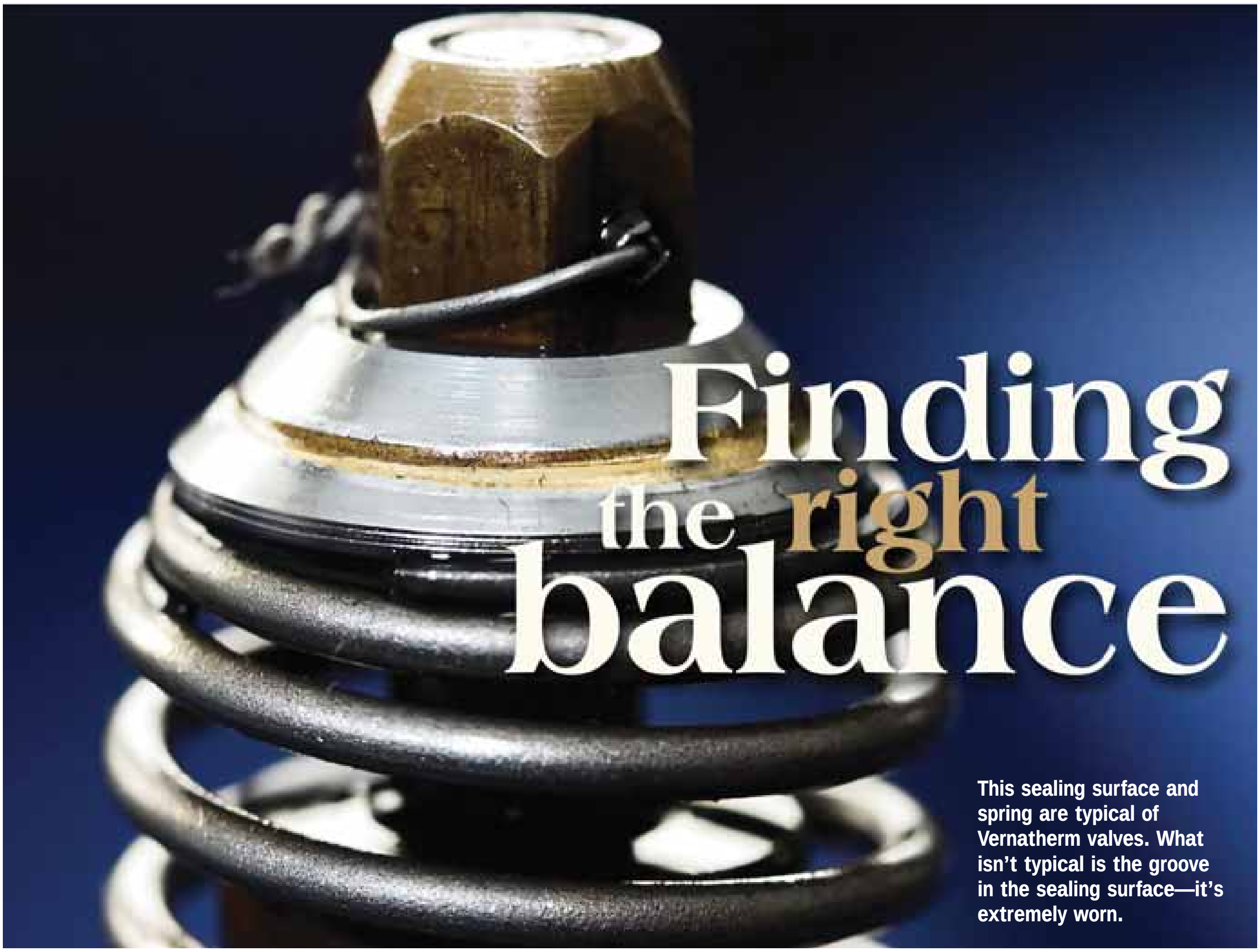


This sealing surface and spring are typical of Vernatherm valves. What isn't typical is the groove in the sealing surface—it's extremely worn.

Finding the right balance

Stabilizing your aircraft's oil system

BY STEVEN W. ELLS

Rip Van Winkle didn't awake from his 20-year nap by jumping up and dancing a jig. He got up slowly and eased into warming up those old joints. Rip set a good example for airplane owners. Engines should be warmed up slowly—engines that are started with too much throttle not only make a heck of a racket, but also they don't last very long. Well before the pilot notices any sign of problems, valves inside the engine oil system that protect its components against too-high pressures have done their job—which causes unfiltered oil to be pumped into circulation.

Oil pressure—too much is as bad as too little

Both Lycoming and Teledyne Continental Motors engines incorporate simple systems to control the oil pressure within the engine. And each manufacturer also equips its engines with at least one other valve to protect against the harm caused by too-high oil pressures.

High oil pressure causes minor problems such as leaks, but the major problem is related to oil coolers. For its popular O-320-series engine Lycoming specifies that the oil cooler must be capable of withstanding continuous pressures of 150 pounds per square inch (psi) and a proof pressure of a minimum of 400 psi. These numbers are so far above anything pilots will ever see on an instrument panel gauge that they dismiss these numbers. Yet oil coolers still burst—and this is most often caused by extreme high-pressure spikes, which occur during cold-weather starts.

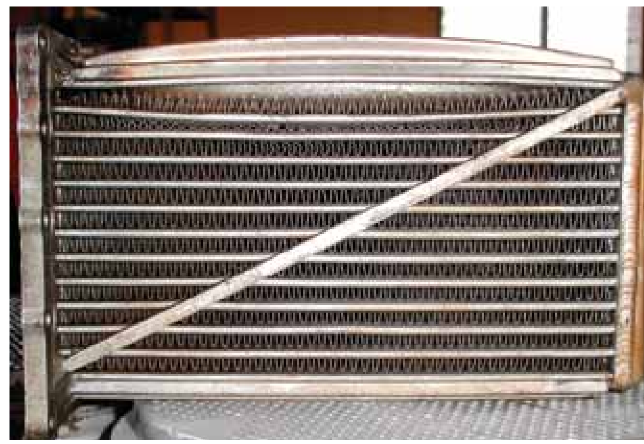
All oil pumps consist of two meshed gears that revolve inside the pump housing—one gear is driven and it in turn drives the second gear. As the

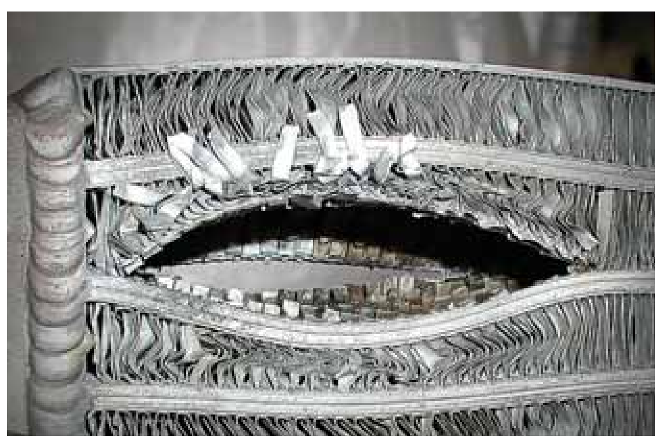
PHOTOGRAPHY BY MIKE FIZER

gears rotate, oil drawn from the sump is forced around the outside of the gears. Before it's circulated to the engine one of these valves comes into play.

High-pressure oil from the outlet of the pump flows through either the oil screen or through the engine oil filter—these both remove contaminants before the oil goes on to the engine.

Both oil screen assemblies and oil filters have filter bypass valves. What does a filter bypass valve do? It keeps oil flowing to the engine should the filter or screen become clogged by oil-borne contaminants. Unlike the slow accumulation of cholesterol that clogs heart arteries, the oil-borne contaminants that clog engine filters and screens are almost always caused by the failure of internal engine parts such as the aluminum wrist pin plugs, or main or connecting rod bearings.





Although it's relatively rare, oil coolers can be damaged because of insufficient preheating.

When the filter or screen becomes clogged it's guaranteed that the engine will fail within a very short time because of lubrication distress. To permit powered flight for those extra few minutes that pilots always need during an emergency, the bypass valve opens, permitting unfiltered oil to circulate until engine failure. Hopefully no pilot will ever experience an opened filter relief valve because of system contamination. On the other hand, it's almost a sure bet that a number of pilots have experienced an open filter (or screen) bypass valve because of a full-throttle-type engine start or the lack of engine preheating.

When the oil is cold and the engine has not been preheated, the high viscosity of the oil unseats the bypass valves and unfiltered oil flows to the engine.

TCM says to preheat when ambient air temperatures drop below 20 degrees Fahrenheit. Lycoming says to preheat anytime the temperatures drop below 10 degrees F except for the O-320-H-series and the O/LO-360-E-series engines, which need to be preheated when temperatures drop below 20 degrees F. Many pilots who live in cold climates believe these limits are too low and start preheating at 30 or 40 degrees F.

Oil-pressure relief valves

The variation in the speed of the oil pump from idling to full throttle and the fluctuation of viscosity of the oil because of temperature changes are compensated for by the tension on the pressure-relief-valve spring.

PACIFIC OIL COOLER SERVICE

After the oil passes through the filter or screen the oil-pressure relief valve controls the oil pressure. Oil pumps are always oversized—this ensures that there will always be a more-than-adequate supply of oil pressure and volume—and the spring-loaded relief valve controls engine oil pressure. This can be likened to a hole in the main oil galley (tube) that is automatically opened to vent off too-high pressures. The hole is opened when the oil pressure pushing against the "oil" side of a round steel ball that rests against a tapered seat exceeds the pressure applied to the other side of the ball by a spring.

One failing of some pilots when they preheat is to ignore the oil cooler.

Depending on the manufacturer, the oil-pressure relief valve is either part of the oil pump assembly or is mounted on the upper-rear part of the engine case. Engine oil pressure is adjusted by changing the spring pressure.

Low oil pressures may be caused by wear or channeling of the oil-relief-valve seat. These seats can be refaced in the engine without too much trouble.

Oil-pressure relief valves rarely cause any trouble. Occasionally a piece of flotsam gets caught between the ball and the seat; the symptom for this malady is lower-than-normal oil pressure. But unlike a major engine or oil system failure, the oil temperature stays steady instead of rising. If this should happen, reduce power and land as soon as possible and get the relief valve cleaned.

Preheating and oil coolers—there's a lot going on

Oil coolers are also equipped with valves; these valves, which operate much like the thermostat that controls coolant flow through an automobile radiator, automatically control oil flow through the cooler. At lower temperatures this temperature-controlled valve is retracted—this opens a route, allowing cold oil to bypass the cooler. When the oil temperature increases to approximately 150 degrees F, a temperature-sensitive bulb inside the valve assembly—often called a *Vernatherm* after the manufacturer's name—will start to expand toward a tapered seat. At 180 to 185 degrees the valve will be fully seated—sealing the bypass route and directing the oil through the cooler.

Another feature of the Vernatherm valve is a spring that assists the bulb in seating the valve end. This spring has one other very important job. In the event of an oil-pressure spike—a high-pressure surge—this spring will be compressed and the high-pressure oil will bypass the cooler. One failing of some pilots when they preheat is to ignore the oil cooler. This is not always their fault since popular plug-in-type preheaters don't always provide a heat source for oil coolers, especially on Lycoming engines where the coolers are most often remote mounted.

If the cooler hasn't been preheated the Vernatherm valve and seat will be damaged because of the following chain of events.

After a few minutes of operation, the Vernatherm valve senses warm oil temperatures and will seat, directing warm engine oil to the cooler. If the cooler hasn't been preheated, this warm oil will run into exceedingly viscous cold oil in the cooler. If it's really cold, the oil in the cooler will be congealed (solid). When the warm oil bumps up against the congealed oil a pressure spike occurs, and the spring pressure that seats the valve of the Vernatherm will be overcome and the bypass path will open. This immediately lowers the oil pressure and the valve then slams shut against the seat. This rapid varying of the oil pressure at the cooler will cause the valve to hammer against the seat, and can also cause damage to the oil cool-

"It's going to blow out all over the belly if you fill it up," the old-timers say.

er. In some extreme cases the cooler will burst.

According to Robert Ohnmeiss of Lycoming Engines, this oil-cooler spiking also occurs when the winterization plate is not installed on oil coolers when outside temperatures fall. Oil-cooler winterization plates are just barely on the periphery of most pilots' experience. Without these plates, oil temperatures never reach the 180 to 190 degrees that is necessary to boil off rust-causing water within the engine. But that's another story for another day.

Engine oil capacities

New airplane owners 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 in layman's language?

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 Powerplant 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?

Why add 12 when nine will do fine?

A good percentage of Cessna 182 owners know this well. The most common Cessna 182 engine is the 230-horsepower Teledyne Continental O-470-R. The oil capacity of this engine is 12 quarts, yet most 182 pilots are comfortable taking off on a four-hour flight with only eight or nine quarts in the sump. Experience has taught these pilots 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—182 owners know that safety is not enhanced when the sump is full of oil—they also find out it's expensive. So if 12 quarts is too much, how much is not enough?

The newest regulations governing the standards of aircraft engines are found in Part 33 of the federal aviation regulations, and a sentence in Part 33.39 sheds some light on this question. The rule 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 (95 percent of the general aviation fleet) "this requirement must be met when only one-half of the maximum lubricant supply is in the engine."

John Frank, the boil-it-down-to-basics guy at the Cessna Pilots 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." To wrap this discussion up, it's clear that, for regulatory reasons, airplane engine sumps are generous in relation to the needs of the engine. Somewhere between very full and half-full is the proper level for all engine airframe combinations—this sweet spot is identifiable by stable oil temperatures and stable oil consumption. AOPA

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Links to additional information about oil system information may be found on AOPA Online (www.aopa.org/pilot/links.shtml).