Light Plane Maintenance™

VOLUME V, NO. 11 NOVEMBER 1983

Engine Break-in After Top Overhaul

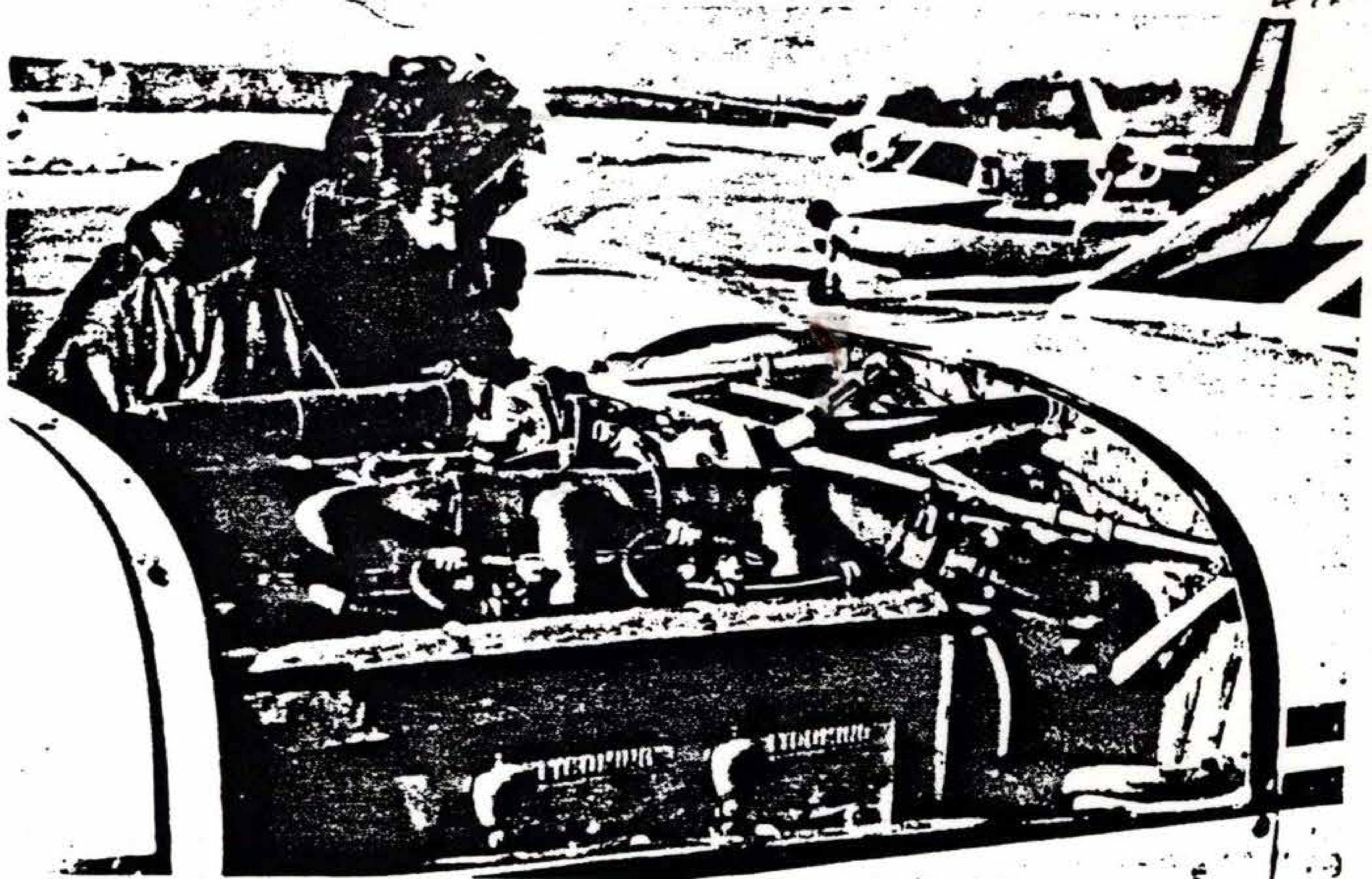
#19
$1.10

Not everyone is going to own his or her plane long enough to have to break in a new engine, but most of us—sometime, somehow—are going to face the prospect of a top (or partial top) overhaul. The question is: How does one "break in" an aircraft engine after, say, a ring job on two cylinders? Do you switch to mineral oil? Should you keep using ashless dispersant oil, but fly at high power settings? (How high is high? Full throttle? Top-of-the-green?) How long should it take to "seat" a new set of rings? How do you know when an engine has finally broken in?

First things first. Whenever any cylinder is reworked—for valves, guides, barrel deglazing, or whatever—the rings should be 100-percent replaced (with darn few exceptions). And whenever rings are replaced, the new ones need to be broken in. In effect, you need to break in your engine all over again . . . even if only one cylinder has been reworked.

What exactly is "break-in"? Basically, it's nothing more than the wearing away of the highest high points (microscopic ridges in the metal that look like mountains under magnification) on the surfaces of any two metal pieces that rub together. In a chrome cylinder, you're wearing cast-iron rings against a chrome-surfaced barrel; in a steel jug, you're wearing chrome-faced rings against a steel barrel.

During break-in, the very high pressure on the individual metallic ridges, as they come in contact, effectively ruptures the oil film that separates them. The resulting friction causes the highest ridges to melt and flow (or weld and unweld) in such a way as to conform to each other; the metal parts "seat" to each other. Paradoxically, an oil with anti-scuff agents (or super-high-film-strength lubricants) in it actually interferes with break-in, by preventing metal/metal contact. For this reason, it's important that molybdenum disulfide, zinc dithiophosphate (ZDP), TCP, and other "extreme pressure" or boundary lubrication additives not be used for break-in. (Many shops knowingly use STP, which contains ZDP, as buildup oil to coat engine parts on assembly. This is probably a bad practice, and may be why some 3 out of 10 aircraft engines fail to break in completely after overhaul.)



With larger engines especially, break-in is a critical process. (Shown here is a Lycoming TIO-540-S1AD in a Piper Turbo Lance. Note unusual top exhaust.) Even if only one cylinder has been topped, it pays to run the engine hard for the first 10 hours. Mineral oil should be discontinued as soon as top spark plug(s) begin to run dry and grey/white.

The oil to use for break-in is straight, unadulterated mineral oil. Texaco mineral oil is said by some mechanics to contain the fewest additives; but Aero Shell in the red can is also an industry favorite.

There are exceptions: Some engines (e.g., Lycoming O-320-H, TO-360-C, and TIO-541 series) must start out on ashless dispersant oil, to ensure adequate lubrication of critical valve and/or turbo parts. (See Lycoming Service Bulletin No. 318, and Service Instruction 1014.)

Merely flying on mineral oil does not

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guarantee good break-in; high cylinder mean effective pressures are also needed to promote rupture of the ring/piston oil film. Translated, that means you have to fly at high power settings.

From the moment a fresh cylinder is put into service, the minute valleys in the surface of the metal begin to fill up with varnish (cooked oil). When the valleys overflow with varnish, the metal acquires a smooth, "glazed" surface, rendering further break-in difficult, if not impossible.

If you think about what's going on, it should be fairly evident that the process of ring seating is actually a race between the countervailing forces of ridge wear-down, on the one hand, and varnish accumulation, on the other. The kinetics of these two processes determine whether you end up with glazed cylinders (and 3-hrs/qt oil consumption), or good ring seating (and dry-running cylinders).

Most aircraft engines have two compression rings, an oil control ring, and (in some cases) a wiper ring below the wrist pin. Optimum oil control depends on proper break-in of all three (or four) rings. But notice what happens when you put a fresh set of rings in service: The top ring, naturally, is exposed to the greatest combustion pressure. The normal pathway for escape of the pressure is for gases to travel *behind* the ring, then down to the next land or groove; then around the inside of *that* ring, and down again. The net effect is that the lower-two compression rings "feels" only about 40 percent as much pressure as the top ring; while the oil-control ring may feel only a *tenth* the pressure of the top ring. Also, there's a corresponding temperature gradient: The top ring runs hot, the second ring a little less so, and so on. What this means, of course, is that the top ring breaks in preferentially over the remaining rings in the set.

The top compression ring is going to break in no matter how you operate the engine (within reason). *But the downstream rings may never break in, if they fail to be exposed to high pressures and temperatures.* This is why overhaulers tell plane owners not to "baby" their engines during break-in—especially low-compression types, which barely produce enough pressure below the top ring to favor good break-in even at 75 percent.

The fact is, if you insist on performing lengthy or repeated ground runs prior to your first post-overhaul flight, you'll only hasten the formation of cylinder varnish, while creating conditions that favor the break-in of your top compression rings *to the exclusion of all other rings*. The country's largest overhaulers recommend the following procedure:

1. Pre-oil the engine before startup, in accordance with manufacturers' recommendations. (If OAT is below freezing, preheat engine and oil.)
2. Keep ground running to a minimum (5 minutes max).
3. Don't cycle the prop.
4. Take off at full power, noting rpm, oil pressure.
5. Leave cowl flaps open. Do not reduce power to below 80 percent.
6. Climb no higher than 5,000 feet. Fly around the airport at *no less than 75 percent power* for an hour.
7. Land and check oil consumption.

How do you know when the engine has broken in? Initial ring seating should occur within the first 15 minutes to two hours. (Thereafter, cylinder head temperatures will stabilize—but remember, your factory CHT is wired to only one cylinder.) Final break-in—signified by stabilized oil consumption—should come in 50 hours.

"If oil consumption hasn't stabilized in 100 hours," says a spokesman for a respected east-coast overhaul shop, "further action—possibly deglazing of the cylinders—is called for."

Not all engines break in at the same rate (chromed jugs take a little longer than steel, for example), nor with the same degree of success. Such engines as the Lycoming O-360-A series with nitrided jugs can be counted on to break in properly, within 50 hours, in a high percentage of cases. On the other hand: "About three out of every ten O-470s we rebuild come back with break-in problems, typically high oil usage," reports one east-coast overhauler. "It has to do with ring design and operator practice, we think."

Overhaulers stress one point over and over again: Owners should not fly at reduced power during break-in. "It's the most frequent problem we have," says one A&P. "Guys are afraid to run at 26-square, or at redline. These engines are built to run wide open. But just try to convince an owner of that."

Some Continental factory reps even recommend leaving the throttle firewalled on climbout, and reducing prop rpm only. (This is for low-compression, normally aspirated models.)

"Basically, you can operate your manifold pressure and rpm anywhere where there's not a red line on the gauges," remarked one engine man. "Frankly, I wish more pilots would take this to heart." ☐

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Light Plane Maintenance (ISSN 0278-8950) is published monthly by Belvoir Publications, Inc., 1111 East Putnam Ave., Riverside, CT 06878. Robert Englander, Chairman and President; Michael Pollet, Senior Vice President, General Counsel; Donn E. Smith, Vice President; Richard B. Weeghman, Vice President; Stanley Person, Vice President, Finance. Second Class postage paid at Riverside and at additional mailing offices.

Subscriptions: $60 annually (12 issues). Canadian subscriptions are $65. Single copies are $5.

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