The Oil Report
March 2013
Oil the News that's Fit to Print!

We will be at Oshkosh this year! Billed as "The World's Greatest Aviation Celebration," Oshkosh is North America's largest airshow. It takes place the last week of July in Oshkosh, Wisconsin, and it's definitely worth seeing if you've never been there. We will have a booth in Hangar A, so if you are in the area, stop by and say hi!

The Acidity Question

by Ryan Stark

Every now and then you hear about oil becoming acidic and causing internal corrosion in an aircraft engine. Usually that goes along with the oil absorbing water and then forming acids, but I've always disagreed with this statement. It's a well-known fact that corrosion is a problem for a lot of aircraft engines that don't see much use, but is it really acidic oil that's causing the corrosion, or simply bare metal parts being exposed to the atmosphere? So I decided to run some testing to see what I could find about acidity and aircraft oils.

Now, think back to high school chemistry. Remember learning about acids and bases? Normally with something like water, you measure the pH to determine how acidic or basic a liquid might be. A pH of 7 is neutral, lower than 7 is acidic, while higher than 7 is basic. The problem with oil is, you can't run a pH on it directly. So instead, we have the Total Base Number (TBN) and Total Acid Number (TAN) tests. These are fairly simple tests and the basic principle is this. After you mix a measured amount of oil with some chemicals, you can run a pH on those chemicals. But that doesn't equate to the TBN or TAN. To get the TBN you add hydrochloric acid to the chemical mixture until it reaches a pH of 3. To get the TAN, you add a base to the mixture (in this case, potassium hydroxide) until the pH reaches 11. (You might wonder why we don't just report the pH of the chemical mixture and have that be the end of it, and the answer to that is unknown, at least to me.)

The TBN test

The TBN test is commonly done on automotive oils, but not aircraft oil. That's because the TBN always reads 0 or close to it with aircraft oil. Automotive oil has a lot of additive packed in there and that is what the TBN reading is based on. That additive makes the TBN increase. Oil salesmen use the TBN test to help sell their oil, with the idea being that the higher the TBN, the better the oil. But the TBN is really just a testament to how much additive the oil starts with, not necessarily how well the oil will work in any given engine. You might wonder why aircraft oil doesn't use the same additives? It's because the additives used in automotive oils aren't ashless. The additives present in all aircraft oils have to be ashless, meaning when the oil burns nothing is left. (This is why it's a bad idea to use anything other than aircraft oil in your aircraft engine.)

The TAN test

The TAN test is commonly done on industrial oil like hydraulic fluid. There is a theory that when oil becomes acidic it will accelerate wear and cause all kinds of problems, but that's just a theory--and a pretty weak one in my book. When most people think of acid, they might think of something like acid reflux and heartburn. Or maybe sulfuric acid burning a hole in their clothes, but that gives acids a bad rap. If it weren't for acid, your food wouldn't get digested and we'd be without a lot of very important chemical compounds. What's more, there is no known correlation between acidic oil and higher wear. It is commonly talked about that water in oil will cause it to become acidic, and maybe it will if the water has something to react to. But with aircraft oil, it doesn't. The additives present aren't sulfur-based like they are with automotive oils, so when water gets into oil, it usually just stays there until the oil gets hot enough to cook it back out.

Testing the theory

So for this newsletter article, I decided to run some TAN tests on various aircraft oils and see what showed up. Virgin aircraft oils usually have a TAN in the range of 0.4 to 0.8. It's important to know where the TAN starts out, so you know how acidic the oil has become after use. (You'd think that oil starts out with a TAN of 0.0, but usually it does not.)

For the used oil data, we tested the TAN on 63 random aircraft samples, and the average TAN reading for those samples was 1.3. That might seem like a fairly large increase, but in the oil analysis world, 1.3 is considered a low acidity reading for any type of system. A reading of 3.0 shows some acidity and anything over 4.0 can be considered fairly acidic. The highest TAN reading we found was 2.3, but in our testing any readings over 2.0 were rare. In fact, only three samples read higher than 2.0 and none of those had water present, but two were considered inactive. Five of the samples we tested did have a trace of water present, but their average TAN was just 1.1, so we didn't find any correlation between water and a high TAN.

So how about inactive engines? Two samples that were inactive did have a TAN of over 2.0, but they were the exception, not the rule. We had 11 samples in our test run that were considered inactive, but the average TAN of those was just 1.2.

Based on this testing, it doesn't look like oil acidity is really a factor at all. Does that mean you shouldn't worry about inactivity? No--we've seen too many examples of poor wear from inactive engines to say that's not a problem. What it does mean is that in our opinion you don't need to worry about your oil being acidic. And in life, one less thing to worry about is a good thing!

Acidity of 63 aircraft samples, arranged by TAN from lowest to highest

Lab #	Water?	Hours	Inactive?	Oil	Engine	TAN
F42364	Yes	40	No	W100+	IO-360	0.6
F42365	No	12	Yes	W80	IO-540	0.7
F41463	No	25	No	XC	IO-550	0.7
F41678	Yes	?	?	XC	IO-320	0.7
F40914	No	34	Yes	W100 M	IO-540	0.8
F40919	No	18	Yes	W120	R-1820	0.8
F41456	No	20	Yes	XC	IO-360	0.8
F42366	No	12	Yes	W80	IO-540	0.8
F41089	No	29	No	XC	O-540	0.8
F40882	No	45	Yes	W100	IO-360	0.9
F41348	No	37	No	W100+	IO-360	0.9
F41458	No	7	No	XC	O-470	0.9
F40925	No	20	?	?	C-85	0.9
F41350	No	33	No	?	TIO-540	1.0
F41093	No	23	No	XC	O-360	1.0
F40923	No	64	No	XC	O-320	1.0
F41459	No	25	No	XC	IO-470	1.0
F41091	No	49	No	XC	IO-540	1.1
F40917	No	25	No	W80	O-360	1.1
F40922	No	48	No	XC	O-320	1.1
F40884	No	60	No	W100	IO-360	1.1
F40889	No	30	No	XC	TSIO-520	1.1
F41460	No	25	No	XC	IO-470	1.1
F41461	No	41	No	W00+	O-320	1.1
F41462	No	30	No	XC	IO-550	1.1
F40883	No	14	Yes	?	TO-360	1.2
F41097	No	8	No	W100	O-320	1.2
F40918	No	52	No	XC	IO-470	1.2
F40890	No	30	No	XC	TSIO-520	1.2
F41457	No	48	No	W100	IO-520	1.2
F41466	No	39	No	W100 M	TSIO-520	1.2
F41680	Yes	46	Yes	15W/50	O-540	1.3
F41347	No	27	No	15W/50	IO-550	1.3
F41351	No	69	No	W100	TSIO-520	1.3
F41090	No	32	No	15W/50	O-320	1.3
F40915	No	32	No	W80	TSIO-520	1.3
F40921	No	35	No	XC	O-360	1.3
F40888	Yes	27	No	15W/50	TSIO-520	1.4
F41349	No	48	No	15W/50	O-360	1.4
F41353	No	50	No	W100	IO-550	1.4
F41355	No	28	No	W80	IO-520	1.4
F40885	No	29	No	15W/50	TSIO-520	1.4
F40886	No	29	No	15W/50	TSIO-520	1.4
F40887	No	27	No	15W/50	TSIO-520	1.4
F41464	No	32	No	XC	IO-550	1.4
F41099	No	24	Yes	15W/50	O-360	1.5
F41352	No	69	No	W100	TSIO-520	1.5
F41354	No	50	No	W100	IO-550	1.5
F41094	No	?	No	Exxon	IO-360	1.5
F40916	No	33	No	Exxon	O-470	1.5
F40920	No	64	No	15W/50	TIO-540	1.5
F41095	No	23	No	W100	TSIO-550	1.6
F41100	No	19	No	15W/50	IO-550	1.6
F40924	No	31	No	15W/50	IO-550	1.6
F41465	No	24	No	15W/50	TSIO-520	1.6
F41739	Yes	42	No	15W/50	IO-550	1.7
F41356	No	28	No	W80	IO-520	1.7
F41098	No	37	No	15W/50	O-470	1.7
F41092	No	37	No	W100	TSIO-550	1.8
F41357	No	61	No	W100	TSIO-520	1.9
F41096	No	70	Yes	15W/50	IO-550	2.1
F40926	No	20	Yes	Exxon	O-360	2.1
F41358	No	61	No	W100	TSIO-520	2.3

Report of the Month

This O-320 was in an accident, then overhauled, then overhauled again. Can you figure out what was wrong?
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	26		22	12	30	22	
MI/HR on Unit	117		511	484	154	75	
Sample Date	09/13/11		06/28/11	11/20/10	09/18/10	05/15/10	
ALUMINUM	13	7	9	7	6	5	6
CHROME	47	31	22	7	66	37	5
IRON	49	65	42	32	42	32	39
COPPER	6	8	5	2	5	5	7
LEAD	3474	2854	2812	1132	4194	2804	1705
TIN	0	2	0	0	4	1	1
MOLYBDENUM	0	1	1	0	0	0	0
NICKEL	4	2	2	1	3	1	1
POTASSIUM	0	0	0	0	0	1	0
BORON	0	0	1	1	0	0	0
SILICON	10	10	14	7	5	7	6
SODIUM	4	3	1	1	1	2	1
CALCIUM	172	97	118	3	136	130	5
MAGNESIUM	3	2	3	0	2	2	1
PHOSPHORUS	213	88	117	7	96	111	580
ZINC	1	5	2	0	0	1	6
BARIUM	0	0	0	0	0	0	0

PROPERTIES		Values Should Be*				
SUS Viscosity @210°F	96.9	86-105	92.5	70.2	102.2	97.8
cSt Viscosity @ 100°C	19.62	17.0-21.8	18.58	13.01	20.87	19.85
Flashpoint in °F	465	>430	405	505	460	460
Fuel %	<0.5	<1.0	1.3	<0.5	<0.5	<0.5
Antifreeze %	-	-	-	-	-	-
Water %	0.0	0.0	0.0	0.0	0.0	0.0
Insolubles %	0.5	<0.6	0.5	0.5	0.4	0.4
TBN						
TAN						
ISO Code						

*THIS COLUMN APPLIES ONLY TO THE CURRENT SAMPLE

This engine was originally salvaged from an aircraft that crashed. After being installed in a new airframe, the engine seemed to run fine. The owner noted that SuperCubs tend to run hotter than you'd think, and before the first sample on this page, he was really having to work to keep CHTs below 400 degrees. Then came a prop strike, and after that the engine was torn down. Subsequent analysis revealed an alarming wear trend of increasing ring wear (see chrome in July and Sept. 2010). They took it *back* in, tore it down (we're up to around November 2010 now), then got it back in the air. It seemed to run well, but the trend of increasing chrome again alerted the owner that something was amiss. This time the rings didn't seat properly. Subsequently, the owner installed new rings, and the story finally ends happily.