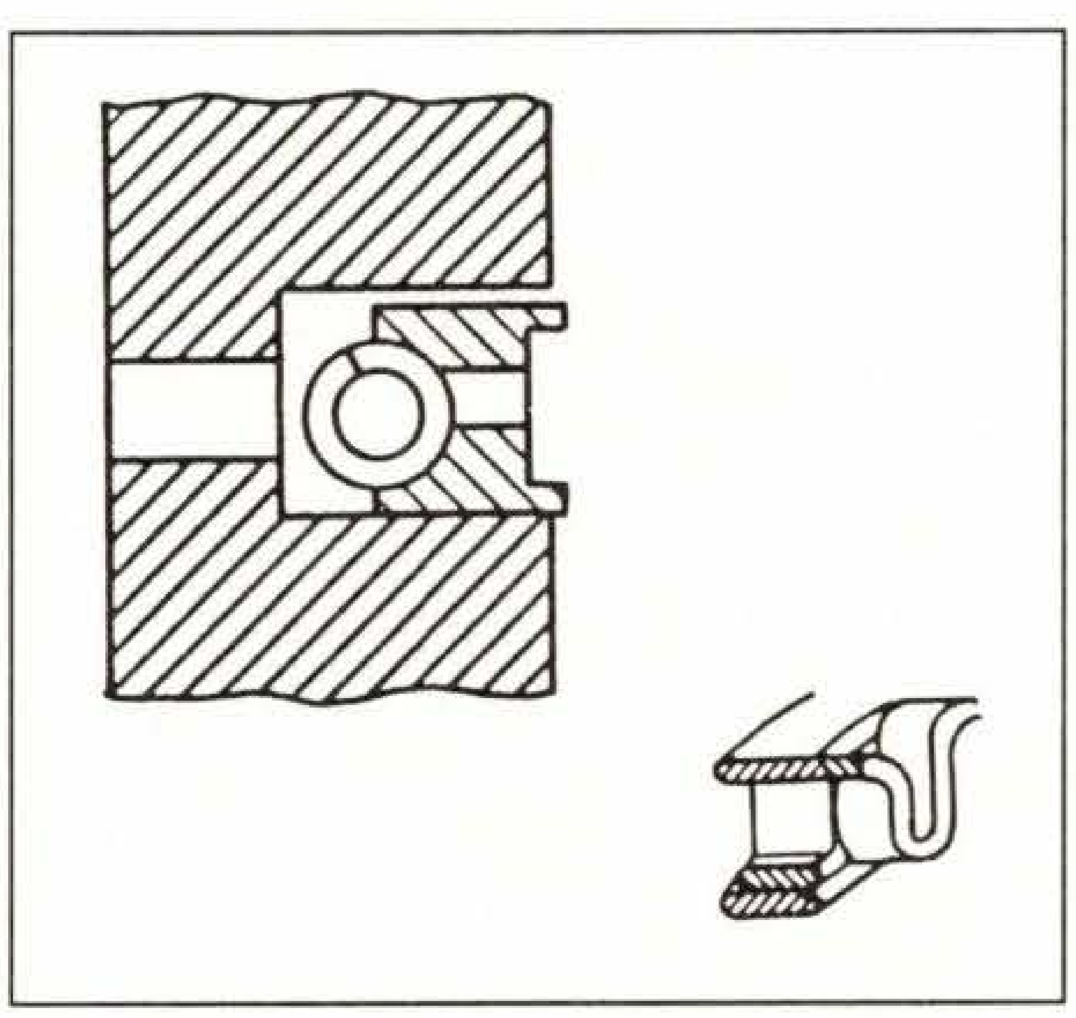
The Engine Clinic

Everybody knows that the function of piston rings is to seal the combustion chamber gas-tight (and thus contain the tremendous pressures developed in combustion)—but this function is really served only by the top one or two rings in the stack, which are (accordingly) called *compression rings.* A second main function of piston rings is to limit the flow of oil into the combustion chamber. (An excess of oil is thrown to the cylinder walls by rod and crank spray. If more than a very small fraction of this oil were to enter the combustion chamber, rapid deposit buildup would result.) Here, as with gas sealing, all rings in the stack participate to some degree in the oil-control process, but the *bottom* one or two rings are most effective. The ring most responsible for oil control is (naturally) the *oil control ring.*

The oil control ring is visibly much different from any compression ring. For one thing, it's wider—typically 5/16 or 3/8-inch. For another thing, it's got slots in it: either one groove down the center, or an arrangement of steps along the sides. (The center-slotted, "twin rail" type is most common.) You can also tell by looking at it that the oil control ring is of different material than the flat-black cast iron of the compression rings. The oil controller is shiny. It's made of steel.

Perhaps the most noticeable difference of all about the oil control ring is that it comes with a springlike *expander* that fits in a recess on the inside (the piston side) of the ring. Why is the expander needed? Recall that the combustion gas pressure differential across each ring is on the order 2:1. That is, the gas pressure is twice as great *above* the top compression ring as below the top compression ring; likewise, the pressure drops another 50% or so after the second compression ring. By the time you get to the oil control ring (the third ring in the stack), there isn't enough pressure behind the ring to force it out to meet the cylinder wall. An expander is necessary to keep the ring firmly seated to the wall.



Top diagram shows the typical coil-spring expander/dual-rail oil ring configuration. Bottom: Wavy expander.

Obviously, for the rings (compression as well as oil-control) to do their job effectively, the thickness of the oil film on the cylinder wall must be controlled. The proper amount of oil can be thought of as enough to lubricate the compression ring face (preventing metal-to-metal contact with the barrel), but not so much oil that the compression rings begin to hydroplane and lift off the cylinder wall. In the latter case, instead of the oil being scraped back down (toward the crankcase) on each piston downstroke, the oil would accumulate, only to be cooked into a thick varnish (and ultimately, hard carbon). The cylinders would quickly glaze over, and oil consumption would skyrocket.

The oil control ring keeps this from happening. With the expander in place, the oil control ring bears against the cylinder wall with tremendous force. (Despite the tiny contact surfaces of the rails, each oil control ring contributes about twice the friction of a compression ring; see Furuhama *et al*, SAE 810977.) The result is to spread a very thin film of oil on the cylinder wall. What actually happens is that a wedge of oil is formed ahead of the advancing rail; the rail is lifted off the wall slightly; and whatever oil passes under the first rail enters a low-pressure region between the rails that vents to the interior of the ring groove, where there are holes (in the piston) to vent the oil—in turn—to the interior of the crankcase. Any oil not so vented is spread thin by the trailing rail. (Obviously, when the piston reverses direction, the trailing rail becomes the advancing rail, etc.)

For the oil control ring to do its job, the expander must remain free, and the ring itself must remain free in its groove. (Also, of course, the piston grooves' drainback holes must remain unclogged.) The use of inferior oils, the depletion of an oil's dispersants (from too-long oil-drain intervals), or anything that causes carbon buildup in the ring grooves, will interfere with oil control ring action. Typically, in an engine using mineral oil, a point is reached (sometimes in as little as 200 hours SMOH, sometimes later) when carbon and varnish have coated the oil ring expander to the extent that the expander simply sticks to the ring, holding the ring in a low-tension or collapsed state. The rails will (at this point) no longer conform to the barrel surface, and excessive oil will pass to the combustion chamber, leading to more carbon, more ring-groove deposits, etc.

Semisynthetic and full synthetic oils are more resistant to thermal breakdown than mineral-based oils and thus resist varnishing of the oil-ring expander. This is one reason a new

(Continued on next page)

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The Cessna 152's Lycoming O-235-L2C can develop high oil consumption, most often because of barrel warpage and oil-control ring expander coking.

(Continued from previous page)
engine should not be operated any longer than necessary on straight (non-dispersant) mineral oil. As soon as a newly overhauled engine has broken in—perhaps in as little as five or six hours—the oil should be changed over to a good-grade semi-synthetic (Aeroshell 15W-50) or full synthetic (Mobil AV 1) for good oil control over the life of the engine. (Obviously, if the oil-ring expander is already gummed, switching to one of these oils won't necessarily help matters. Once the gum has formed, it's too late.)

A poor overhaul, incidentally, will only accelerate ring gumming. If choke (barrel taper) is not properly restored, or if the barrel is out of round (as most barrels eventually become)—or if the barrel warps in service—there will be localized areas on the cylinder wall where the rings (compression *and* oil-control) won't be able to conform to the surface, and where, as a result, hot gases passing under the rings will scorch the oil on the cylinder wall. The burned oil will ultimately clog the oil-control ring groove and/or expander and/or drainback vents. Oil consumption then goes on a long, steady slide.

The design of the oil-ring expander itself plays some role in the gumming-up tendency. Two styles of ring expander are currently in use (in aviation): a wavy style and a coiled style. The coiled style is by far the most common, although some are more tightly coiled than others. When the oil control ring is of the center-vented style, efficient oil drainback depends on having a lot of open space for oil to flow through, and wavy expanders offer better performance in this regard. John Schwaner of Sacramento Sky Ranch (a popular West Coast overhauler) agrees, saying: "The lack of free space of the coil expander results in rapid sludge buildup if there is any burning of oil on the cylinder wall. We often see coil-style expanders completely sludged up in many Continental and Lycoming engines."

One engine for which a wavy-type expander is available is the Lycoming O-235-L2C/N2C. Schwaner highly recommends the wavy expander for this engine. "When removing the cylinder from an -L2C engine for high oil consumption, look to see if the oil control ring is stuck due to sludge buildup. For a temporary repair, you can simply replace the oil control ring with a new one, preferably with the wavy expander, and reinstall the cylinder."

The repair is temporary, Schwaner says, because if blowby scorching is occurring, barrel distortion (which is the source of the problem) will have to be removed by regrinding the barrel. Simply deglazing the barrel won't do the trick.

Until wavy oil-ring expanders are available for every engine model, the best advice is simply: Use a good grade of oil, and *change oil often*. (Users of full-synthetic oils can go longer between changes than mineral-oil users, obviously.) At overhaul time, insist on a top-notch barrel grind to restore roundness and choke; don't return a marginal jug to service and expect good oil control. And finally: Switch to a semisynthetic or fully synthetic oil *as soon as possible after break-in*. After a ring expander gums up, it's all downhill from there.