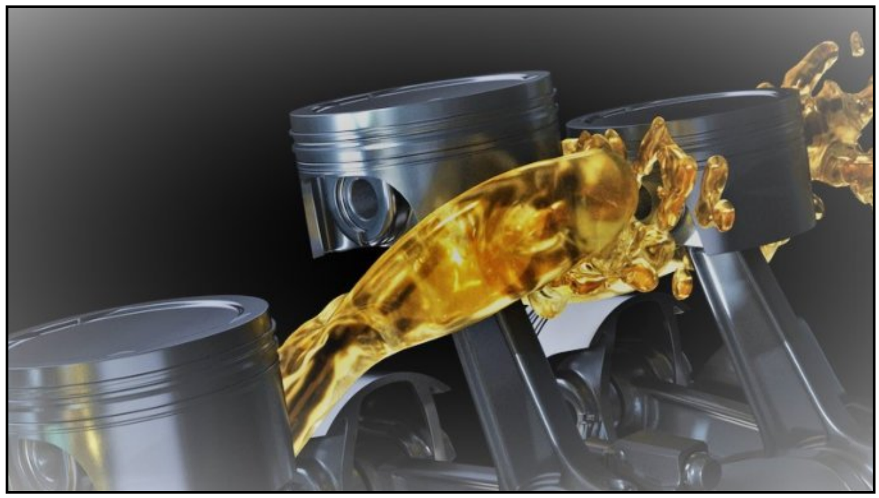
BLACKSTONE LABORATORIES

The Oil Report
August 2021

Oil the News that's Fit to Print!

All About Viscosity

by Jim Stark & Kristin Huff



Most of us have only a vague understanding of viscosity. We tend to choose an oil with a viscosity that we believe is correct for our particular engine, but would another viscosity improve or reduce the life of the engine? Can we pick and choose a viscosity outside the manufacturer's recommendations?

Technically, viscosity is defined as resistance to flow. Commonly, though, we think of it as an oil's thickness. To be more specific, it is the thickness of oil at a given temperature. The plot thickens (ha!).

The viscosity of an oil could be reported at any temperature, but to standardize things, most laboratories report either a low temp (100F or 40C) or a high temp (212F or 100C) and stick with either Fahrenheit or Celsius. At Blackstone we report the high-temp viscosity, which is generally the temperature the engine is at while it's running, and the temperature at which the oil spends most of its time. We can do the low-temp viscosity too, if you're interested, but the engine spends so little time running at the low-temp viscosity that it's not a useful test for most people.

An apple is an apple, no matter what language you use to describe it. In the same respect, there are many ways to describe viscosity: engines use the SAE engine chart, industrial equipment mostly uses the ISO chart, gear oils use the SAE gear chart, etc. (Download your own viscosity chart here.) No matter what you call it, the number given defines the thickness of the oil at the standard high temperature.

Multi-Grades Explained

Engine oil can be either straight weight or a multi-grade viscosity. A major difference between the two is simply the addition of a VI additive, which allows the oil to maintain more or less the same flow rate regardless of its operating environment. Think of the difference between honey and water. Cold honey flows very slowly, but if you put it in the microwave and heat it up, it will flow much more easily. Water, on the other hand, flows at pretty much the same rate whether it's hot or cold. That's because water has a very narrow viscosity range, whereas honey's is much wider. When it comes to engine oil, it naturally has a wide viscosity range, like honey, flowing slowly when it's cold and faster when it's hot. But we want it to act like it has a narrow viscosity range, like water, maintaining a fairly consistent flow rate regardless of whether the oil is cold or warm. That's where viscosity improvers enter the picture. The VI additives in multi-grade oil help it move more easily through a cold engine upon start-up, but still provide cushion and lubrication when it's hot.

Straight Weight vs Multi-Grade

Originally, all oils were straight weights. Relatively few straight weights are manufactured today, since most gas- or diesel-engine manufacturers recommend multi-grades. The aircraft world is one area where straight-weights are more common (marine engines also use straight-weights somewhat often). There is nothing wrong with using a straight weight. At operating temperature, a straight-weight performs just as well as a multi-viscosity oil. It's just a simpler form of oil.

Could an aircraft engine use a thinner oil? Sure. We've seen many samples of nicely wearing engines on W65 oil (which is a 30W oil). That oil has been discontinued, but you can still get W80 oil, which is a 40W. Mostly, we suspect, engine manufacturers call for thick oil because they already know it works and see no reason to change.

There are various schools of thought on whether to use a straight-weight or a multi-grade oil. Look online and you can find strict adherents to both types. Some people swear by a straight-weight. Some will only use a certain multi-grade. Some switch back and forth, using a straight weight in the winter and a multi-grade in the summer. We have not found that the data supports either school of thought. So much of how an engine wears depends on your engine, how you fly, and how often you fly that the viscosity of the oil (all of which end up at about the same thickness when the oil is at operating temp) doesn't make much difference in wear. One thing we can tell you is that if you're trying to decide what to use, it's fine to play around with oils and try different types to see what suits your engine best.

Changes in Viscosity

Lots of things can affect the viscosity. Adding anything foreign to your oil can change its viscosity -- some types of non-aircraft aftermarket additives cause a high viscosity, and some solvent-type additives (like engine cleaners) can cause the viscosity to thin out. Contamination can change a viscosity, while exposure to excessive heat (leaving the oil in place too long, engine overheating) can increase the viscosity of the oil.

When your oil's viscosity comes back as either lower or higher than the "Should Be" range, something is causing it. The key is to find out why and repair your engine or adjust your flying habits accordingly to correct the viscosity and optimize your engine's efficiency. Because all engines and pilots are different, there is no one best answer for everyone. Test your oil while figuring out what to use. Your wear metals don't lie!

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Report of the Month

This was a weird sample from a TIO-540 engine.
Can you guess what happened?

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

UNIT

MAKE/MODEL:	Lycoming TIO-540-AJ1A	OIL TYPE & GRADE:	Aircraft Engine Oil
FUEL TYPE:	Gasoline (Leaded)	OIL USE INTERVAL:	Hours
ADDITIONAL INFO:	Cessna T206H		

COMMENTS

Overall, these numbers relate quite well to what we've been seeing from this engine over the last year or so. The biggest change that stands out is at elements like moly, calcium, magnesium, and zinc, which together can show that regular automotive oil was added before at the last oil change. Internal wear still looks okay, with aluminum (from pistons) even coming down a little. Still, we'd suggest sticking to only using ashless dispersant oils that are approved for aviation use. No fuel or water contamination was found. Check back for an update.

ELEMENTS IN PARTS PER MILLION

		UNIT / LOCATION AVERAGES						UNIVERSAL AVERAGES
MI/HR on Oil			37	8	32	35	14	
MI/HR on Unit			1,542	1,514	1,506	1,439	1,366	
Sample Date	7/5/2021		2/28/2021	11/1/2020	6/26/2020	4/1/2020	9/19/2019	
Make Up Oil Added					2 qts	1 qt		
ALUMINUM	**15**	20	**19**	**15**	**21**	**29**	**19**	7
CHROMIUM	9	17	11	11	**20**	**29**	**21**	10
IRON	69	84	69	58	110	133	**65**	59
COPPER	11	11	13	9	16	14	4	10
LEAD	3642	4525	4645	3311	6034	5838	3678	5080
TIN	2	1	1	1	0	2	1	1
MOLYBDENUM	**39**	7	0	0	0	0	0	0
NICKEL	6	11	8	8	**14**	**22**	5	7
MANGANESE	1	1	1	1	1	1	1	1
SILVER	0	0	0	0	0	0	0	0
TITANIUM	0	0	0	0	0	0	0	0
POTASSIUM	0	0	0	0	0	0	0	0
BORON	**85**	14	1	0	0	0	0	1
SILICON	6	7	5	5	7	7	12	9
SODIUM	2	2	2	2	2	2	0	1
CALCIUM	**542**	160	99	108	112	89	7	23
MAGNESIUM	**279**	49	4	2	3	3	1	3
PHOSPHORUS	**446**	118	64	90	58	50	0	455
ZINC	**458**	83	11	6	8	9	3	6
BARIUM	0	0	0	0	0	0	0	0

PROPERTIES

		Values Should Be*					
SUS Viscosity @ 210°F	87.0		94.8	94.3	**106.9**	**106.5**	94.6
cSt Viscosity @ 100°C	17.25		19.13	19.01	**21.96**	**21.87**	19.08
Flashpoint in °F	515	>440	510	500	505	495	465
Fuel %	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5
Antifreeze %	-		-	-	-	-	-
Water %	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insolubles %	0.4	<0.6	0.3	0.3	0.4	0.4	0.4
TBN							
TAN							
ISO Code							

* THIS COLUMN APPLIES ONLY TO THE CURRENT SAMPLE

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If you read the comments, this was an easy one. We noted higher levels of moly, boron, calcium, magnesium, phosphorus, and zinc in the oil - typical additives in non-AD oil, like the oil you use in your car. The owner didn't add 5W/30 to his aircraft engine, but he did add it to the sample, thinking it needed to be diluted since it came from the filter. No harm done since he only added it to the sample, not the engine itself.

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Report of the Month

This Wright R-1820 radial has a problem. It's not obvious at all. Can you figure it out?

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

UNIT

MAKE/MODEL:	Wright R-1820-86B	OIL TYPE & GRADE:	Aeroshell W120 (AD)
FUEL TYPE:	Gasoline (Leaded)	OIL USE INTERVAL:	32 Hours
ADDITIONAL INFO:	North American T28B; BL-519096, oil screen and spin-on AirWolf filter		

COMMENTS

CHIP: This report looks a lot like the last one, though that's not necessarily a positive finding considering this oil run was about half as long as the previous sample. Metals holding steady over a shorter run actually means wear is higher on a per-hour basis. That being said, these results beat outright increases, and metals still compare nicely with averages for the engine type. We'll continue tracking silver (master rod bearing) and aluminum/iron (pistons/steel parts) in the next sample, but at this point no major issues stand out.

ELEMENTS IN PARTS PER MILLION

		UNIT / LOCATION AVERAGES						UNIVERSAL AVERAGES
MI/HR on Oil	32		63	50	50	53	55	
MI/HR on Unit	803		771	708	658	608	555	
Sample Date	1/4/2021		10/22/2020	11/19/2019	7/9/2019	11/10/2018	7/2/2018	
Make Up Oil Added	84 qts		128 qts	109 qts	120 qts	140 qts	145 qts	
ALUMINUM	5	5	6	3	3	2	2	5
CHROMIUM	1	2	2	1	1	1	1	2
IRON	10	17	10	8	7	6	5	15
COPPER	5	7	7	5	6	3	4	7
LEAD	1213	1556	1715	1227	1397	1151	1039	1245
TIN	0	1	1	1	0	0	1	1
MOLYBDENUM	0	0	0	0	0	0	0	0
NICKEL	2	2	2	2	1	1	1	2
MANGANESE	0	0	0	0	1	0	0	0
SILVER	1	0	1	0	0	0	0	0
TITANIUM	0	0	0	0	0	0	0	0
POTASSIUM	0	1	0	0	1	0	0	1
BORON	0	1	0	0	1	0	0	0
SILICON	7	8	10	10	11	7	11	8
SODIUM	2	1	3	1	2	1	2	1
CALCIUM	4	3	3	3	5	3	4	4
MAGNESIUM	4	5	4	5	5	2	3	4
PHOSPHORUS	4	5	3	4	4	6	8	4
ZINC	2	2	2	2	3	2	2	2
BARIUM	0	0	0	0	0	0	0	0

PROPERTIES

		Values Should Be*					
SUS Viscosity @ 210°F	110.6	105-125	119.5	112.7	116.3	109.8	113.5
cSt Viscosity @ 100°C	22.83	21.5-26.3	24.86	23.29	24.12	22.64	23.48
Flashpoint in °F	510	>450	525	500	500	495	500
Fuel %	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5
Antifreeze %	-		-	-	-	-	-
Water %	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insolubles %	0.2	<0.6	0.4	0.4	0.2	0.3	0.5
TBN							
TAN							
ISO Code							

The answer to this one is hidden in the comments. We briefly mentioned the 1 ppm silver and said, "no major issues stand out." But silver is a master rod bearing metal in radial engines, and because radials use so much oil, all the metal levels are diluted. When the owners saw the 1 ppm silver, they checked the filter and found small, visible silver flakes. Upon analysis, the flakes were found to be from the rod bearings. As a result, the owners ended up replacing the engine. They write: "That sample may have prevented and engine failure and/or subsequent loss of aircraft or life. We are firm believers in your process and company."