Synthetic Oil

It's a very slippery subject.

About five years ago, we published an article on aircraft oil. It began this way: "The general aviation industry is often accused of being stodgy and behind the times—a technological retard. A good example is engine oil."

That's not quite true anymore. At long last, a pilot can now pour into the crankcase of his Bonanza an oil that's just as good as the oil he puts in his Audi.

It hasn't always been that way. Motorists have been using multi-viscosity oils to ease winter starting for decades, but the first all-season aircraft oil didn't hit the market until 1979. But by then, motorists were already buying the latest in oil technology—the super-slick, highly durable synthetic oils. Once again, aviation was lagging behind.

Well, aviation has finally caught up. Since then, a pair of small upstart companies have received FAA approvals for 100-percent synthetic aircraft oils. The stuff is expensive ($6 to $9 a quart) and hard to find (neither company has a decent way to market the oil to pilots), but the potential benefits are intriguing.

Oil Evolution

In the beginning, there was plain old mineral oil. It did the job well enough in aircraft for decades. In the fifties, however, Shell introduced a "detergent" aviation oil. The idea was that metallic additives ("ash") would help clean out gum and varnish deposits.

It was a good idea, but two problems surfaced: First, in an especially dirty engine, the detergent oils broke loose so much crud that sometimes oil passages got clogged up and the engine seized. (Oil filters were rare in aircraft in those days.)

The second problem was pre-ignition. In engines that burned a lot of oil, the metallic detergent additives could form combustion chamber deposits that glowed red-hot—so hot that they ignited the fuel/air mixture before the spark plug fired. In a severe case, the engine would shake itself to pieces in a few seconds.

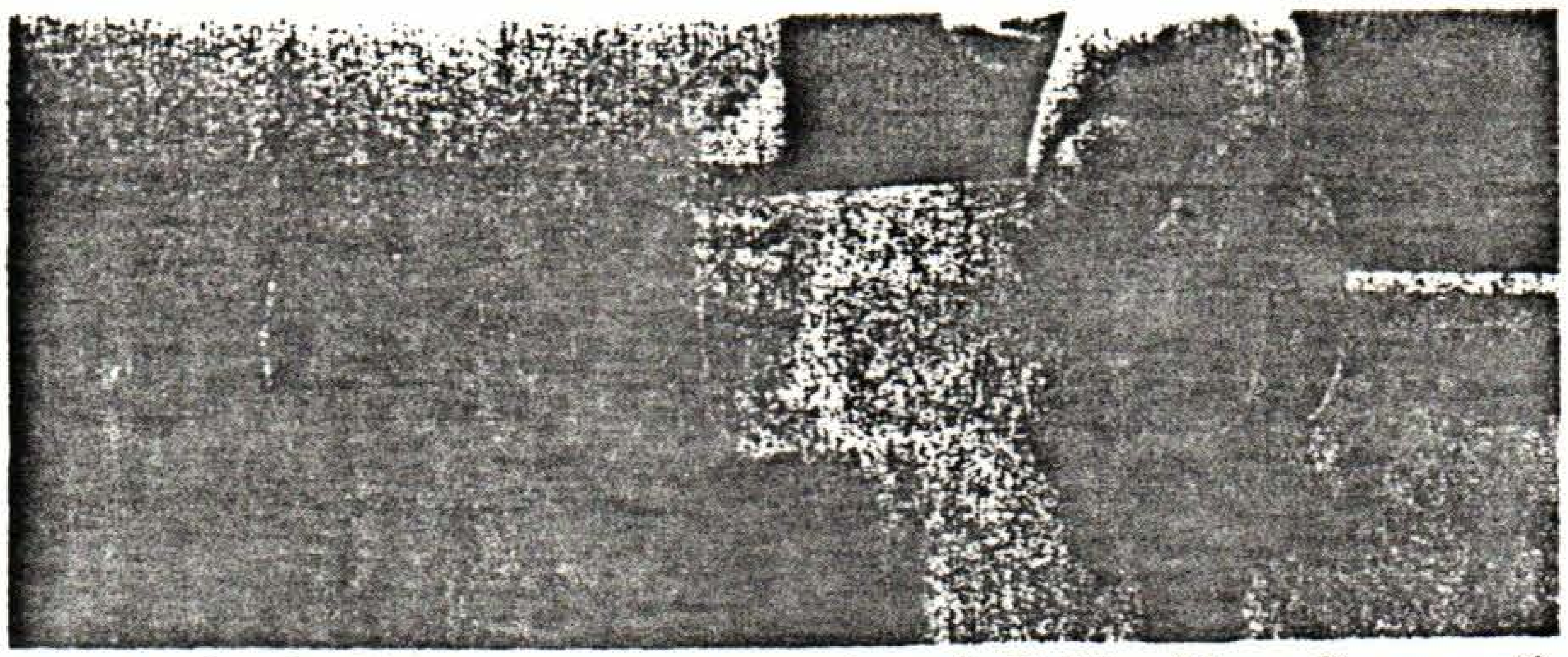
Ashless Dispersant Oil

Detergent oil for aircraft quickly disappeared, to be replaced by ashless dispersant, or AD, oil. The "ashless" meant that there were no metallic additives (ash) to trigger pre-ignition; the "dispersant" meant that engine dirt was held in suspension and prevented from agglomerating into sludge. (Dispersant oils lack the powerful active cleaning action of a detergent oil; they merely keep the engine from getting so dirty in the first place.)

AD oil was the general aviation standard for two decades. The most popular AD oil, Aeroshell W, was introduced in 1958 and is still widely used today. Straight mineral oil, essentially the same stuff that's been around since the 1930s, is still used, mainly in new or freshly overhauled engines during break-in. (See the box nearby.)

In the late 1970's came the multi-viscosity aircraft oils, only a couple of decades behind automotive multi-grades. Phillips Cross-Country 20W-50 was the first multi-viscosity oil; at about $3 a quart it is now among the best-selling aviation oils in the country. X-C was quickly followed by Aeroshell 15W-50, a 50-50 mixture of petroleum and synthetic oil that was labeled a semi-synthetic. It was also semi-expensive at about $4 per quart, but is widely used. The multi-viscosity oils had one obvious advantage: in cold weather, the engine cranked over more easily and the oil pressure came up faster. (See the box nearby for an explanation of viscosity.)

Our six test oils ranged from old-fashioned mineral oil to the latest synthetics.



Here's what happens to standard aircraft oil at near-zero temperatures.

The Multi-viscosity Bandwagon

With the success of the Shell and Phillips multi-weight oils, Mobil and Gulf jumped on the bandwagon. But both have jumped right back off, at least for now. Mobil introduced a 20W-50 petroleum oil last spring, but jerked it off the market almost immediately due to contamination and other problems. Mobil has also been testing a 100-percent synthetic oil for several years now and seems ready to bring it to market in the near future. Gulf did a lot of testing of a 15W-50 semi-synthetic designed to go head-to-head with Aeroshell, but it was never put on the market.

The oil giants may fear to tread in the land of 100-percent synthetic oils, but two small companies have bravely entered the new world. Bel-Ray,a New Jersey industrial lubricant manufacturer, introduced Aero-1, a fully synthetic 15W-50 aircraft oil, in 1982. Amsoil, another small company that had previously made automotive synthetic oils, followed suit in 1983. Right now, they're the only FAA-approved 100-percent synthetic oils available.

How good are the new synthetic oils compared to the old standbys? And how good an oil does a pilot really need?

To answer the first question, *The Aviation Consumer* tested in a laboratory six aircraft oils: two old-fashioned single-grade lubricants (Aeroshell straight mineral oil and Aeroshell W ashless dispersant), the two popular multi-weights (Phillips X-C and Aeroshell 15W-50) and the two aviation synthetics (Amsoil Avoil and Bel-Ray Aero-1).

What's A Synthetic?

In brief, a synthetic oil is one that didn't get pumped out of the ground. Petroleum oils percolate out of dinosaur bones and prehistoric bat guano, over millions of years, while synthetics are brewed up in chemical laboratories in a few hours. Because they are man-made, synthetics can be better tailored to their role as lubricant.

There are two basic types of synthetic oils. Polyalphaolefins are essentially man-made hydrocarbons, the same family of compounds that make up natural petroleum oils. But chemists fiddle with the compounds to keep the good hydrocarbons and throw away the bad ones. Mobil One automotive synthetic is a polyalphaolefin; so is the synthetic half of Aeroshell 15W-50.

The second major type of synthetic oil is the ester, a chemical combination of an alcohol and an acid. (Don't try pouring Jack Daniels into your Die-Hard; it's more complicated than that.) Synthetic oil esters come in two varieties, di-esters and polyol esters. Amsoil is a di-ester, while Bel-Ray is a polyol ester. The synthetic oils used in aircraft turbine engines are also polyol esters.

The Advantages

The claimed advantages of synthetics over petroleum oils are many. Among them:

- Better viscosity index. Synthetics don't thin out in the heat or thicken up in the cold as much as standard oils. That means easier cold starting and better lubrication at high temps.

- Better oxidation stability. Normal petroleum oils start to oxidize, or break down, at around 250-300 degrees F. Synthetics will stand 400 degrees or more. When oil breaks down over time, it starts to thicken up and lose its lubrication qualities. For the pilot, this low rate of oxidation breakdown allows longer oil-change intervals.

- Lower friction. Synthetics are simply more "slippery" than petroleum oils. Theoretically, this should result in less wear and slightly more power and/or less

All About Viscosity

The most obvious trait of any aircraft oil is its viscosity, or thickness. A high-viscosity oil is thick like molasses, while low-viscosity oils are thin like water.

Viscosity is measured by a number that can range (in motor oils) anywhere from 5 to about 60. The number corresponds to the time it takes a sample of oil to drain through an SAE-standard glass tube at a temperature of 210 degrees F. For example, if it takes between 85 and 115 Saybolt Universal Seconds (SUS) for the oil to drain from the tube, it is assigned an SAE viscosity number of 50. You'd call it 50-weight oil. Thinner oil drains more quickly, and has a lower number. A 30-weight oil would drain in 60 seconds or so.

To confuse matters, aviation oils are also referred to by grade number. This hangover from military aviation goes something like this: the grade number is twice the SAE viscosity number, except when it's not. Grade 120 is the equivalent of SAE 60; grade 100 is SAE 50; grade 80 is SAE 40; but grade 65 is SAE 30. Got it?

High-viscosity oils, SAE 50 and 60, are preferred in hot weather because they don't thin out so much at high temperatures. Low-viscosity oils, 20 and 30, are preferred

for cold weather because they don't turn to molasses when the mercury plummets.

To eliminate the hassle of seasonal/geographical oil changes, the oil companies came up with multi-viscosity oils that don't thin out in the heat or thicken up in the cold as much as normal oils. Multi-viscosity oils have two identifying numbers: the familiar SAE number measured in the usual way, and a second "W" number that measures its viscosity at low temperatures. A 15W-50 oil acts like a 15-weight oil in the cold, but a 50-weight in the heat.

The W number is determined by two standard tests. The first is a cold-crank test at several sub-zero temperatures; the second a so-called mini-rotary viscometer test. The results of these two tests are correlated by a standard table to an SAE "W" viscosity number. (If the two tests result in different "W" numbers, the higher one is used.)

The two cold tests are necessary because there are two kinds of viscosity. Kinematic viscosity describes the way a fluid reacts to gravity—in other words, how it pours. Dynamic viscosity describes the way it reacts to shear forces—how it pumps.

Consider honey and mayonnaise. Honey will pour all right (low dynamic viscosity), but is difficult to stir (high kinematic viscosity). Mayonnaise won't pour at all (high dynamic) but stirs easily (low kinematic).

For the aircraft owner, kinematic viscosity—pumpability—is the critical one for cold weather, since it determines how quickly (or whether) the oil pump will be able to pump the cold oil out to the far reaches of the engine.

Unfortunately, in most cases the "W" number of the multi-viscosity oil doesn't necessarily reflect pumpability. The rules require use of the higher number from the two tests, and the dynamic viscosity number usually comes out highest. Bel-Ray synthetic, for example, is called a 15W-50, but actually pumps like a 5W oil. But the oil buyer has no way of knowing how well his oil pumps at low temperature.

Not to worry. In every case, the multi-weight oils pump much more easily than any single-grades, and a 15W will pump better than a 20W. But there's no way to tell from the label which of the 15Ws pumps most easily, and is thus best from the pilot's point of view.

The engineers know, however. A standard industry test measures what's called "borderline pumping temperature." It's the temperature below which the oil simply can't be pumped. Don't *ever* try to start your engine below this temperature! Unfortunately, the oil makers don't all measure borderline pumping temperature the same way.

The viscosity number on the bottle is only part of the viscosity story. The number that really tells how well an oil resists thinning at high temperature and thickening in the cold—how well it maintains its viscosity—is a laboratory number called the viscosity index, or VI for short. The higher the VI, the more the oil resists thinning and thickening, and the more the pilot wants to have it in his engine.

Typical old-fashioned single-grade oils have a VI of about 100. Phillips X-C is 140; Shell semi-synthetic 15W-50 is 175. Best VI on the market is Bel-Ray, at 200, followed closely by Amsoil at about 195.

There are two ways to get a high viscosity index. One is to start with a base stock that naturally has a high VI. The other is to "soup up" the index with polymer additives called VI-improvers. Unfortunately, VI improvers tend to break down with heat and can wear out because shear forces tend to break down the polymer chains. Obviously, it's better to start with a base stock with the highest natural VI, since it requires less of the wearout-prone and heat-prone VI-improvers.

fuel consumption, particularly at high rpms. Engines should also run cooler because of the better lubrication.

• Higher film strength. The oil sticks more tenaciously to engine surfaces, providing better lubrication under extreme conditions.

• Better acid neutralization. Oil acids don't build up nearly as fast as in natural oils. That's another reason oil-change intervals can be extended.

• Lower volatility. Synthetic oils don't boil off as quickly as standard oils, so oil consumption is often less.

It all sounds pretty miraculous, doesn't it? Makes you wonder why anybody still uses the old stuff. Before getting into our lab tests, let's look at the two aviation synthetics, up close and personal.

Bel-Ray Aero-1

Bel-Ray is a small industrial-lubricants company in Farmingdale, N. J., right in the heart of Bruce Springsteen country. We don't know if the Boss uses Bel-Ray synthetic oil while he's out cruising through the darkness at the edge of town, but we do know that Bel-Ray is a big name in racing motorcycle lubricants. It also provides industrial lubricants for vehicles as diverse as Mercury outboard motors, Caterpillar tractors and aircraft carrier steam catapults.

One day in 1976, an industrial customer who happened to own a Piper Cherokee Six suggested to Bel-Ray president William Kiefer that he should develop an aircraft synthetic oil. Kiefer, although not a pilot, had always liked airplanes (the company operates a Chieftain). A chemical tinkerer, he retired to his lab to fool around with an aircraft synthetic formula. "At the beginning, there was no marketing study, no plans to sell it," says Bel-Ray's Gary Geber. "He was just having fun in the lab."

Since money was no object at that point, the best (and most expensive) ingredients went into the Bel-Ray formula. "Our raw materials alone cost us about $2.50 a quart," says Geber. Bel-Ray chose a polyol

The Thousand-Hour Oil Change

One of the big advantages of synthetic oils is longer drain intervals. Pilots typically change oil after 25 or 50 hours, but the synthetic oil makers claim 100 hours or more is possible. Bel-Ray, in fact, was certified by the FAA for 100-hour change intervals, since that was the drain interval used during the certification flight tests.

Synthetic oils eliminate or blunt most of the traditional reasons for changing oil. For example, petroleum oils eventually just break down due to oxidation. Synthetics, with their more stable molecules, are virtually oxidation-proof.

Another reason to change petroleum oils is acid buildup. Synthetics, however, have stronger anti-acid qualities. And as for plain old dirt (silicon from a leaky air filter, for example, or loosened varnish deposits), a good full-flow oil filter takes care of that. Synthetics

synthetics had problems with lead buildup. According to Weldon Garrelts, who's supervised thousands of hours of long-term oil testing at the University of Illinois, "Synthetics don't hold lead in suspension as well." But U of I testing of an experimental Mobil synthetic for 1,000 hours without changing showed no problem with lead salts.

The record for oil longevity may be held by a U of I Cessna 310, which ran the Mobil synthetic 2,000 hours in the right engine with one change. (The filter was changed every 100 hours.) After 2,000 hours, the right engine showed less internal wear than the left engine, which had run on Aeroshell 15W-50 changed every 100 hours.

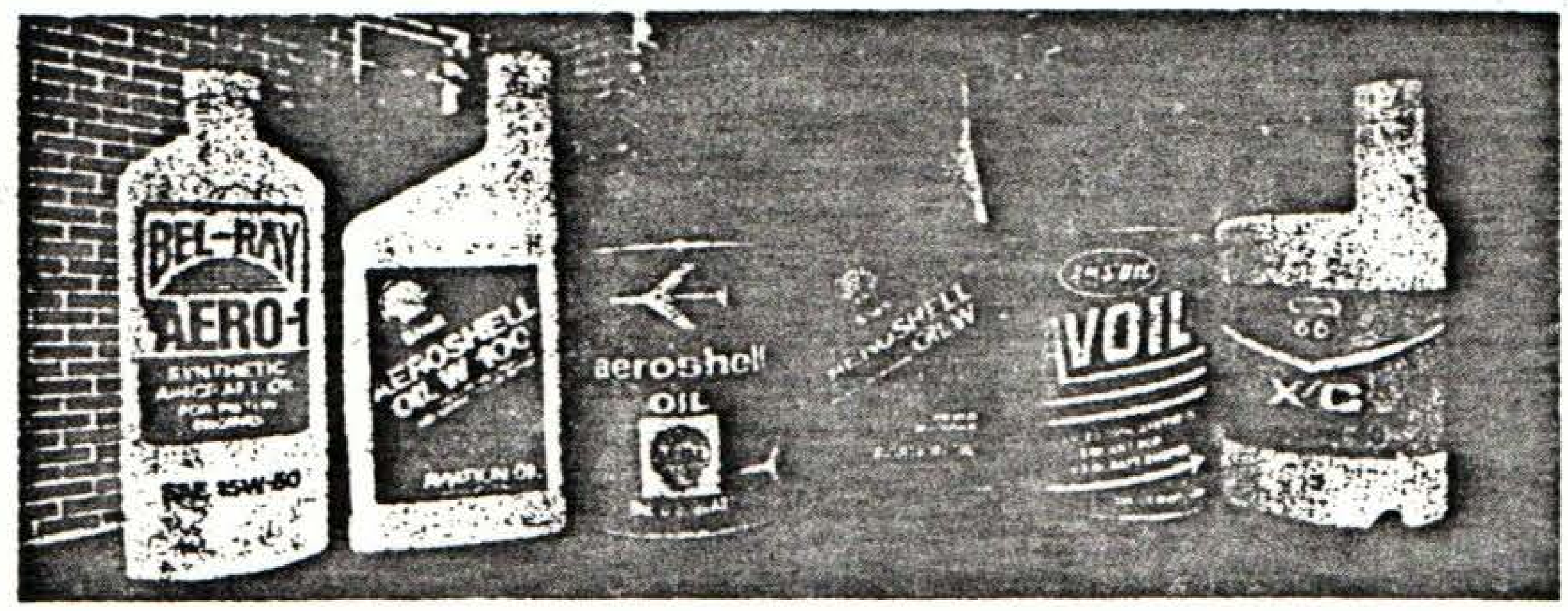
U of I is currently testing an advanced two-micron filter (typical oil filters are about 20 microns) so effective that it seems to remove varnish. With such a super-filter and synthetic oil, Garrelts sees the day when oil will have to be changed only at major overhaul—a time that

But even old-fashioned oil can turn in some eye-opening oil-drain intervals under the right conditions. Back in 1978, the U of I ran plain old Aeroshell W for 2,000 hours in a Beech Sundowner using 200-hour oil drain intervals. When the engine was torn down, it was found to be in excellent shape.

The Bottom Line

The longer oil-drain intervals and lower oil consumption of synthetics make them economically competitive—in the long run—with standard oil, despite the much higher cost of the synthetics. Example: our company Mooney uses Aeroshell 15W-50. We change oil every 50 hours (eight-quart sump), and burn about a quart every 10 hours. Over 100 hours, total oil usage is 24 quarts. Cost at $4 per quart: $96. Labor cost for two oil changes: $100. Total: $196.

Using Bel-Ray synthetic, we would stretch the drain interval to 100



Oil Comparison

	Typical Retail Price	SAE Viscosity Number	Viscosity Index	Pour Point (°F)	Dispersant	Anti-Wear Additive
Bel-Ray Aero-1	$8.85	15W-50	200	−45	Yes	Yes
Amsoil Avoil	$6.25	15W-50	195	−60*	Yes	Yes
Aeroshell 15W-50	$4.00	15W-50	175	−25	Yes	No
Phillips X-C	$3.00	20W-50	140	−20	Yes	No
Aeroshell W	$2.00	30,40,50, or 60	105-110	−10 to 0	Yes	No
Aeroshell mineral oil	$1.75	30,40,50, or 60	96-100	+10 to +25	No	No

*Aviation Consumer tests suggest pour point is actually about −45°F.

thinking about aircraft synthetics back in 1976. A prototype formula was tested in the Amsoil racer, a biplane racer designed and built by Burt Rutan which plied the race circuit and set various speed records. The racing experience led to some changes in the formula.

The reformulated Amsoil, using a di-ester base stock, was approved by the FAA in 1983 for Lycoming engines only. (Amsoil says approval for Continentals is pending.)

In great contrast to Bel-Ray's low-key marketing, Amsoil uses the evangelistic multi-level direct-sales approach *a la* Amway or Mary Kay cosmetics. The idea is that thousands of hustling individual entrepreneurs sell Amsoil products to their friends and neighbors, signing up sub-dealers and taking commissions on their sub-dealers' sales. (Detractors call this "pyramid" marketing.) According to Amsoil, the company has something like 75,000 dealers around the country.

In practice, many Amsoil "dealers" are simply customers who want to get the dealer discount and don't bother trying to sell the stuff. And those dealers that do make active sales pitches are selling all sorts of other Amsoil products for cars, boats and lawn tractors. (They even sell vitamins and shampoo as part of Amsoil's "Quality of Life" product line).

Few Amsoil dealers are pilots, and you're not likely to find one in your local pilots' lounge hustling aviation synthetic oil.

The result is that Amsoil's aviation synthetic is nearly as hard for pilots to find as Bel-Ray. To get the name of your nearest dealer, contact the factory: Amsoil, Inc. Amsoil Bldg., Superior, Wisc. 54880, (715) 392-7101. Retail price is $6.25 per quart; the dealer price is $5.60.

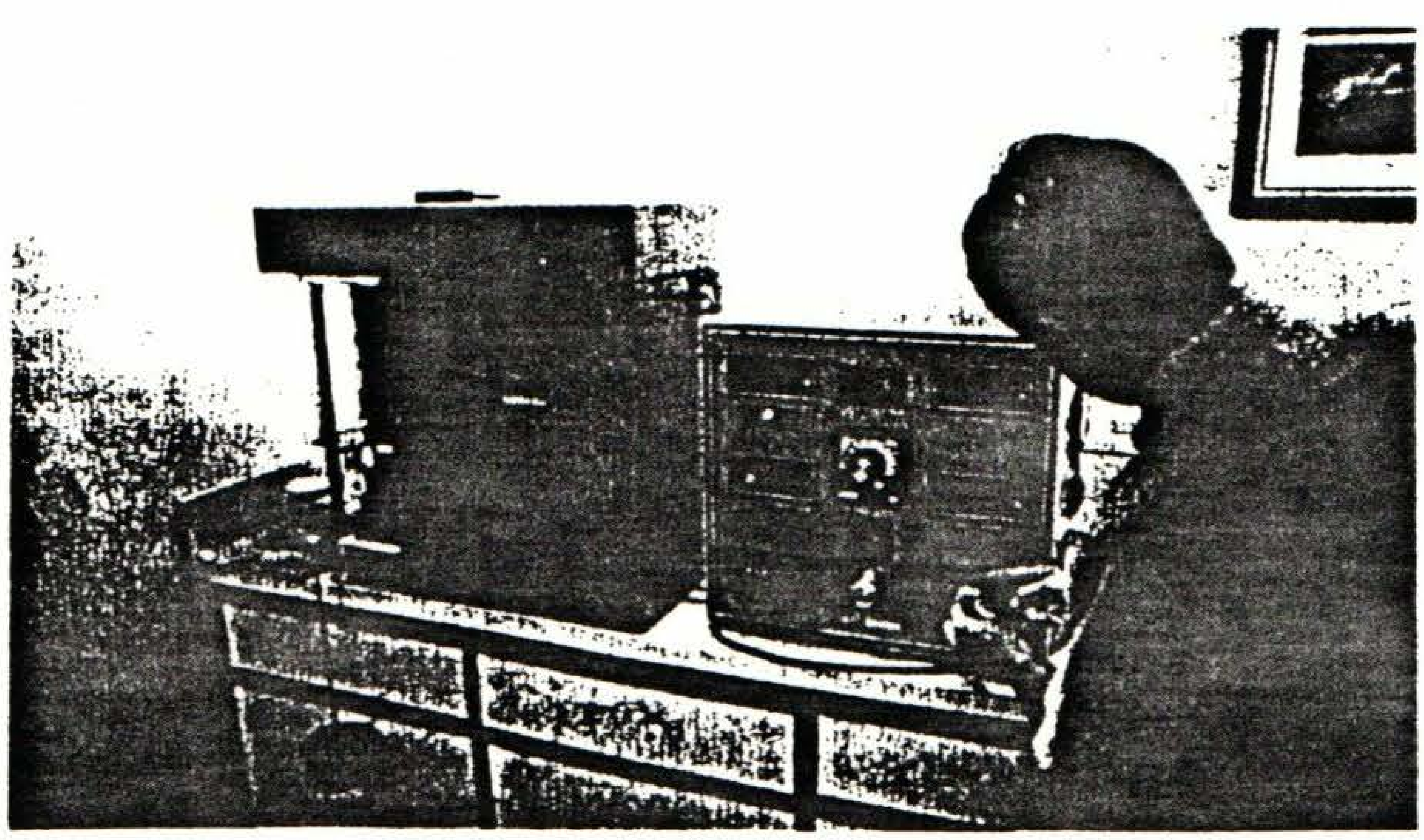
Lab Test Results

We subjected the six oils to three standard industry friction/wear tests, plus cold-weather pour-point tests. We used the lab at Bel-Ray Co. since it was close by our Connecticut offices. (For those who question the objectivity of the tests for this reason, we can assure you that an editor participated directly—recording data, looking over the shoulder of the Bel-Ray technician, peering through microscopes to confirm wear patterns and generally doing his best to make sure the tests were fair and accurate.)

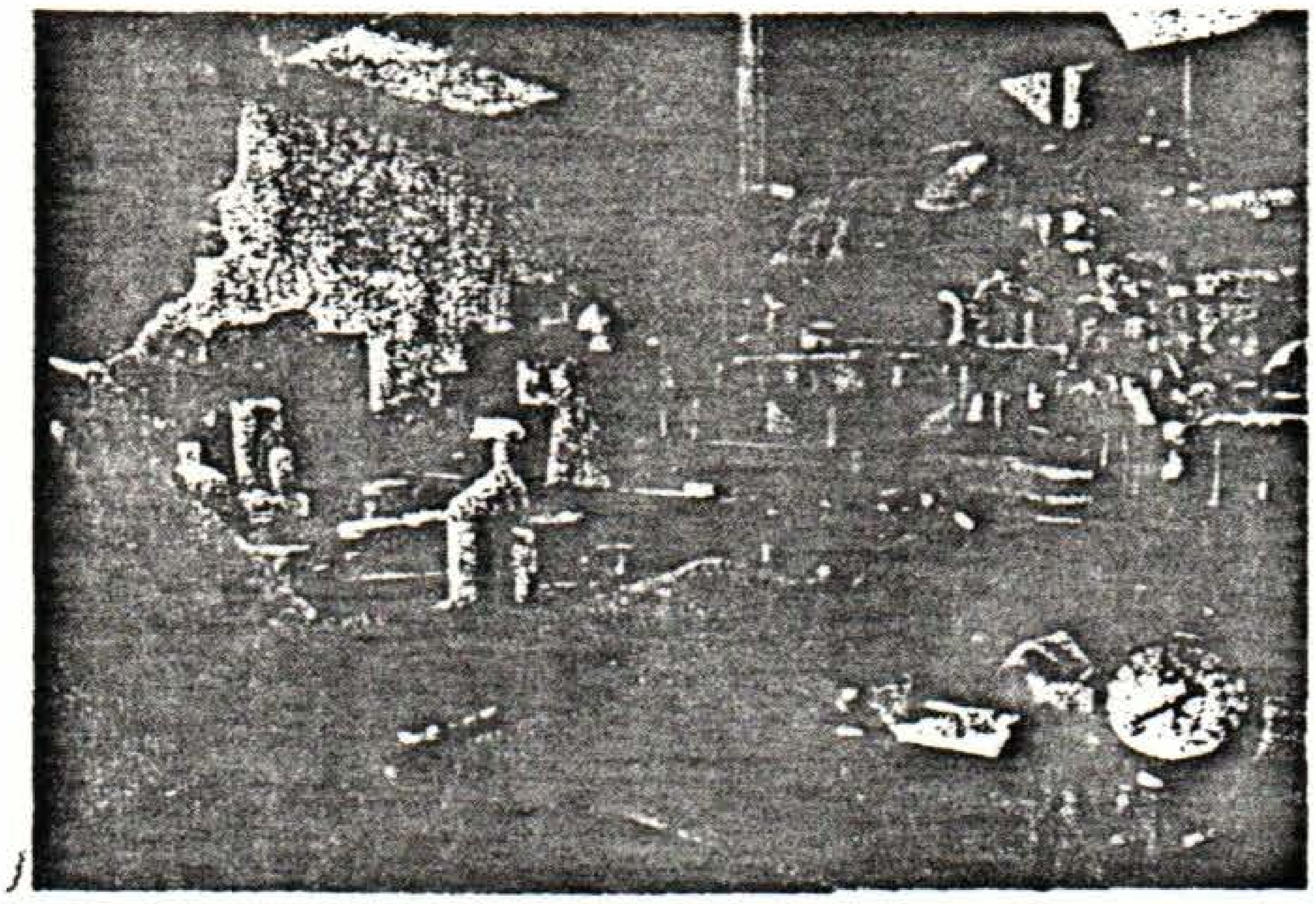
In a nutshell, the two synthetic oils, Bel-Ray and Amsoil, performed noticeably better than the five petroleum oils in all but one of the tests.

Extreme-Pressure Test

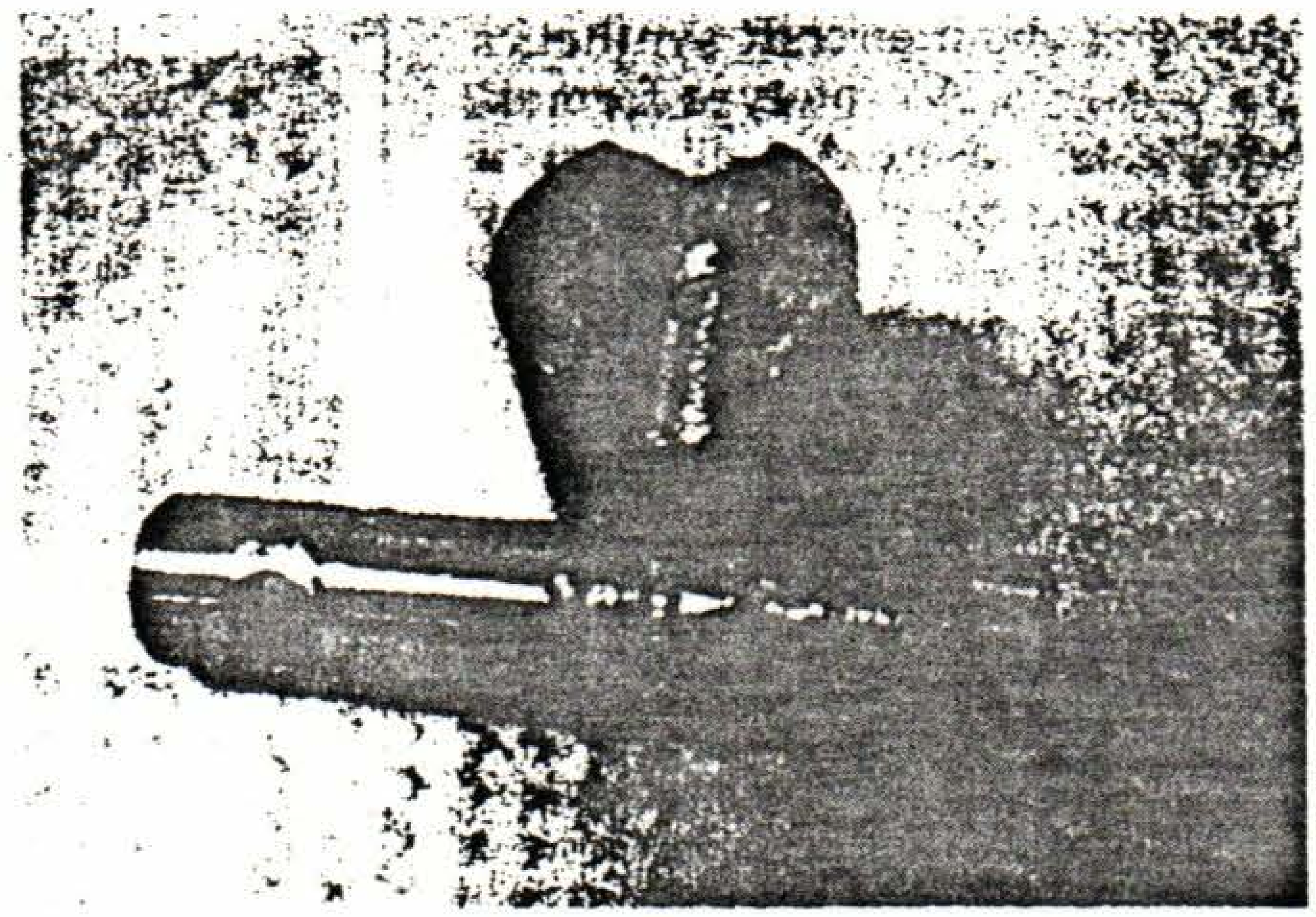
No.1 was the four-ball extreme pressure test. A ball-bearing was spun against three others, immersed in an oil bath, under very high loads. It simulates a boundary-lubrication situation in



Four-ball extended-wear test measured size of wear scar at 1,200 rpm and 75°C.



Falex pin and V-block test measured friction under varying loads.



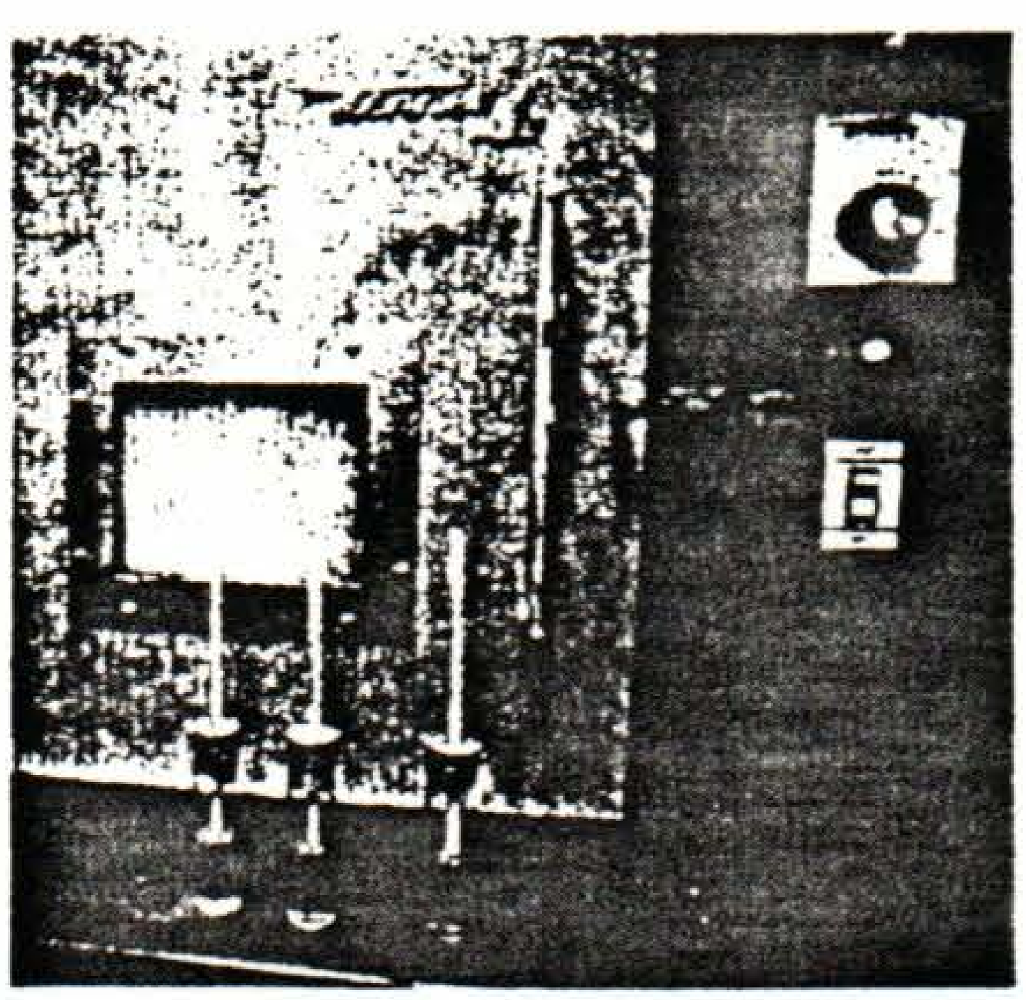
Pin and V-block seized after 55 seconds under a 500-kg load while being lubricated by Phillips X-C oil.

which there is direct metal-to-metal contact—a much harsher condition than normally occurs in a healthy engine.

Under a 100-kg load, the three Shell oils and Phillips X-C performed about the same. All showed torque resistance values of about 2 for the duration of the 10-second run. Wear scars on the bearings were virtually the same size—3.0 to 3.1 mm.

Amsoil was clearly better. Torque resistance dropped from an initial value of two to nearly zero after three seconds, and the wear scar was smaller—about 2.2 mm.

Bel-Ray performed even better, however. Startup resistance torque was only one, and it dropped to nearly zero after a half second. After 10 seconds, the wear scar was only 1.6 mm wide, only half the size of the petroleum oil scars.



Three oil samples about to enter the cold chamber for pour-point tests.

We then doubled the load to 200 kg. With Shell mineral oil, the bearings seized up and welded together almost instantaneously. With Amsoil, failure occurred after about one second. In its bath of Bel-Ray, however, the bearing survived the full ten-second run. Wear scar was 3.0 mm—same as for the petroleum oils under the 100-kg load.

These results suggest that the antiwear additive in Bel-Ray is very effective.

Long-Term Wear Test

Test No.2, called the four-ball wear test, was generally similar to the first one, except that pressures were much lower, and the oil bath was temperature-controlled at the outset. It simulates normal hydrodynamic lubrication, in which a film of oil prevents actual metal-to-metal contact. Load was 40 kg, and the bearing spun for one hour at 1,200 rpm in an oil bath that started at 76 degrees C (169 degrees F.)

Time restraints prevented testing all six oils, so we ran the straight Shell mineral oil, Phillips X-C and Amsoil. Results were fairly similar. Wear scar with mineral oil measured 0.65 mm; with X-C it was 0.55. Amsoil also showed 0.55, but its scar had a slightly more polished appearance. (Bel-Ray's Gary Geber said that its Aero-1 usually scores about 0.5 to 0.6 on this test, with 0.6 being the quality control point above which a batch is rejected.) Torque values and final oil bath temperatures were quite similar for all three oils tested.

These results suggest that synthetic oils do not greatly reduce wear under normal conditions. Switching to a synthetic oil won't guarantee a 4,000-hour TBO, but you might get a few hundred extra hours.

Pin and V-Block Tests

The final friction/wear test we tried was the Falex Pin and V-Block. A small steel pin is rotated between two slotted steel blocks under various pressures. A torque readout shows the resultant friction.

Under a load of 300 kg, all six oils registered torque values between 7 and 9 at startup, and all torque values climbed slightly during the one-minute run. With the pin still rotating, the load was increased to 500 kg. Torque immediately jumped to 14-16 ft-lbs in all cases. With Shell mineral oil, however, the pin seized and broke after 25 seconds under the 500-lb load. Phillips X-C seized at 55 seconds into the one-minute run at 500 kg. Both Aeroshell W and Aeroshell 15W-50 survived the full run, but seized and failed as the load was being increased to 750 kg. Only the two synthetics made it to 750 kg.

Amsoil made it through the 750-kg run, but finally failed after 10

The Myth of Mineral Oil

Ask any old-timer about straight mineral oil, and he'll likely say, "Sure, you gotta use it during the first 50 hours or so on a new engine. Otherwise it won't break in right." Aviation folklore says that ashless dispersant oil, the kind used by most pilots for normal flying, somehow delays or prevents piston ring seating, with resultant high oil consumption and low compression.

The folklore has some persuasive authority behind it. Lycoming service bulletin 1014K states, "...engines must be operated on straight mineral oil during the first 50 hours of operation, or until oil consumption has stabilized. If an ashless dispersant oil is used in a new engine, or a newly overhauled engine, high oil consumption might possibly be experienced."

Why should this be so? The main difference between straight mineral oil and AD oil is the dispersant additive, which, as far as we can tell, does not really change the oil's anti-wear qualities. When we started asking around, we got some interesting answers.

Bill Witt of Phillips: "There's not much difference, if you really want to know the truth. There's no reason to use mineral oil for break-in. But all the old-timers have been using it for years. The only reason we sell straight mineral oil is because the customers demand it."

Paul Eberle of Continental: "Using mineral oil for break-in is a questionable thing. People have been doing it for years, but it's a practice based more on history than technical fact."

Weldon Garrelts of the University of Illinois, who has tested many oils for thousands of hours in U of I aircraft, agrees. "There's no difference in break-in. We've run Aeroshell, Gulf and Amsoil ashless dispersant and synthetic oils in new engines right from the start and never had a problem with break-in. It's an old wives' tail."

Shell takes a middle ground. According to spokesman Ben Visser. "We tell people to follow their engine manufacturer's or overhauler's recommendations. But we feel that with nitrided cylinders you get just as good a break-in with AD oil. On hard chrome cylinders, you might break in a little faster with mineral oil. Theoretically, the dispersant in the AD oil carries the wear particles away quicker so they don't grind away as much, and you get less wear."

Lycoming seems to stick by its service bulletin. A spokesman told us, "My understanding is that mineral oil gives you poorer lubrication, which is what you want during break-in."

Our lab tests, however, suggest that the anti-wear qualities of mineral oil and AD oil are similar. Under the SAE standard four-ball extreme-pressure test and the Falex pin and V-block test, Shell mineral oil performed virtually as well as Aeroshell W AD oil and even Aeroshell 15W-50.

Some oils do have anti-wear additives, however, and these should definitely not be used for break-in. Our lab tests showed that the two synthetic oils, Amsoil and Bel-Ray, permitted much less wear in the aforementioned tests. And Phillips' new X-C II has an anti-wear additive that may make it unsuitable for break-in. (At presstime, we hadn't had a chance to test it yet.)

Do we recommend pilots abandon the use of mineral oil for break-in? Not necessarily. Choosing an oil is an exercise in the psychology of the unknown; the benefits are hazy and long-term, and it's virtually impossible to determine the oil's precise role in any problem or failure. Using mineral oil for break-in certainly can't hurt anything, and you'll have the peace of mind of following manufacturers' dictums. (If you have a break-in problem and didn't use mineral oil, Lycoming might well look squintily at your warranty claim.)

But there's one thing everybody agrees about: for proper break-in, run the engine hard. Don't baby it; otherwise the rings may never seat properly.

Our recommendation: For break-in, use either mineral oil or any other oil without an anti-wear additive—whichever one makes you feel good. And run it hard.

seconds at 1,000 kg. Torque readout just before the failure was 28.5. Bel-Ray cruised through the 1,000-kg test with no problem. The friction actually declined from 25 to 18 during the run. Astonishingly, the pin kept turning smoothly in its Bel-Ray oil bath as the load was increased to 1,250, then 1,500, 1,750 and finally 2,000 kg. Torque remained steady at around 22-24.

This result impressed us. Bel-Ray performed just fine under a load three times higher than the failure level of the four petroleum oils, and twice that of Amsoil. Once again, it seems that Bel-Ray's anti-wear additive is very effective.

Pour Point Tests

Our final test determined the approximate pour point of the oil—that is, the lowest temperature at which the oil remains in a semi-liquid state. Below that temperature, the oil essentially freezes solid and, obviously, is useless as a lubricant.

Using Bel-Ray's low-temperature chamber, we started at 20 degrees F and worked our way down. At 20, the Shell mineral oil (SAE 40) and Shell AD (SAE 50) had both thickened noticeably, to about the consistency of honey. The others looked fine. At 8 degrees, the Shell SAE 50 was frozen solid, while the Shell SAE 40 just barely flowed, like very heavy molasses. The Phillips X-C had started to thicken slightly at this point.

At minus 8 degrees F., the Shell SAE 40 had frozen solid, and the Phillips had thickened noticeably. Aeroshell 15W-50 and the two synthetics still flowed easily. At minus 15, the Phillips was heavy molasses, and had frozen solid by minus 30. Aeroshell began to lose it at about minus 30 and had frozen solid by minus 40. Bel-Ray and Amsoil were still liquid at that point.

Finally, at about minus 45 degrees, both Bel-Ray and Amsoil locked up.

Generally, this test confirmed the published pour points for all the oils, with the exception of Amsoil, which claims a pour point of 60 below. Our test showed that this is simply not the case.

Conclusions

Our tests show a fairly clear pecking order. Best performer was Bel-Ray, followed closely by Amsoil. Bringing up the rear, in order of performance, were Aeroshell 15W-50, Phillips X-C and the two Shell single grades.

But an airplane is not a laboratory. There's many a slip 'twixt the test tube and the crankcase, as hard experience shows. (Aeroshell 15W-50's prop seal compatibility problems, for example.) Before you rush out to buy synthetic oil, consider a few caveats.

Sudden Failure

We recommend great care in switching to synthetic oil in high-time and/or dirty engines. Reason: the cleansing action of Amsoil and Bel-Ray is strong enough ("It's like a vacuum cleaner in there," commented a Bel-Ray spokesman) that great hunks of varnish and crud may break loose and block oil passages, causing oil starvation.

Precisely that happened to one Twin Comanche owner who switched to synthetic oil. He changed to Amsoil in February, 1983. The engines had about 900 hours since major. Five days and 38 flying hours later, the right engine began running very rough and was shut down. Subsequent teardown showed a broken rod and other internal damage. The mechanic reported "heavy sludge deposits... all crankshaft oil holes blocked except front main bearing...recommend not using any oil with detergent qualities in a high-time engine that may have sludge deposits that could be loosened."

The Twin Comanche owner has filed suit against Amsoil.

The lesson is clear: if you switch to a synthetic (or any other oil with a strong cleansing action) in a high-time or dirty engine, install an oil filter if you don't already have one. And it might be a good idea to change the oil and/or filter after the first few hours. A Bel-Ray spokesman agrees. "We strongly recommend a filter be installed in any aircraft that switches to Aero-1."

Lead Deposits

Another potential problem with synthetics is deposits of lead compounds. While developing its 15W-50, Shell tested a 100-percent synthetic and ran into problems in high-performance low-usage aircraft. Lead salt deposits caused stuck rings, low compression and high oil consumption after 500 to 600 hours, according to Shell's Ben Visser. He says that was one factor in Shell's decision to go semi-synthetic.

An experimental formulation of Amsoil (not the certified product, insists the company) had lead problems in a preliminary flight test at the University of Illinois. Reports Weldon Garrelts, who oversaw the test program for the U of I, "We had problems with lead paste buildup and stuck valves."

Lycon Approval

Neither Lycoming nor Continental officially "approves" Amsoil or Bel-Ray. The engine makers don't approve any oils, in fact. Continental publishes a list of oils for which the oil marketers, in Continental's words, "have supplied data indicating the products conform to TCM (Continental) specifications." Continental goes on to say that it "makes no claim of verification of the marketers' claims."

Lycoming publishes no list at all, simply saying that any oil used in its engines must meet Lycoming specification 301-F.

Neither Amsoil nor Bel-Ray is on the Continental list. Bel-Ray has simply not bothered to submit data to Continental, since Bel-Ray ran certification tests of its own in a Continental-powered Turbo Skymaster and received FAA approval for Continentals as well as Lycomings. Amsoil, however, ran its FAA test in a Lycoming only, and hence got FAA approval only for Lycomings. (Amsoil's certification was based on a 150-hour test-cell run rather than a flight test.) Amsoil sent Continental a batch of oil and has requested a 150-hour certification test cell run. But Continental, primarily for economic reasons, hasn't gotten around to doing the tests yet. For now, it's illegal to use Amsoil in a Continental engine.

Summing Up

All things considered, it's hard to resist the allure of the synthetic oils. They seem to have clear performance advantages, and the

Synthetic Oil User Comments

We have been using Amsoil 100-percent synthetic oil in both our airplanes since 1982. We have a Piper PA-11 with a 108-hp Lycoming O-235 engine and also a 1968 Mooney M20G with a 180-hp Lycoming.

Both planes start great in winter, and we have not needed pre-heat for starting in three years. We feel the engine runs smoother and cooler. The oil consumption is down, and it remains very clean. We do not change oil, but rather add small amounts as necessary to keep proper levels.

We are sold on this product 100 percent.

William Weiss
Paramus, N.J.

I have been using Amsoil Avoil in my Mooney M20B. The engine now has 2,500 hours total time, but recently had a chrome major. I used non-detergent oil for the first 30 hours after the overhaul, at which time the oil consumption had stabilized at a quart every five hours. I then switched to the Avoil. Oil consumption is now a quart per 7.5 hours.

One other significant modification

was an Amsoil BF-06 external oil filter, since the engine had only a screen and no possibility of converting to a spin-on filter.

At the annual inspection, the engine was in excellent condition. Compression was 75/80 or better on all cylinders and the plugs were clean enough to elicit a comment to that effect from the inspector.

I can't confirm marvelous increases in power or reductions in temperature, but Avoil does seem to be quietly going about its intended job of lubricating. The one area that is noticeably impressive is cold-weather starting. The engine turns over much more easily, and there is oil pressure instantaneously at temperatures well below freezing.

L. Carl Howlett
Richmond, Utah

I used Amsoil Avoil in my 1963 Bonanza with IO-470N Continental (100 hours SMOH) and in a Lycoming O-320-D2J in a Cessna Skyhawk. I saw an immediate drop of 8-10 degrees in CHT in the Bonanza. The Skyhawk had been treated with the Matrix Teflon additive, and when changed over to Avoil, the engine ran past redline in level flight at full throttle. I get about 20 hours per quart.

One can reduce the oil cost by 15-25 percent by becoming an Amsoil dealer (I am one). A dealership costs $25 per year for the computer billing setup.

Curtis Pool
Odessa, Texas

I changed to Bel-Ray Aero-1 synthetic oil in my 1981 Cessna Skyhawk due to engine vibrations that the Cessna and Lycoming factory representatives failed to alleviate. I have not experienced the vibrations since changing to Aero-1 at 228 hours. Total time is now 448 hours. The aircraft had previously been using Phillips and Aeroshell.

I have also noticed increased idle speed and oil pressure, lower oil temperature and reduced fuel and oil consumption.

I preferred the Aero-1 over the Amsoil because it is a polyol ester base, rather than the di-ester base of Amsoil.

Daniel Vale
Londonderry, N.H.

We have used Bel-Ray Aero-1 in our 1960 Cessna Skylark, both with the original GO-300 Continental engine and the Lycoming O-360 that was recently installed. The oil has been excellent. The new engine came with mineral oil, but we changed to Bel-Ray after six hours. During the break-in, we've changed oil every 25 hours. It's expensive, but we feel it's worth it. The engine now has about 100 hours, and it hasn't burned any oil at all.

Mrs. Charles Buford
Pleasonton, Tx.

I bought a 1964 Twin Comanche a couple of years ago with 1,700 hours on it. Original engines, never been overhauled. Each engine was using a quart of Aeroshell 30 every four hours, compression was down, and the owner told me it needed an overhaul. I switched to Phillips 20W-50, and oil consumption went down to a quart every 10 hours or so, but I had a problem with a sticking valve and had to use that Lycoming oil additive. Then I switched to Bel-Ray synthetic at about 1,900 hours.

After 150 hours on the Bel-Ray, I think it's unbelievably good. My oil use has declined to zero—literally not a drop. (Forty hours since the last change, and the dipstick still shows full.) Compression is excellent; my worst cylinder is 76/80. Oil pressure is higher, oil temp is lower. CHT is lower. Not bad for a 22-year old engine. I'm shooting for 3,000 hours before overhaul.

Austin Cole
Evanston, Ill.

higher prices may be moot because of longer oil-change intervals. (See the box nearby for a discussion of extended drain intervals.) Based on our research and lab tests, we'd have to rate Bel-Ray and Amsoil (in that order) as clearly superior to other aircraft oils.

But just how good does an oil have to be? It's hard to tell a pilot whose engine has given him 1,500 smooth, trouble-free hours on mineral oil that he's using an inferior product, that he should switch to a synthetic oil. What does he have to gain? His engine will simply continue to run smoothly and trouble-free, as it always has.

That's what makes choosing an oil such an exer[illegible]e of faith. Like taking vitami[illegible] r giving up cigarettes, switching to synthetic oil has benefits that are very long-term and may be more statistical than tangible. You've got to *believe* you're doing the right thing.

On the other hand, the downside of switching oils can be immediate and disastrous. Just ask the Twin Comanche owner who switched to Amsoil. We would imagine that gentleman is a firm adherent to the philosophy "If it ain't broke, don't fix it."

The dilemma is well illustrated by the debate currently going on in our editorial offices. Should we switch the company Mooney 201 from Aeroshell 15W-50 to Bel-Ray synthetic? The Mooney has hummed like a top ever since we've owned it, and oil consumption is very low, a quart every 10 or 15 hours. It starts great in cold weather. Yet our lab tests show pretty conclusively that Bel-Ray is a superior lubricant in almost every way.

The editor who votes "Aye" is the one who watched test bearings seize up in Aeroshell 15W-50 at less than half the load under which the same bearings kept rolling in Bel-Ray. The editor who says "Nay!" is the one whose budget will pay the $8.85 per quart and underwrite the cost of any oil-related engine problem, no matter slim the chances.

We'll let you know how it comes out.

Dave Noland