BLACKSTONE LABORATORIES

The Oil Report
July 2017

Oil the News That's Fit to Print!

Our return labels are now pre-paid!
That's right: We are paying the postage for you to send your samples back to Blackstone. Why? Well, we wanted to increase our "awesome" level to a 10 (and also eliminate some problems with the post office accepting samples). If you jot down the tracking number before you send it off, you'll know when it arrives!

Heading to Oshkosh this year? So are we!
Stop by and see us in Hangar B, Booth #2142,
and we'll be happy to talk about your latest oil reports!

A *Brand* New Perspective

Digging Into the Timeless Question, "Which Oil is Better?"

by Travis Heffelfinger

I was talking to a customer recently, going over the results from his latest oil report, and the conversation went a little something like this:

Him: "So, I'm using Aeroshell W100 in this engine… is that the best choice?"
Me: "Well, it seems to be doing a good job. You'd probably get good results with whatever oil you used, but this is working fine."
Him: "Would I be better off if I switched to a multi-vis? My mechanic wants me to use Aeroshell 15W/50."
Me: "Well… you could, of course, but I wouldn't expect much change in engine wear. We find that the type of oil typically doesn't matter when it comes to wear metals."
Him: "What about Phillips XC? I've heard that's the best oil out there."
Me: "That's a good brand as well. We just don't tend to see much difference in wear metals between different oil types, so whichever one you want to use is fine."
Him: "Okay, but what about Exxon Elite? My buddy uses that, and he says it's good stuff."
Me: [sigh…]

This discussion went on for a while. And I know I'm not the only analyst who's had a similar conversation.

There are several different types of oil to choose from... but does it make a difference in how your aircraft's engine is wearing?

By far, the most common question we get is, "Which oil should I use?" Mostly we get that from our automotive customers, but it applies to aircraft as well. Should you use a straight-weight oil or a multi-viscosity oil? Does the brand matter? There have got to be some differences from one oil to another, right?

Well, of course there are. Different brands have different levels of additives, start from different base stocks, and undergo different manufacturing processes, making some types of oil a lot more expensive than others. But the real question is, do those differences have a meaningful effect on how your engine is wearing?

We've got the data. What does it say?

From time to time, we'll get a sample from an engine with a long history of steady wear trends using, say Phillips XC 20W/50, and for whatever reason, the owner suddenly decides to switch it over to a different type of oil, such as Aeroshell W100 Plus. In those cases, we look extra closely to see if there are any changes in wear, and in most cases, there aren't.

To really put this question to rest, though, we need to look beyond individual oil samples and see how the different oil types affect lots of engines of the same type. This way, we can factor out any differences due to how an individual engine is used or maintained, so that oil type is the only variable.

When you send in a sample from your aircraft, we give you a set of Universal Averages, which we use for this exact purpose. The Universal Averages show typical wear levels from all the samples we've seen from a specific type of engine (not counting those going through wear-in or with other obvious issues). For example, shown at left are universal averages for the Continental IO-550-N, which is the most populous aircraft in our database. The average oil change interval is around 40 hours.

Fig. 1 - Universal Averages for Continental IO-550-N After ~40 hours of oil use.

Element	Universal Average
Aluminum	7
Chromium	8
Iron	49
Copper	6
Lead	5778
Tin	1
Molybdenum	3
Nickel	11
Calcium	35
Phosphorus	483
Zinc	7

The top section of elements shows the average levels of wear metals (aluminum, chromium, iron, copper, tin, and nickel) as well as lead, from fuel blow-by, and molybdenum, which is a piston coating in some engines. These are the elements that we're typically looking at the most in an oil analysis, because this is where we'll see signs of mechanical problems developing in the engine. The other elements (calcium, phosphorus, and zinc) are additives, and we'll get into more detail about those later.

These averages aren't separated by oil type, because typically, we expect each engine to produce similar levels of wear, regardless of the type of oil used. We prefer to have all those samples in one big average file, rather than a lot of smaller average files separated by oil type. So the first step was to create a new set of averages for each oil type, with the five most popular oil types shown in Fig. 2.

Fig. 2 - Continental IO-550-N Averages, Separated by Oil Type

	Universal Averages	Phillips XC (A/C) 20W/50	Aeroshell W100	Aeroshell 15W/50	Exxon Elite 20W/50	Aeroshell W100 Plus
Count	3386	966	850	778	280	254
Hours	39	40	39	40	37	37
Al	7	7	7	9	9	6
Cr	8	9	7	8	9	7
Fe	49	53	46	52	45	39
Cu	6	5	5	9	8	5
Pb	5778	6006	5226	6218	6239	5413
Sn	1	1	1	2	1	1
Mo	3	4	3	3	3	3
Ni	11	11	11	11	11	10
Ca	35	48	45	14	21	36
P	483	141	226	956	943	834
Zn	7	5	6	8	9	7

You can see that, for the most part, there's not a lot of variation in metals between each oil type. You can expect about 6-9 ppm of aluminum and 7-9 ppm of chromium, for example, regardless of the oil type you choose. These readings are based on engines with steel cylinders, of course. We try not to include engines with chrome or nickel cylinders in the universal average file, so that they don't skew the results with extra chromium or nickel.

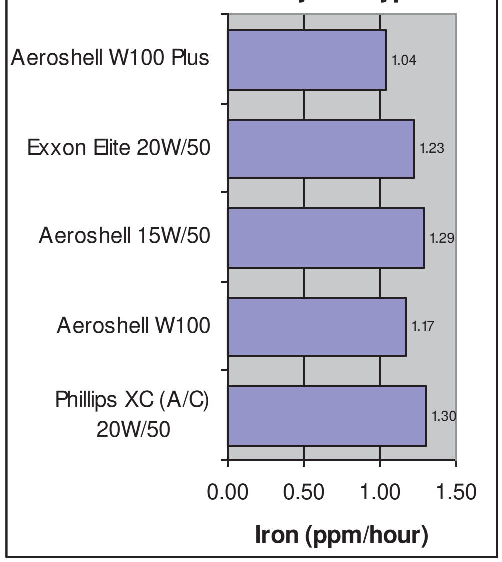
The main difference between the oil types is the level of phosphorus present. Aeroshell 15W/50, Exxon Elite 20W/50, and Aeroshell W100 Plus all contain phosphorus as an additive in the oil itself, while Phillips XC 20W/50 and Aeroshell W100 don't use phosphorus (some phosphorus does show up in the averages, though, due to the use of aftermarket additives like CamGuard that contain phosphorus and calcium, as well as residual phosphorus left behind after someone switches from one oil type to another.

Certain engines require the use of an oil with phosphate, so if you've got a Lycoming O-320-H2AD or an O-360-E1A6D, for example, it's important to use one of the types of oil that contain phosphorus. In most other cases, though, that additive doesn't seem to have a lot of effect on wear; if it did, the oil types with the additive would have consistently lower wear than the others, and that's not the case based on this data.

Surprisingly, though, one type of oil did seem to have lower wear overall than any of the others. Aeroshell W100 Plus had the lowest level of each wear metal (tied, in some cases, but the best overall). It didn't have the lowest level of lead, from fuel blow-by, but on the face of it, it looks like Aeroshell W100 Plus might have outperformed all the others, on average. Is that the best oil? Not so fast – we need to dig a little deeper.

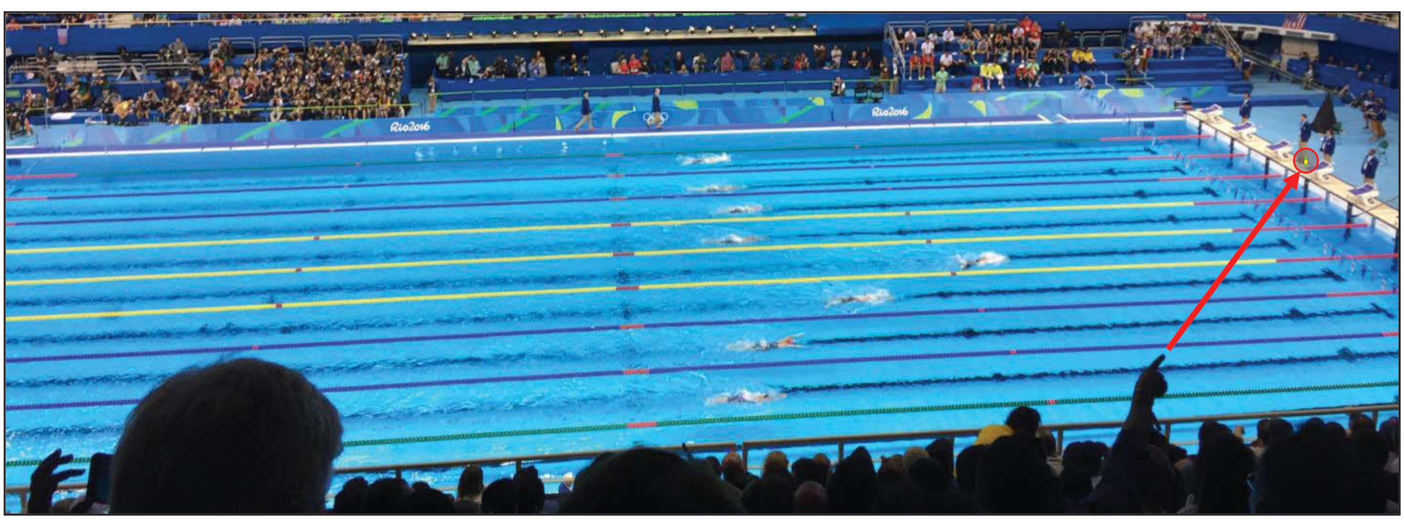
Since iron tends to track with oil use, it's good to look at the level of iron produced by the engine on a per-hour basis (shown in Figure 3). Aeroshell W100 Plus did have the lowest wear-rate, but the second-lowest was Aeroshell W100, not Exxon 20W/50, which had the lowest average iron level overall in Figure 2.

Fig. 3 - Continental IO-550-N, Iron Wear Rate by Oil Type



Based on these results, you might be tempted to think that straight-weight oils produce lower levels of wear than multi-viscosity oils, but we're not ready to jump to conclusions yet. This is just one type of engine, after all, so we need to look at other engine types and see if there's a pattern. Even if there is, there might be some other explanation. Perhaps people tend to use straight-weight oils in nicer weather, for example, or other conditions that would naturally lead to lower wear.

More importantly, though, it's worth noting that the highest wear-rate was only 1.30 ppm/hour (from Phillips XC 20W/50). That's a difference of just 0.26 ppm per hour from the Aeroshell W100 Plus wear-rate, which is almost negligible. To put that in perspective, an Olympic-sized swimming pool holds about 660,000 gallons of water. One part per million of that volume is a little more than two liters, so a quarter of a part per million would be like pouring a 20-ounce bottle of Sprite into the pool, and it makes about as much impact on your engine; if you know it's there, it may bother you, but realistically, you'll never notice the difference.



How much is a part per million? We drew a 2-liter-sized bottle in this picture from the Rio Olympics, next to the Lane 3 judge. It's barely visible in this picture, even with the guy a few rows in front of you pointing right to it. You could pour this bottle into the pool, and not even Michael Phelps would know it unless he actually saw you do it!

One part per million of the area of this page is about the size of the red dot inside this circle.

Still, the Aeroshell W100 Plus might seem like the best choice, at least for the Continental IO-550-N, so let's take a look at another popular engine and see if the same pattern holds.

Shown at right (Fig. 4) are the separated averages for the same five oils used in the Lycoming O-360-A4M engine, the second-most populous aircraft engine in our database. Once again the wear levels are very similar across the board, but it turns out that Aeroshell W100 Plus once again has the lowest iron level of the five different oil types. It didn't have the lowest copper, in this case (that honor goes to Phillips XC 20W/50), but W100 Plus at least tied for the lowest reading at all the other wear metals.

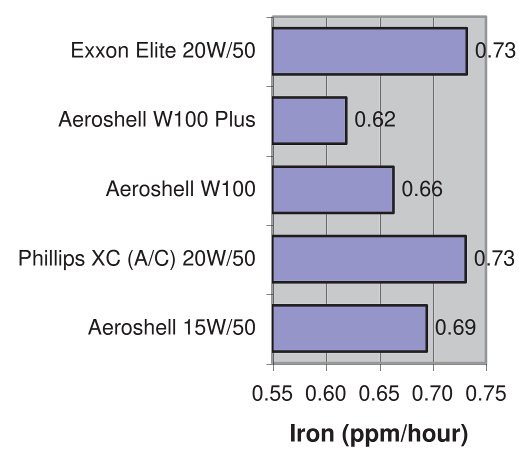
Fig. 4 - Lycoming O-360-A4M Averages, Separated by Oil Type

	Universal Averages	Aeroshell 15W/50	Phillips XC (A/C) 20W/50	Aeroshell W100	Aeroshell W100 Plus	Exxon Elite 20W/50
Count	3047	1081	589	515	336	248
Hours	39	38	40	41	37	37
Al	5	6	5	5	5	6
Cr	4	4	5	4	4	4
Fe	27	26	29	27	23	27
Cu	6	9	4	5	5	5
Pb	4159	3944	4633	4262	3944	4393
Sn	1	1	1	1	1	1
Mo	0	0	1	0	0	0
Ni	2	2	2	2	2	2
Ca	15	10	30	8	19	15
P	675	1061	106	277	997	990
Zn	8	10	6	4	9	9

Speaking of copper, it's worth pointing out that Aeroshell 15W/50 produced 9 ppm of copper in this engine, while all the other oil types produced only 4-5 ppm. That's not a wear problem, though – there's a harmless chemical reaction that occurs between Aeroshell 15W/50 and certain compounds used in Lycoming's nitriding process, and the result is a high copper reading in the oil. It's not harmful, so it's fine to use Aeroshell 15W/50 in Lycoming engines (note that we've seen almost twice as many samples of that oil type in this engine as we have from any of the other oil type), but if you're trying to track down a problem with brass/bronze parts, using a different oil will help us get a clean copper reading.

Anyway, back to iron. Aeroshell W100 Plus once again produced the lowest level of iron, and it had the lowest wear-rate as well, shown in the bar graph in Fig. 5. The differences here are even smaller (only 0.11 ppm per hour difference between the lowest and highest readings), so while the W100 Plus did have a slight edge, it's even less of a significant difference here than it was for the first engine we looked at.

Fig. 5 - Lycoming O-360-A4M Iron Wear Rate, Sep. by Oil Type

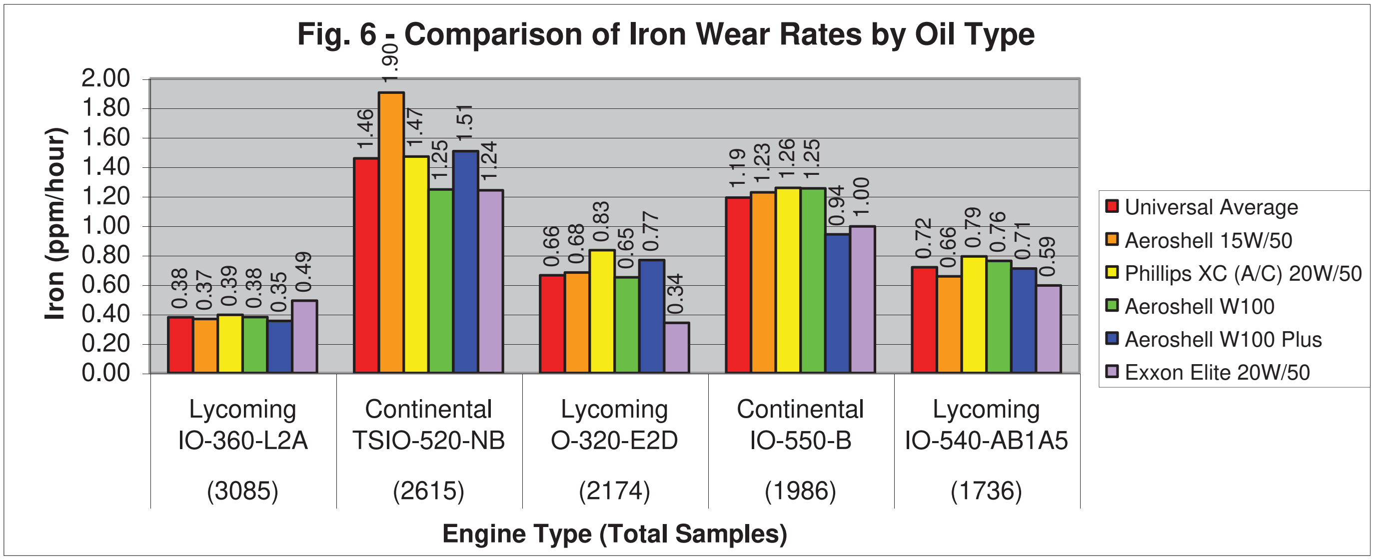


Update: Running the eBay Oils In My Truck

Back in April 2012, I wrote an article about buying old cans of oil off of e-Bay and testing them out. At the end of the article, I mentioned that I was actually going to run some of that oil in my truck. There was a follow up article to that in October 2013 as well, where I talked about running more of the e-Bay oils after I changed out the first batch. Well, I'm happy to say my classic GM 350 is still running.

Of course, I have noticed the engine is starting to smoke a bit on start-up. It also has some morning sickness which I suspect is due to sticking valves, though I have to say it was kind of like that after the initial rebuild (see the July 2010 newsletter). Still, the truck does start and once it gets going, it runs fine. I hauled about 20 loads of wood with it during the summer of 2015 without a problem at all. So is the smoke on start-up due to using the e-Bay oil? I really can't say, but I doubt those oils helped anything. I guess the best conclusion I can draw here is, don't run oils you buy off of e-Bay! There you have it, words of wisdom from the oil gurus.

~ Ryan Stark



Still, that's two for two showing that Aeroshell W100 Plus has lower wear, on average. That's not the result we expected going in, but hey, if that's where the numbers take us, we won't argue with the data. Still, we need more examples before we draw any definite conclusions. We dialed up the next five most populous engines in our database, and generated averages for the same five oil types we've looked at so far.

Since this article is getting pretty long already, we'll dispense with showing you the full charts… suffice it to say that most of the metals showed no significant variation from oil type to oil type (except for the high copper in Lycomings using Aeroshell 15W/50, of course), so we're just going to focus on iron to wrap this up.

In Fig. 6, we're looking at the iron wear rates for five different engines: The Lycoming IO-360-L2A, the Continental TSIO-520-NB, the Lycoming O-320-E2D, the Continental IO-550-B, and the Lycoming IO-540-AB1A5. The universal average wear rate is shown by the red bar, and the average wear rate for each of the five oil types are shown by the other colors. One interesting thing to note about having the data displayed this way is that, in general, the iron levels from each engine type are more similar to each other than they are to the same oil type from different engines. In other words, engine type is a much bigger factor than oil brand.

The IO-360-L2A, for instance, is a notoriously low-wearing engine… we consistently see single-digit wear from this type of engine even after 50 hours of oil use or more. The TSIO-520-NB, on the other hand, typically produces a lot more wear, partly because it's a larger, turbocharged engine with six cylinders as compared to the IO-360's four cylinders – larger engines with more moving parts tend to produce higher wear levels overall.

We're specifically interested in the levels of iron for Aeroshell W100 Plus, though… that's the dark blue bar in the chart above. Aeroshell W100 Plus did give the lowest level of iron for the IO-360-L2A and the Continental IO-550-B, but it was actually the second-highest in the Continental TSIO-520-NB and the Lycoming O-320-E2D. For the Lycoming IO-540-AB1A5, it was right in the middle of the pack. Exxon Elite had the lowest levels of wear in three of these engines, but the highest in one of the others, so there's no consistent pattern that holds true for every oil.

So what does all of this tell us?

Well, we're no closer to saying that one type of oil is better than another, that's for sure. We see much more variation in wear levels from the type of engine, the time on the oil, the use the engine sees, etc. Of the seven engines we've looked at in this article, no single oil had the highest or lowest level of any metal in all cases, and it's also very important to remember that the numbers shown here are just averages – individual samples may have had readings significantly higher or lower than average, so individual trends are very important.

After looking at the first couple of engine types, it was starting to look like Aeroshell W100 Plus might lead the pack, but we did this to illustrate the danger in drawing conclusions based on just a couple of data points – the more engines we looked at, the clearer it became that there was no overall pattern. That's why we're pretty confident in saying that, in general, it doesn't matter what oil you use, as long as you're following the manufacturer's recommendations. If you want to try something different, feel free to give it a shot! We'll track the trends and let you know if it's making any difference in your particular engine.

Report of the Month

Whoa, daddy. That's a lot of metal. Can you tell what's going on with this O-300-D?

To learn more about where the elements are coming from, click here.

ELEMENTS IN PARTS PER MILLION		UNIT/ LOCATION AVERAGES					UNIVERSAL AVERAGES
MI/HR on Oil	25		28	27	32	34	
MI/HR on Unit	149		98	38	1724	1689	
Sample Date	6/11/2016		6/20/2015	5/10/2014	5/29/2013	10/16/2012	
ALUMINUM	192	7	29	26	10	6	8
CHROME	11	11	11	3	15	10	5
IRON	124	34	87	77	43	39	39
COPPER	21	10	21	48	14	11	10
LEAD	3379	2620	2902	1697	4069	3099	2185
TIN	4	1	3	4	2	1	1
MOLYBDENUM	9	2	5	4	3	2	1
NICKEL	6	1	3	2	2	1	1
POTASSIUM	2	1	0	9	0	0	1
BORON	0	0	1	1	1	1	1
SILICON	46	6	28	42	9	2	7
SODIUM	2	1	2	2	1	1	1
CALCIUM	6	4	7	2	7	2	13
MAGNESIUM	7	2	4	4	2	2	8
PHOSPHORUS	2	3	4	0	0	0	361
ZINC	2	2	3	3	3	1	5
BARIUM	0	0	0	0	0	0	0

PROPERTIES		Values Should Be*				
SUS Viscosity @210°F	91.6	86-105	96.3	77.1	90.7	94.1
cSt Viscosity @ 100°C	18.36	17.0-21.8	19.48	14.80	18.14	18.97
Flashpoint in °F	465	>430	465	525	485	520
Fuel %	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5
Antifreeze %	-	-	-	-	-	-
Water %	0.0	0.1	0.0	0.0	0.0	0.0
Insolubles %	0.5	<0.6	0.3	0.4	0.4	0.4
TBN						

We had given the owner of this Cessna a phone call when we found so much metal in his oil, so he and his mechanic did some investigative work. The borescope came up clean in all cylinders with no problems found, but one cylinder had low compression..."almost zero," he said. When they pulled the cylinders off, chunks of metal literally fell out of the cylinder and into his hand. The second ring had completely broken, and that actualy detroyed the ring land between the second and third ring. The pieces of the broken ring itself were still in the cylinder, but the aluminum from the ring land was small enough to escape. They cut the fitler open (which they hadn't done prior to sending us the sample) and found many large pieces of aluminum throughout the filter, which corresponds with the large spike in aluminum in analysis. The elevated chrome is from the rings. The owner said that without our analysis, he never would have known anything was wrong, since on a six-cylinder engine he wasn't noticing a loss of power and there were no obvious problems apparent on his end (until the oil filter was cut open, anyway). The mechanic said the problem was caught early enough that they wouldn't have to replace the whole cylinder - just rehone and put in a new piston and rings - so we definitely saved him a few bucks this time around!