

The Trailing Edge

February 2025

Crankshaft Oil Seal

Rotary engines of World War I, such as the Gnome, Le Rhône, and Clerget used a total loss oiling system, which led to pilots ingesting much castor oil with the expected results after the mission debrief. The Curtiss OX-5, one of the first widely used aero engines, required the pre-flight regimen of greasing the exposed valve gear with a grease gun, similar to the actions required before running a steam locomotive.

A major factor in the success of Lindbergh's New York to Paris flight in the *Spirit of St. Louis* was the reliability of the Wright J-5 engine. A significant part of the J-5's reliability came from fully enclosed valve gear, unlike the previously exposed pushrods and rocker arms. This allowed the valve gear to be continuously oiled by the engine's lubrication system instead of being intermittently greased between flights. Most significantly, this meant that all of the lubrication oil was intended to stay *inside* the engine. While this can be mostly done by sealing up the engine with gaskets, anywhere a rotating shaft exited the engine casing some sort of seal around that shaft is required to keep the lubricating oil inside the engine.

What's all this fuss about lubrication?

In any heat engine, there will be some parts that move and other parts that don't. Alternatively, there may be moving parts that are moving at different speeds. Where these parts are touching is generally referred to as a "bearing" and these bearings need some sort of lubrication to keep them from eroding each other or generating unwanted heat like some sort of super-fine sandpaper.

The axles on train cars were originally plain bearings, nothing more than a rod stuck in a close fitting hole. To keep the friction down to a reasonable amount, large amounts of grease were liberally packed into these bearings. This worked well enough, but if one of the many axles were to run low on grease it would become a "hot box" from the heat generated by the friction, which tended to lead to fires and other failures. Trains would eventually transition to roller bearings, where rods would roll between the stationary and moving parts. These still use grease, but aren't as dependent on the grease. Other bearings use metal balls instead of rods, hence ball bearings. These bearings do a great job of reducing friction, but cannot handle extreme loads because the roller bearing takes all of the load along a line, and the ball bearing takes all of the load at a point. If the loads are high enough to plastically deform the roller or ball the bearing fails.

Because of the very high forces placed on the crankshaft by the pistons and connecting rods, the crankshaft in a Lycoming engine uses plain bearings. Rather than use grease, these bearings are lubricated by oil delivered under pressure, typically around 65 psi, from the oil pump. This ensures that the bearings do not go dry from lack of lubricant. As this oil is forced between the bearing and the journal, the parts slide on a film of oil rather than metal-to-metal contact.

The clearances between the bearing and journal are very tiny. My Lycoming Overhaul Manual calls out allowable clearances on the crankshaft as 0.0015 to 0.0045 inches. This is less than the diameter of a human hair, which can be up to 0.0070 inches.

Figure 1 gives an idea of how pressure oiling works. The oil enters the bearing under pressure through a hole. The oil fills up the clearance between the bearing and the journal, which is exaggerated in this drawing. Because there are no seals at the end of the bearing, the oil squirts out the end, either dropping back into the oil pan or being slung through the crankcase to lubricate other parts that don't receive pressure oiling. Even though the oil is flowing through the clearances, there is always oil in the clearances to provide lubrication.

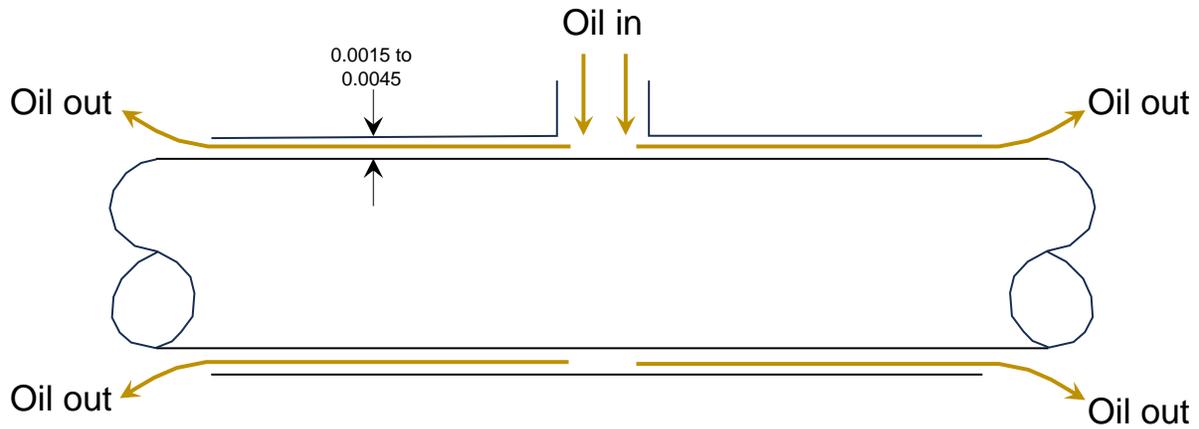


Figure 1. Pressure Oil Lubricated Bearing

Keeping the Oil Inside the Engine

Keeping all of this oil inside the engine is fine, except for the engine to be useful there needs to be at least one shaft coming out of it. On a Lycoming, this includes the propeller shaft (the front part of the crankshaft) as well as various accessories, such as magnetos, vacuum pump, fuel pump, and tachometer drive. All of these accessory drives are splash lubricated, so the oil pressure is very low and simple rubber seals are sufficient.

The rear end of the crankshaft is fully inside the accessory case, so oil coming out of the rearmost bearing simply flows back to the sump. The front end of the crankshaft has the largest bearing, which is intentionally large to be able to handle the propeller loads. This bearing has a large amount of oil flowing through it. The oil flowing out the back end of the bearing flows between the thrust bearing of the crankcase and the thrust face at the front of the first crank. This oil lubricates the thrust bearing.

The oil flow out the front end of the bearing is sufficient to overwhelm a simple rubber seal. Therefore, the crankshaft is equipped with a double flange known as an “oil slinger”. Oil coming out of the front end of the bearing strikes this flange and is flung outward (or “yeeted” as the kids say) rather than just spraying forward. Figure 2 shows a four cylinder Lycoming crankshaft with the front bearing, the thrust face, and the oil slinger labeled.

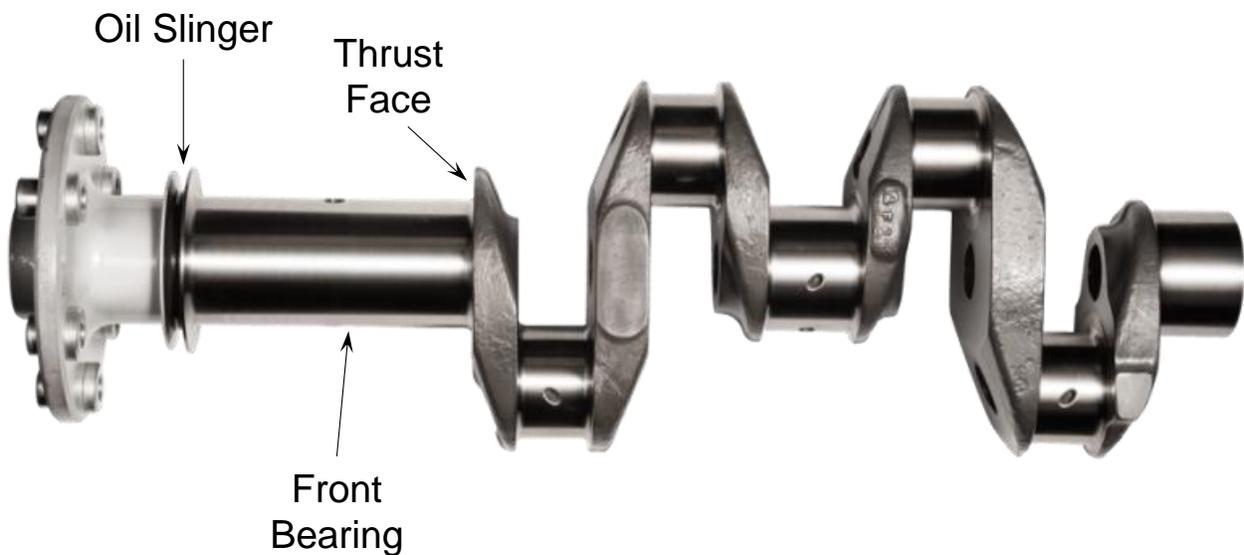


Figure 2. Lycoming four-cylinder crankshaft

Figure 3 shows a drawing of the mating side of the right half of the crankcase. The propeller would be to the left of the drawing. The front bearing is labeled as well as the thrust bearing which takes the thrust loads from the crankshaft. Also labeled are the oil slinger well and the front crankshaft oil seal well. Though this is a drawing of a six-cylinder crankcase, the front part of the crankcase is the same as for the four-cylinder crankcase.

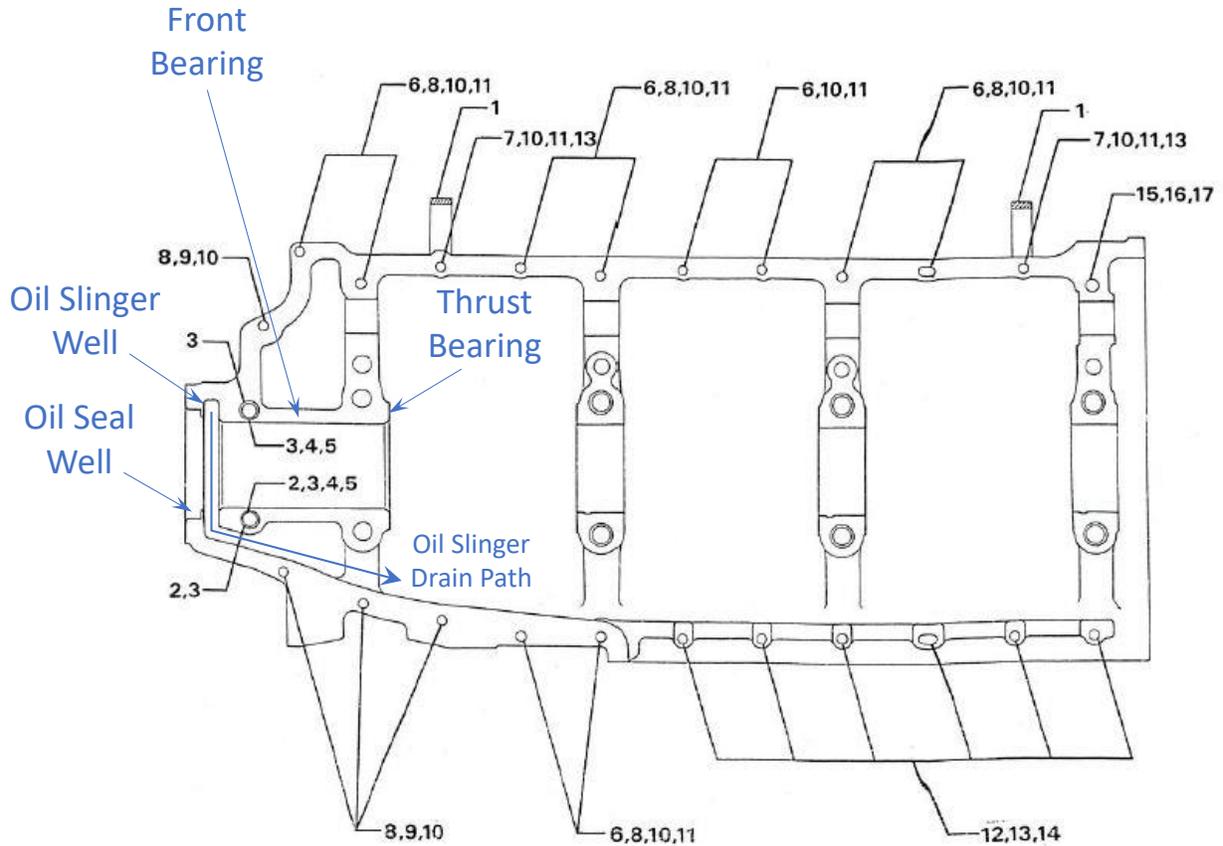


Figure 3. Mating face of right side six cylinder crankcase

Figure 4 shows the flow of oil through the front main bearing. Oil comes into the bearing through a hole at high pressure. The oil squeezes its way between the bearing and the crankshaft. The oil that comes out the back of the bearing, presumably still at significant pressure, squeezes between the thrust bearing and thrust face of the crankshaft. After that it is slung around the crankcase to lubricate other items.

The oil coming out of the front of the main bearing sprays on to the oil slinger, which slings the oil out radially such that it is captured in the oil slinger well and drains back into the crankcase. Oil that gets by the first oil slinger flange encounters a second oil slinger flange with similar effect. Any oil that gets by the second oil slinger flange is at fairly low pressure and can be stopped by the rubber crankshaft oil seal.

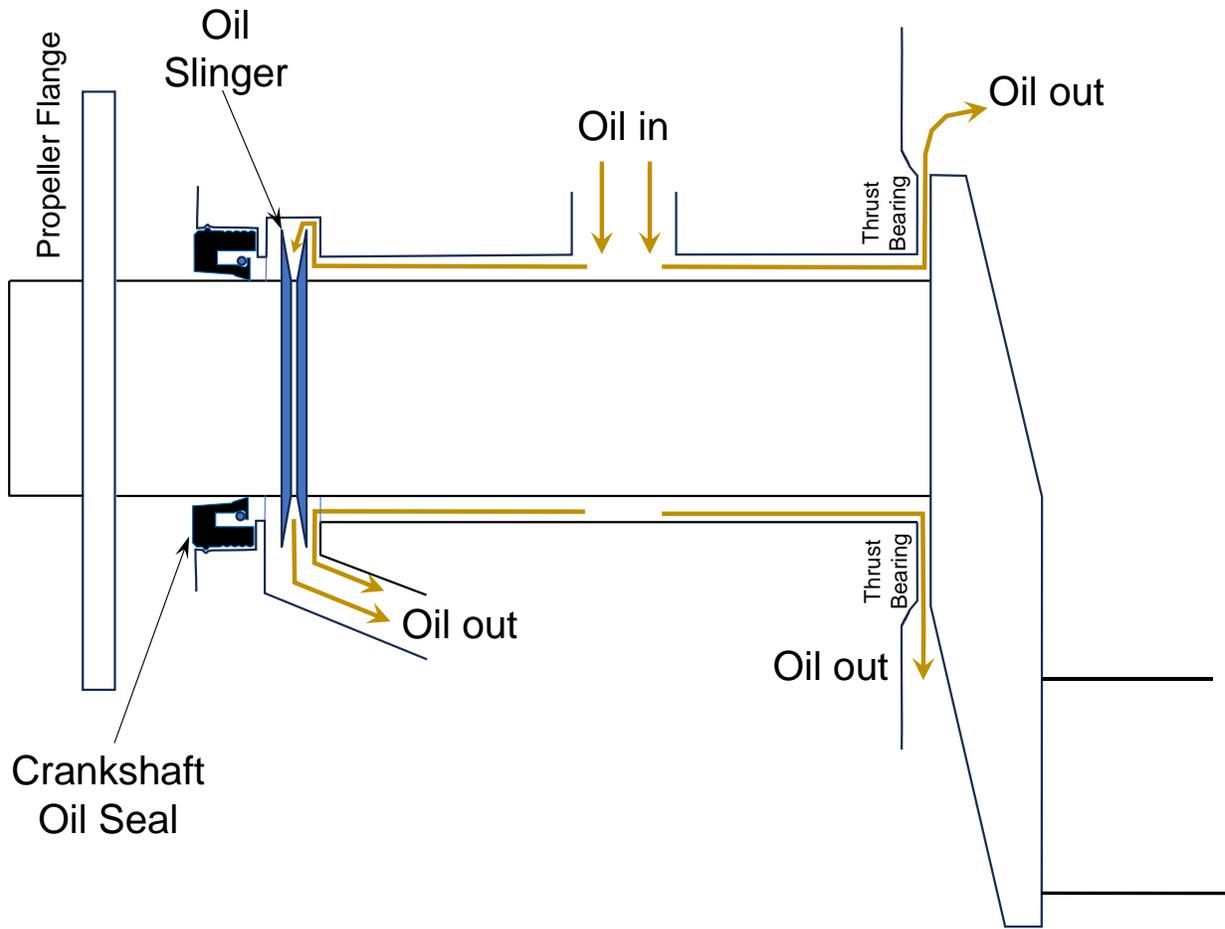


Figure 4. Front main bearing oil flow

Figure 5 shows the cross section of the crankshaft oil seal. As depicted, the crankshaft would be vertically on the left side and the crankcase oil seal well would be on the right. The propeller would be at the top. The right side has ridges to allow space for the sealant/adhesive. The retention ridge fits into a groove in the crankcase to provide some mechanical retention. On the left side the “sharp” edge is the actual seal that presses against the crankshaft to make the seal. Behind this edge is a cavity where a coil spring presses the sealing edge against the crankshaft.

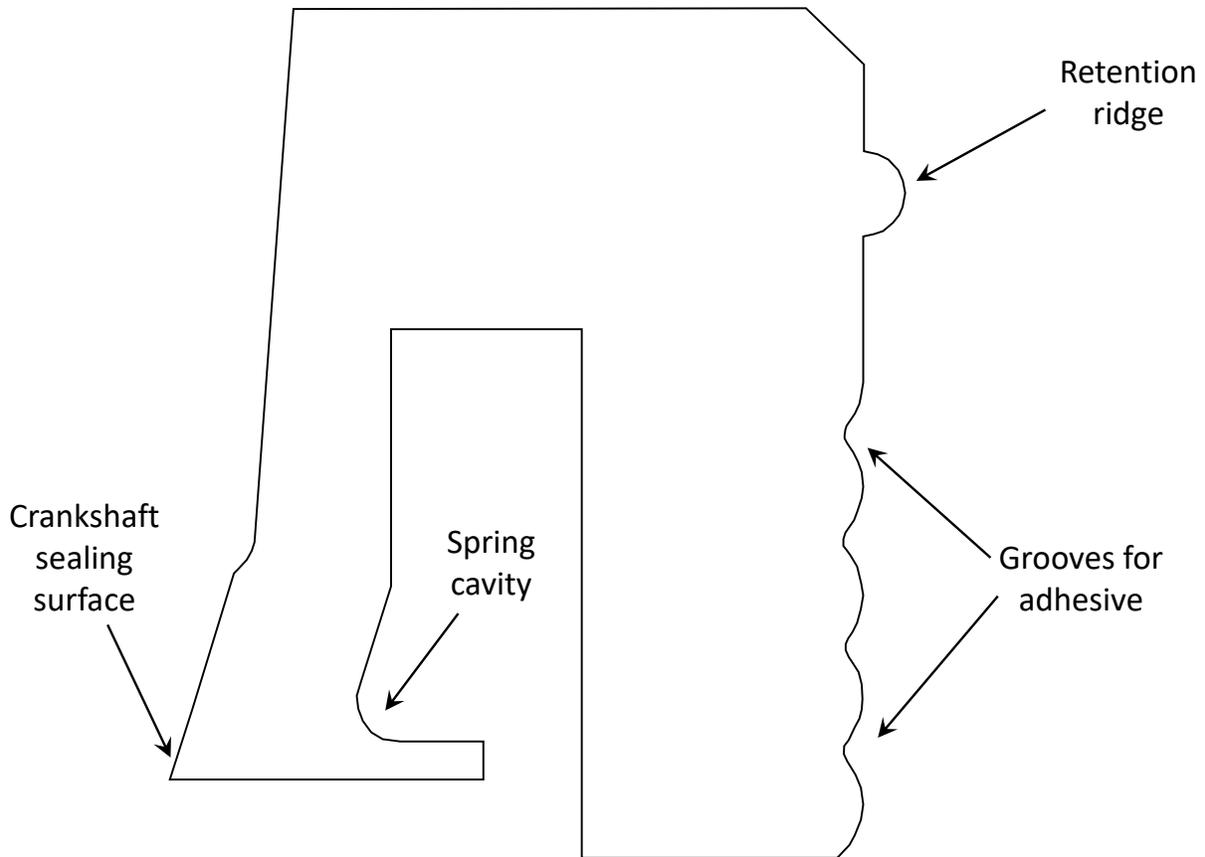


Figure 5. Cross section of crankshaft oil seal

I have installed one of these seals on my Lycoming O-540 three times. The engine was purchased and was represented as having a fresh overhaul. After a few ground runs, a mess of oil was in the cowling. I checked the crankshaft oil seal to see if that was the problem. The problem was that the seal was never installed.

After determining that the engine had been assembled improperly, it was disassembled, refurbished, and reassembled with many new parts. This required installation of another crankshaft oil seal.

After 686 hours of operation, large amounts of oil were accumulating in the cowling again, so the crankshaft oil seal was removed and replaced. Figure 6 shows the cross section of the worn oil seal. The wear on the seal was approximately 0.030 inches.

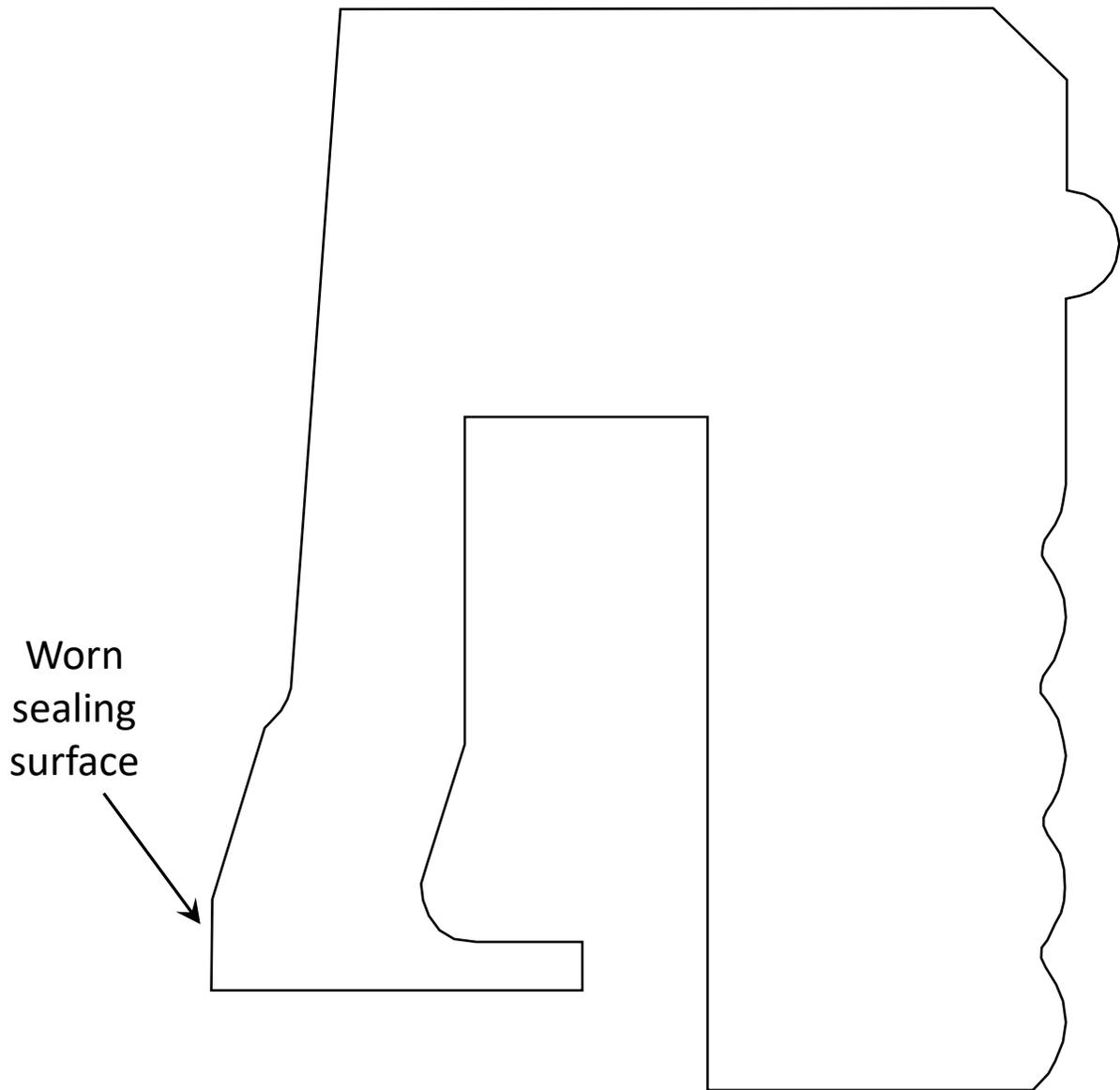


Figure 6. Worn crankshaft oil seal cross section

Installing the Crankshaft Oil Seal

To remove the old oil seal, simply poke it with a sharp tool and pry it out of its well. The sealant used to install the seal does not make a very strong bond between the aluminum of the crankcase and the rubber of the seal. Once it is out of the well, remove the coil spring and cut through the rubber seal to remove it.

I will not cover the details of how to install the crankshaft oil seal in this article because it is covered very well in Lycoming Service Instruction No. 1324D dated 25 January 2023 (available at <https://www.lycoming.com/service-instruction-no-1324d>). I will cover a few significant details that may not be obvious without reading the service instruction.

The crankshaft oil seal comes as a donut without a split for installation. To install the seal, the propeller must be removed. Replacing the alternator belt also requires removing the propeller, so if you are removing the prop to replace the oil seal, you probably should change the alternator belt at the same time. If you are removing a constant speed propeller, be sure to order a replacement O-ring for putting it back on.

The crankshaft oil seal is glued in place using a specified sealant. The latest version of SI 1324D recommends Permatex Optimum Max Flex Black sealant, with Pliobond #20, Pliobond #25 and Dow Corning 737 Neutral Cure Sealant also approved. In previous versions of SI 1324 Pliobond #20 was the primary sealant recommended. I used

this for the first two seals I installed. By the time I installed the third seal, Pliobond #20 was no longer available for sale in California and 16 other states because of its high VOC content. The suitable replacement was Pliobond #25, a low VOC version of Pliobond #20. All of these are available for purchase from Aircraft Spruce and Specialty. Do not buy Pliobond #20 until you are ready to use it, as it has a shelf life of only one year from the date it was shipped from the manufacturer, and that year includes the time it was sitting in Aircraft Spruce and Specialty's warehouse. The shelf life on Pliobond #25 is only six months.

Installing the solid seal requires stretching around the propeller flange. This requires a special though simple tool. Lycoming tells you to use their tool ST-383. They are very proud of this tool, as they charge \$1938.00 for it through Aircraft Spruce and Specialty AND it's not in stock—you have to special order it. If that seems a little excessive to you for a bent piece of metal, you can buy a clone from Aircraft Spruce and Specialty (Part# 12-04566) for only \$108.75.

SI 1324D calls for a 9/32 inch diameter brass pin for holding the seal while installing. Brass is used so that it doesn't damage the threads in the propeller bushing. I simply used a 1/8 inch brass pipe nipple from the hardware store and it worked fine.

You can see a video of me stretching the oil seal to install it on YouTube at <https://www.youtube.com/shorts/scSNT43RlrQ>. After stretching the seal around the propeller flange, you install the coil spring into the back of the seal, apply the cement to the outside of the seal, and push the seal into its well.

- Russ Erb