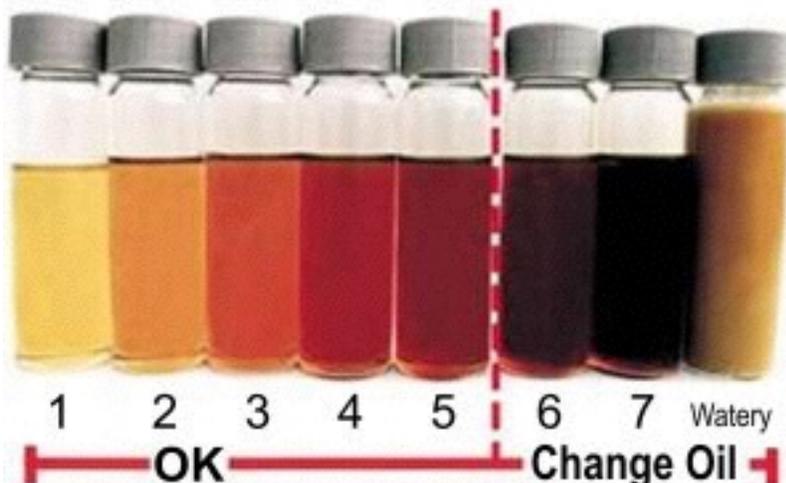
However, this approach obscures the fact that oil consumption is not linear over the oil change interval. If you keep track of when you add each quart of make-up oil, you'll find that less oil is consumed at first, and progressively more oil is consumed as the oil's time-in-service increases.

The reason for this accelerating oil consumption is that the viscosity of the oil decreases as the oil deteriorates. Mineral oils lose viscosity due to a phenomenon called "polymer shearing" in which the long organic molecules are actually broken apart by mechanical action of the engine's moving parts. Multigrade oils also lose viscosity because their viscosity-index improvers oxidize when exposed to high temperatures.

The increased rate of oil consumption provides tangible evidence that your engine oil is getting "long in the tooth" and ought to be changed soon.

## WHAT DOES YOUR OIL LOOK LIKE?

Whenever you check the dipstick, it's also important to make note of the oil's appearance—particularly its color and clarity. The oil's appearance offers valuable clues to its condition and that of your engine.



*Color and transparency are important indicators of engine condition. When oil becomes dark and opaque, it should be changed. If this happens rapidly, it suggests that the engine has too much blow-by past the rings, or that oil temperature is too hot.*

Fresh engine oil has a light amber color and is so transparent that it's sometimes hard to read the dipstick level. As the oil remains in service, it gradually darkens in color and becomes progressively more opaque.

The darkening of engine oil is caused by contamination and oxidation. Contaminants include carbon (soot), lead salts and sulfur from combustion byproducts that get past the compression rings and into the crankcase ("blow-by"), as well as any dust or dirt that gets past the induction air filter. Oxidation of the oil occurs when it is exposed to high localized temperatures as it circulates through the engine, and results in the formation of coke. Various oil additives are also vulnerable to oxidation, particularly the viscosity-index improvers used in multiweight oils.

Dispersant additives are blended in the oil to help keep these so-called "insolubles" in suspension in order to keep the engine clean and minimize sludge deposits. As the quantity of insolubles in suspension increases, the oil darkens and becomes opaque. It is important to note how quickly this darkening occurs. If your oil remains relatively light-colored and translucent after 25 hours in service, you can be reasonably confident that your cylinders and rings are in fine condition and that your oil can prudently remain in service for 40 or 50 hours. On the other hand, if your oil gets dark and opaque after 10 or 15 hours, you'd be wise to change your oil more often—perhaps at 25 hours—and you may want to investigate the possibility that one or more cylinders are excessively worn.

Such rapid discoloration is often a good indicator that the oil is distressed. In one study, 90% of oil that appeared abnormally dark on the dipstick was subsequently found by laboratory analysis to be non-compliant with required specifications. Oil that is dark and opaque from blow-by past the rings is very likely to be rich in acids and other corrosive compounds that can attack your cam and lifters, and that's probably the #1 cause of engines failing to make TBO. Any time your oil appears dark or opaque, you would be wise to drain it and replace it with fresh oil and a new oil filter, regardless of the oil's time-in-service.

### **Mike Busch**

Mike Busch is arguably the best-known A&P/IA in general aviation, honored by the FAA in 2008 as National Aviation Maintenance Technician of the Year. Mike is a 7,500-plus hour pilot and CFI, an aircraft owner for 45 years, a prolific aviation author, co-founder of AVweb, and presently heads a team of world-class GA maintenance experts at [Savvy Aviator](#). Mike's book *Manifesto: A Revolutionary Approach to General Aviation Maintenance* is [available from Amazon.com](#) in paperback and Kindle versions.

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**GENERAL AVIATION MAINTENANCE OWNERSHIP**