BLACKSTONE LABORATORIES

The Oil Report
March 2024

Oil the News that's Fit to Print!

It's been a while since our last newsletter; we've been too busy to send one out! We spent all of January working Saturdays to catch up and our turnaround time has returned to normal. We apologize for being so behind!

Under Pressure: Part 2

An O-360, a stray paper towel, and a potential bearing problem

by Amanda Callahan

In Part 1 of this saga, our flying club's newly installed O-360 lost oil pressure in flight with a student pilot at the controls. After a fair amount of sweat and tears – but fortunately no blood – we found the engine had digested an errant paper towel, which was blocking the suction screen (see horrifying figure 1).

The hard part begins

Now that we knew the engine actually suffered a loss of oil pressure (it wasn't just the gauge) and the metal indicated in the filter analysis showed that some damage had been done, our next step was to figure how to proceed.

We consulted as many experts as we could and received suggestions ranging from "just go fly it" to "pull a cylinder and look for damage" to "overhaul it" and everything in between. The jury was out, and we had to decide whose suggestion to follow.

Lycoming has a convenient Service Bulletin about what to do if you find metal in the oil filter, so we started there. Service Bulletin 480F suggested, based on the amount and size of metal in the oil filter, that we remove the oil pan and check for metal. That seemed like a good idea; not only were we still troubleshooting mechanical wear, but also, we didn't know how much paper towel was still in the engine.

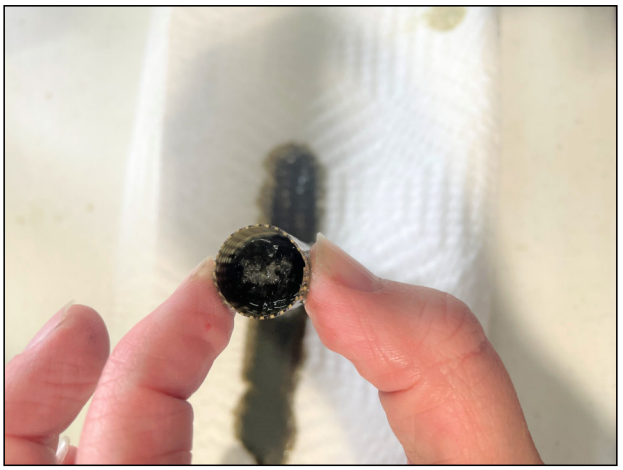

FIGURE 1: Suction screen and a paper towel: two things that do not play well together

It took two solid days of work to remove, inspect, clean, and reinstall the oil pan, which still had paper towel in it (see figure 2, next page). Once that was done, after finding no large pieces of metal in the sump and being sure there wasn't any leftover paper towel in the engine, we did a 30-minute ground run

FIGURE 2: The oil sump/pan, with paper towel lingering in it

then drained the oil, and cut the filter to check for metal, as per the Service Bulletin's instructions.

Intestinal fortitude

The oil analysis was unremarkable, but the oil filter report noted 10-15 non-ferrous metallic flakes per pleat with a few dozen larger pieces that had scrape marks on them (see figure 3). This filter was a little better than before, but certainly not clean. But this was only a 30-minute ground run compared to the 20-some hour sample. Were the improvements from the shorter oil change or an actual improvement? We didn't know.

Now, I've been an analyst at Blackstone for over a decade. I've helped countless customers diagnose their own engine issues and told people to go fly it and check back, but there isn't any amount of intestinal fortitude that prepares someone for the reality of experiencing a problem, diagnosing engine damage, and doing what you can to fix it, knowing that the next step is to go flying and see how it goes.

The two A&Ps on the field agreed that if we made it past the first 10 hours (*if*) without any oil pressure issues, then we should be fine. "But watch that oil pressure," they cautioned.

Going up

We took all the precautions we could: we went up in pairs (so one person could watch the oil pressure), we selected calm days, affording us four runway options for an emergency landing, and we stayed within glide distance of the airport for 10 long hours of circling the airport.

I am glad to say that those first 10 hours were uneventful. Oil pressure remained strong, the engine ran great, and we had no issues. With each hour that passed, our confidence grew, so we eagerly sent another oil and filter sample for analysis, hoping for hard data to bolster our confidence.

The oil analysis was unremarkable, but the filter – not great (figure 4, next page). Approximately 30 variously sized non-ferrous flakes were present per pleat, along with one piece of steel.

This wasn't what we were hoping for, but this oil run was 10 hours long as opposed to the previous 30-minute ground-run sample. There was bound to be more metal, right? Regardless, there was still more metal after 10 hours than there was in our previous 50-hour samples, so we weren't in the clear yet.

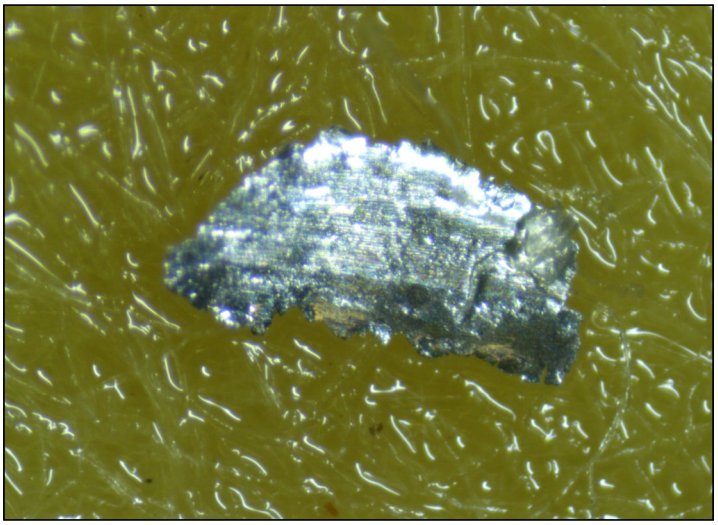

FIGURE 3: Metal from the filter

Our solution? Do another 10-hour oil run for an apples-to-apples comparison. At this point, with 10 hours of uneventful flying under our belt, our confidence was starting to grow, so we ventured out a little from the airport environment. After 10 hours, we sent the oil and filter for analysis, fairly confident that this second sample would reveal the improvement that was bound to come.

Instead, we received the disheartening news that “the overall quantity and size of the non-ferrous flakes was similar to the previous filter” (figure 4). *Dang*.

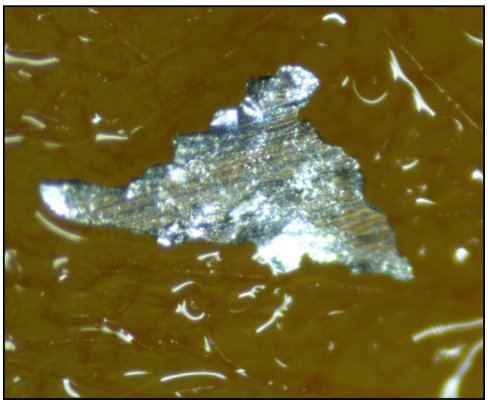

Figure 4: Still with the filter metal

Hard discussions

We debated what to do next. Are we throwing money away on oil and filters when we might need an overhaul anyway? Do we keep wasting filters when the nationwide filter shortage might ground us anyway? Do we run 25 hours, despite not seeing an improvement in the metals?

We reconsidered an earlier suggestion to pull a cylinder and look for crank/bearing damage, but that might raise more questions than answers: what *should* a 1500-hour crank/bearing look like? How will we know if the damage is excessive without pulling all four cylinders and comparing? And at that point why not just overhaul?

Opinions varied among our club members. One thought we were overreacting and that a paper towel couldn’t cause engine damage. Others of us were more cautious, remembering how little metal our engine used to make in 50 hours. As a group, we exchanged some vibrant text conversations as we decided how to proceed.

With our concern about irreversible, ongoing damage, we opted to do another short 10-hour oil change to try and limit further damage and get another good comparison to gauge progress. I was afraid that if this sample didn’t come back cleaner, we’d start considering exploratory surgery and watch the summer tick by from the ground.

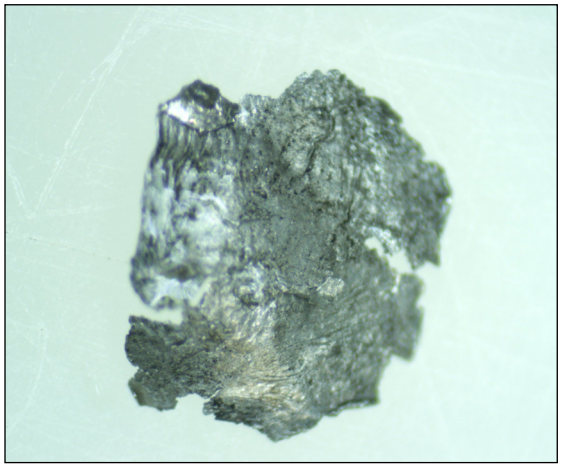

Figure 5: Will the metal ever end?

Baby steps

We knocked those 10 hours out in less than a week and had results early the following week. I jokingly told my coworker that I’d bribe him with beer if he gave us a good enough report that we wouldn’t have to ground the aircraft for the summer.

As it turned out, no bribery was needed: the oil analysis came back clean and the filter report contained good news: less metal than before. Finally! Maybe everything was going to be okay. That night of the improved report was the best night’s sleep I’d gotten in months. Over the next several months, we inched our oil change intervals up to 25 and then 50 hours, and presently we have about 200 hours on the engine since the oil pressure incident. We do oil and filter analysis diligently with each oil change as well as borescope and compression testing. We still watch our oil pressure like a hawk, and we're considering getting an engine monitor to help us keep an eye on things. Our engine is just shy of 1900 hours on a 2000-hour suggested TBO.

Lessons Learned

Hindsight is always 20/20, as they say, but looking back I think there are several lessons to be learned. First, when you’re troubleshooting a problem, do your research and get as much data as you can. It

honestly shocked me how many different opinions we received. At one point I called Lycoming. They called me back several days later, and after listening to my story the tech said we needed an overhaul.

I replied, “Well in the week I was waiting for you to get back to me, we did a 30-minute ground run, tested the oil and filter, and we’ve since flown a couple of uneventful hours, as per SB 480 and we’re planning on flying a total of 10 hours before retesting.”

He said, “Okay, that’s good. Do that and proceed as planned.”

In less than five minutes he went from telling me to overhaul to “go fly.” There’s a vast dichotomy there. I get that there’s a lot of liability in aviation, but that just makes it harder to make good, educated decisions. We did a lot of research, gathered data, and consulted with as many people as we could to make the best decision for us. Do your homework.

Second, remember that you have many tools in your toolbox for diagnosing problems. Our oil reports came back clean all along – it was the filter analysis that was showing metal. Oil analysis measures the microscopic particles in the oil; the filter/screen is where you’ll see visible metal. Always cut your filter open, and use oil analysis in conjunction with other tests (like borescope and compression checks). The more data you have, the better decision you can make.

Third, as we said last time – trust your gut. If your intuition tells you something is wrong, don’t ignore it. But the inverse is also true: after all those hours of flying the pattern with strong oil pressure, good RPMs, and normal oil temps, we had a strong feeling that our engine was going to be okay – we just had to wait a few oil changes for the data to support our intuition. And last but certainly not least – keep the damn paper towels far away from your engine!

Editor’s Note: The flying club’s Cessna is still flying today, and the engine has made a full recovery from the Great Paper Towel Incident of 2022-23.

A happy ending!

Report of the Month

This Lycoming IO-540 has a problem. What is it?

To learn where the elements are coming from, click here and scroll down.

UNIT

MAKE/MODEL: Lycoming IO-540-K1G5
FUEL TYPE: Gasoline (Leaded)
ADDITIONAL INFO: Piper PA32R

OIL TYPE & GRADE: Aeroshell 15W/50
OIL USE INTERVAL: 31 Hours

COMMENTS

Thanks for letting us know what you found and were able to fix the issue with the alternate air door! Doing that looks to have helped wear, and there's no evidence of long-term damage. We left the mark on chrome since it was 18 ppm last time, but this level isn't unusual for your plane. As long as it at least holds steady, we won't worry about it and will probably remove the mark next time. Silicon is still a touch high, but it's improving, and we'll see if it continues to do so in the next sample. Unless it starts going back up again, we also won't get too concerned.

ELEMENTS IN PARTS PER MILLION

		UNIT / LOCATION AVERAGES						UNIVERSAL AVERAGES
MI/HR on Oil	31		33	33	41	33	48	
MI/HR on Unit	719		689	594	499	957	393	
Sample Date	11/23/2021		10/21/2021	3/19/2021	9/8/2020	6/16/2020	1/23/2020	
Make Up Oil Added	3 qts		3 qts	3 qts	2 qts	1 qt	2 qts	
ALUMINUM	8	9	**15**	5	9	8	17	7
CHROMIUM	**12**	11	**18**	6	11	10	14	4
IRON	40	39	**65**	26	41	35	51	30
COPPER	9	12	10	10	14	11	18	8
LEAD	3828	4871	4800	3921	5850	4745	6009	4143
TIN	2	2	2	1	2	2	2	1
MOLYBDENUM	0	0	0	0	0	0	0	0
NICKEL	2	2	3	1	2	2	4	2
MANGANESE	0	0	1	0	0	0	1	0
SILVER	0	0	0	0	0	0	0	0
TITANIUM	0	0	0	0	0	0	0	0
POTASSIUM	0	0	0	0	0	1	1	1
BORON	0	1	0	0	0	1	2	1
SILICON	**15**	8	**20**	3	6	8	6	6
SODIUM	2	2	1	2	3	2	2	1
CALCIUM	29	7	60	1	1	1	3	17
MAGNESIUM	4	8	7	5	7	9	16	6
PHOSPHORUS	998	1194	262	1196	1275	1253	1250	724
ZINC	16	21	19	13	23	18	37	8
BARIUM	0	0	0	0	0	0	0	0

PROPERTIES

		Values Should Be*					
SUS Viscosity @ 210°F	94.1	82-105	97.4	90.3	93.7	93.8	89.7
cSt Viscosity @ 100°C	18.96	16.0-21.8	19.75	18.05	18.87	18.90	17.90
Flashpoint in °F	480	>440	470	480	480	480	485
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 %	0.3	<0.6	0.4	0.1	0.3	0.4	0.4
TBN							
TAN							
ISO Code							

When the owner saw the high silicon and read the report from October 2021, he took our advice and checked the air filtration system and alternate air door. It wasn't closed all the way, and it was letting unfiltered air into the system. Check out the improvements after he fixed it - not only did silicon drop, but wear improved too. He mentioned that if it hadn't been for this report, he never would have thought to look at it.

Report of the Month

This Continental O-300-A has a problem. What is it?

To learn where the elements are coming from, click here and scroll down.

UNIT

MAKE/MODEL: Continental O-300-A
FUEL TYPE: Gasoline (Leaded)
ADDITIONAL INFO: Cessna 172, Millennium Cyls
OIL TYPE & GRADE: Aeroshell 100 Mineral
OIL USE INTERVAL: 19 Hours

COMMENTS

Thanks for the note about the overhaul. High metals and silicon are typical to find in the first few samples after an overhaul. The high metals are from wear-in of new parts, and silicon is from sealers/lubes used during the work. Iron (from steel parts) seems a little high even for an overhaul, but if the engine is making full power and temps are normal, we'll just look for iron, the other metals, and silicon to improve as wear-in washes out. Decreasing oil filter metal (if any) and stabilizing oil consumption will be signs of successful cylinder break-in on your end.

ELEMENTS IN PARTS PER MILLION

		UNIT / LOCATION AVERAGES						UNIVERSAL AVERAGES
MI/HR on Oil	19		31	38	23	21		
MI/HR on Unit	19		1,079	1,048	1,011	972		
Sample Date	12/24/2021		1/17/2021	5/28/2020	10/2/2019	3/31/2019		
Make Up Oil Added	3 qts		2 qts	4 qts	1.5 qts	1 qt		
ALUMINUM	7	37	**140**	10	7	**23**		8
CHROMIUM	6	5	5	3	3	**10**		4
IRON	**118**	59	31	19	21	**108**		36
COPPER	**29**	17	**25**	10	10	10		9
LEAD	1547	1636	912	1374	1380	2965		2124
TIN	4	2	1	2	1	2		1
MOLYBDENUM	3	1	0	0	0	2		1
NICKEL	2	1	1	1	1	2		2
MANGANESE	2	1	1	0	0	1		1
SILVER	0	0	0	0	0	0		0
TITANIUM	0	0	0	0	0	0		0
POTASSIUM	0	0	0	0	0	0		1
BORON	1	1	0	2	0	0		1
SILICON	**42**	21	8	10	**13**	**30**		7
SODIUM	4	3	3	3	2	2		1
CALCIUM	3	60	53	62	82	98		19
MAGNESIUM	8	17	28	26	10	14		10
PHOSPHORUS	8	194	87	99	330	446		430
ZINC	8	17	27	30	14	7		5
BARIUM	0	0	0	0	0	0		0

PROPERTIES

		Values Should Be*					
SUS Viscosity @ 210°F	93.9	82-105	**93.6**	**85.8**	88.8	**84.3**	
cSt Viscosity @ 100°C	18.92	16.0-21.8	18.84	**16.97**	17.70	**16.59**	
Flashpoint in °F	490	>440	**410**	480	475	445	
Fuel %	<0.5	<1.0	**1.0**	<0.5	<0.5	<0.5	
Antifreeze %	-		-	-	-		
Water %	0.0	0.0	0.0	0.0	0.0	0.0	
Insolubles %	0.3	<0.6	0.3	0.2	0.3	0.5	
TBN							
TAN							
ISO Code							

After receiving the 1/21 analysis with very high aluminum and finding a “loaded” oil filter, the owner had the engine inspected. He found excessive piston pin plug wear (see the picture above) as well as a worn front thrust bearing.

The December sample is post-overhaul and shows a much happier engine, with iron, copper, and silicon from normal wear-in.