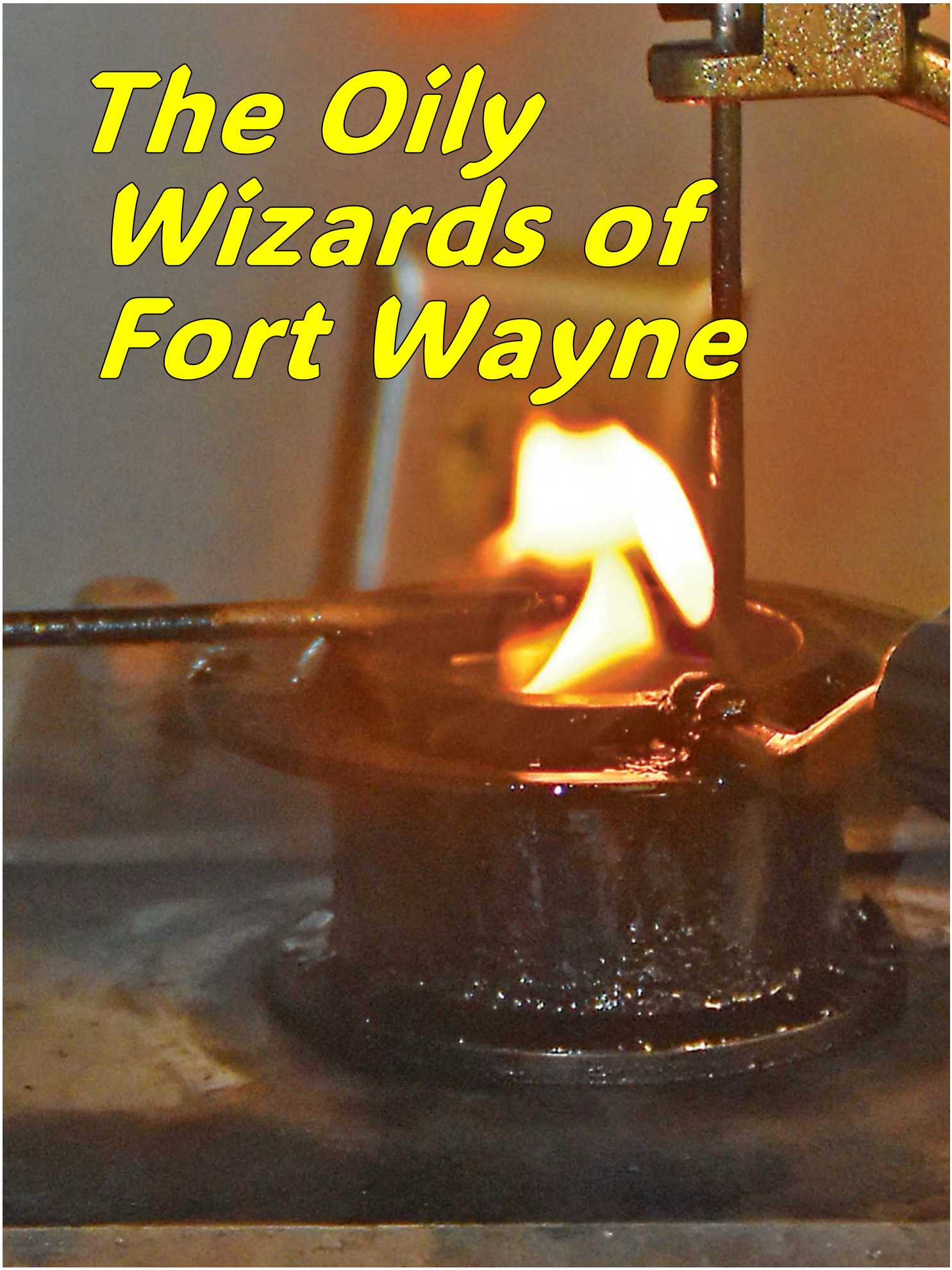
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Wizards of
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By Mike Jones

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Ask ten flyers to name the single most essential ingredient in aviation and if you don't get at least five different answers I'll buy you a pizza. The results from my unofficial poll at a weekend EAA meeting included av gas, money, and a poetic "long runways and blue skies." I heard "maintenance" from a pilot who also was an A&P, "training" from a CFI, and "coffee", to which almost everyone nodded their heads.

Oddly, no one mentioned oil.

But nobody gets far off the ground without at least a couple quarts of dinosaur juice splashing under the cowling. Aircraft oil works all sorts of magic. It reduces the friction between moving parts which enables our engines to work longer and harder with astounding reliability. Oil enhances the seals between the piston rings and the walls of each cylinder, preventing power-loss and "blow-by." Oil keeps the engine cool, removing roughly 40% of the heat trapped in the engine, and collects dirt, soot and metals.

Oil keeps working even when the plane is not. Oil forms a temporary layer over the bare innards of your engine, protecting those parts from corrosive humidity. Abundant, clean, cool engine oil is the secret to a happy engine. It's also quite a bargain, delivering truckloads of functionality for about $9 a quart.

The Doctor Is "In"

At my old airport, the resident A&P scoffed at oil analysis. "It won't tell you anything I can't see," he told me. "Save your money and the aggravation." Sadly, that is the attitude of many mechanics who tout their observational skills over a "second opinion" from a desk jockey in a distant lab.

I ignored that talented but ill-informed gentleman, and for twenty years have been sending half-pint samples to a lab for analysis with every oil change. Oil analysis is like the "DEW line" for my engine (Google it, youngsters), seeing changes my eyes cannot. It is as essential for aeronautical well-being as frequent oil changes. Oil analysis can save you an arm and a leg, and maybe your life.

Ryan Stark, president of Blackstone Labs in Ft. Wayne, Indiana. Stark is a vibrant entrepreneur, a skilled engineer and an enthusiastic pilot with almost 500 hours in his logbook. His bird is an RV-12 he built with his dad, Jim Stark. It's a glossy speedbird with a handsome panel, a rugged Rotax engine and the shiniest black and white paint job I've ever seen.

Aircraft maintenance guru Mike Busch, of Savvy Aviation, agrees. "I'm a big believer in oil analysis. We recommend it to our clients," he told me. "But it is kind of misunderstood, which is why some mechanics are reluctant to recommend it to their owners."

Busch went on to explain the layers of self-protection built into an aircraft engine. The first layer is the oil itself, cooling parts and preventing friction. The

oil pump is an engine's "heart" which moves the oil to where it is needed. Because of the importance of the oil pump, the second layer of defense is a small metal screen directly in front of it. The screen captures metal particles bigger than 1/16th of an inch because those pieces could cause the oil pump to fail catastrophically. Basically, the oil screen prevents engine "heart attacks."

The oil pump then forces the oil through the third layer of defense, which is the oil filter itself. Importantly, the filter only removes small particulate. It does not remove liquid contamination — like acids, water or fuel — carried in the oil, nor does it remove microscopically-small particles. Both of those remain in suspension in the oil until the next oil change, which is the fourth and final layer of defense of the engine.

That's why my old A&P didn't like oil analysis: only the liquids and microscopic particles end up in the oil sample jar. The big chunks never make it that far. Since oil analysis doesn't predict every failure, only *certain kinds* of failures, he felt it was less than useful.

"Engine failures come in two categories," Busch told me. "There are fast events which happen in a few hours, and slow events which accumulate over years." Fast events, like lifter spalling, can be detected by an alert pilot and an energetic A&P. "But a slow event like a gradually wearing exhaust valve guide shows up in the oil analysis long before anywhere else."

I asked Busch about my mechanics assertion that oil analysis causes "false alarms." Busch felt those people were mis-using oil analysis, looking at transient anomalies instead of trends. They were asking oil analysis to do a job for which it is not designed.

"The two engines on my C310 have very different oil analysis signatures," he told me, suggesting that if he wasn't cautious he could spend a lot of time and money trying to figure out exactly what was happening under each cowling.

"You have to baseline each engine with multiple oil samples. Then look for substantial departures from those baselines."

He suggested oil analysis should be used like a medical MRI. It's not the individual scan that's important but the changes from scan to scan that gives the most relevant information. Oil analysis isn't an emergency room procedure but a long-term diagnostic tool.

The Stark family of oil analysis entrepreneurs: Jim Stark, Kristen Huff, and Ryan Stark enjoying a baseball game a few years before Jim passed.

He offered me an example from not too long ago. One owner repeatedly saw high levels of silicon in his oil analysis, which was alarming because silicon is abrasive and there are no silicon parts in an aircraft engine. However, silicon is found in sand and dirt. High levels of silicon meant the engine was breathing dirty air. As they tracked the problem down, they found the carb heat door was not sealing tightly. It was allowing small quantities of unfiltered air into the engine even when the carb heat was off. Fixing the carb heat system was trivial and prevented gritty silicon from abrading the engine. But without the prodding of the oil analysis it was highly unlikely anybody would have noticed such a subtle failure.

Off to Fort Wayne

While many labs perform oil analysis, only a few are both capable and willing to test aircraft engine oils. I have been sending my samples to Blackstone Laboratory in Fort Wayne, Indiana. In return I have received

insightful and sometimes amusing full-page reports of the health of my engine. This month I decided *to deliver* my sample to Blackstone. I spent a fun day with the Blackstone team, plus Ryan Stark, the company's president, and veep Kristen Huff, Ryan's sister and co-owner. I learned more about oil analysis than I ever expected.

Stark greeted me at the Fort Wayne FBO with a big smile and a tiny yellow Mini-Cooper. Blackstone's facility is a four-building campus, roughly halfway between the airport and downtown. Part warehouse, part strip mall, part unexpected opportunity, the Blackstone strategy is "make it work" — buy what they could get, use what they needed, and adapt as the business evolves. It's not glamorous but it's highly functional and affordable.

The volume of samples racing through the Blackstone facility is amazing to see, but each sample gets personalized handling and tracking every step of the way. Here, Mary unpackages an incoming oil sample and categorizes it by the source: aviation, diesel, marine, and so on.

The business was founded by Stark and Huff's dad, Jim Stark, in 1985. Jim learned about lab processes while working at Dana Corp. which is a billion-dollar leader in "propulsion solutions that power mobility across the globe." Whew. A real person would say they make axles for pick-up trucks but that's not quite as sexy. In any case, Jim was laid off during a recession and migrated to a lab at a company that made diesel fuel additives, but he wanted to get out on his own.

"My father planned to be in the photography business. He came up with the name 'Blackstone Photography' and had a logo," Stark recalled. "But when he started the lab business, he just swapped out the word 'photography' and put in 'laboratory' and it worked."

Photo, right: Maggie preps the samples in the lab. Maggie is handling as many as 500 or more samples each day. It is vital that each sample be assigned a computerized tracking code so when the results come out of the lab they can be properly matched to the correct customer.

The early years were tough. Jim sold testing services to factories with compressors and generators, to GM and Ford, and some trucking firms. Gradually Blackstone expanded into new regions and new markets, acquiring a bit more stability along the way. Aviation and marine engines now make up about 50% of their business.

"At least with boats and airplanes, you're usually talking to the owner, and they're a little less price sensitive," Stark explained. "But we do a lot of work for farmers and individuals, so I want to keep our services affordable."

A surprising discovery was that neither Stark nor Huff are chemists. Stark studied mechanical engineering at Purdue and came to the business after he graduated in 1996. He says that chemistry isn't the big mystery: the engines are.

"If you think about what we're testing, it's all mechanical, you don't need to be a chemist," he elaborated. "You need to know where the aluminum's from, what kind of problems can happen with pistons, and the metallurgy of rings. It helps being a mechanical engineer."

Into the Lab

All of the sample kits Blackstone receives are born in the Test Kit Assembly Building on the Blackstone campus. Just two members of the Blackstone team, Ashley and Amber[1], are responsible for assembling and shipping thousands of test kits each week. They pre-build the kits by application (aviation, diesel, hydraulic, and so on). Ashley and Amber even individualize sample slips for existing customers.

Lydia works all day in the dimly-lit flashpoint lab. Lydia is one of the many lab techs working at Blackstone. She is monitoring the kinematic viscosity bath which measures the viscosity of the oil; behind that is the flashpoint testing bay.

"We send out a ton of them," Ashley told me.

And a ton of them come back; thousands of samples, every week. The pre-lab receiving area is staffed by Mary, Eric, Maggie, Megan, Jason and Ben. The process starts on a long steel shelf filled with Post Office crates, each one brimming with oil samples. Mary opens the packages and sorts them. Eric checks the billing paperwork, ensuring that Blackstone gets paid. Maggie organizes the samples into lots of 36 items, looking for special requests or double samples, like Mike Busch's paired left- and right-hand engines. Megan is

[1] In compliance with Blackstone's privacy and personal security policy, we're only using first names in this report. Who knows who might be in a witness protection program?

"email central" answering questions and selling supplies, while Ben puts the technical details of each sample into the computer before it goes to the labs.

I was surprised to learn that Blackstone offers a semi-secret priority service.

"Say, a sample comes from a pre-buy inspection. Everybody's always hot to get those answers back," Stark explained. "If you pay that extra money to overnight your sample, we'll unpack it before the others, run it through the lab first, do the report first, and email it back to you all in the same day. It's our fastest turnaround time, no charge."

Once the samples are all prepped, they go to two different labs.[2]. The more sophisticated lab is spectroscopy but the most exciting one is the flashpoint lab.

Flashpoint Flares

We visited Lydia in the Flashpoint and Viscosity Lab. The room is spacious but dark; everything seems to be coated with smokey residues. Digital read-outs glow brightly, throwing pin-points of color into the dungeon-like room. Bunsen burners hiss like diminutive dragons. The pungent smell of hot oil fills the air. Lydia moves skillfully and precisely, working in the semi-dark space like a wizard from a Harry Potter movie. She poured a tiny sample of oil into a thimble-sized caldron (more Harry Potter!) and heated with a gas flame. Lydia listened to each sample as they warmed.

"When you have [a sample] that's got water in it you can hear 'em crackle a little. They sizzle, like bacon in a frying pan." Water in airplane engines is a bad idea, suggesting corrosion will be a problem.

[2] Actually, there are four labs, clones of each other but split between aviation and non-aviation applications. I was intrigued to learn that aircraft samples cannot be mixed with other types of tests because aircraft fuel contains lead, which contaminates the oil, which would contaminate the testing machinery. They won't even let aviation samples into the non-aviation building. Another reason to get rid of leaded avgas as quickly as we can.

The darkened room allowed Lydia to observe the flashpoint test more precisely. This test requires a bit of nerve because you're waiting for the sample to explode. When the oil reached its "flashpoint" there was an eye-popping burst of flame which made me jump. A puff of soot lazily floated into the room before being sucked out by the exhaust system. Lydia carefully recorded the temperature into Blackstone's custom software.

The flashpoint for most aircraft oils, like Aeroshell 15/50, should be around 440˚F.

The flashpoint test involves heating the sample until it bursts in flame. The flashpoint test is fairly boring until the sample flashes, then it's like a strobe going off in your face. The sample uses about an ounce of oil which is heated in a calibrated manner until the oil ignites with a "poof" of flame and smoke. Lydia tests three samples simultaneously which keeps the techs very busy.

"If there's a leaking cylinder or something, a little bit of fuel gets into the oil," Lydia told me. "It'll flash at a really low temperature which means the oil's not protecting the engine."

The second test Lydia performed was the viscosity test. Stark told me this test was developed a century and a half ago when engines were just beginning to be used for transportation and machinery.

"The kinematic viscosity bath is really simple, as old as the hills," he said. "It simply measures the speed with which the oil will flow at a given temperature."

Lydia used a vacuum to "suck" a tiny sample of the oil up into a glass tube which is heated to a calibrated temperature.

"Then we let gravity take over," she said. "The oil flows down the glass tube. I use digital timers that plug directly into the software, which computes the viscosity. This way you can identify if it's within normal margins or not."

Watching these tests was fascinating, but I wondered if it might be boring to work there day after day. That would be true, Lydia told me, but everybody is cross-trained.

"We're not doing the same thing every day," she said. "We divvy up the jobs so that we switch every day, like a weekly rotation."

It's Elementary, Watson

We visited the non-aviation spectroscopy lab which is in a completely separate building. As dark and gloomy as Lydia's lab was, this space is vibrantly white and hospital clean. Techs expertly move around the room, test tubes in hand. Four principal measurements are collected in these labs. The labs can add other tests if a customer or chemistry requires it, such pH tests, but just four tests are their bread-and-butter.[3]

Justin poses with one of Blackstone's three spectroscopy machines. The digital spectroscopes heat the oil samples to determine the presence of twenty different elements which are tracked to measure engine performance. At this moment, Justin was recalibrating the machine, a task they perform every dozen samples just to be sure their samples are pin-point precise.

Blackstone has three spectrometers (one for

[3] Interesting tidbit about engine oils: technically, oils don't have a pH; the chemistry doesn't work. If a customer really needs to know, Blackstone performs two equivalent tests called TAN (Total Acid Number) and TBN (Total Base Number). For example, TBN tells the quantity of certain additives in an automotive sample. But aircraft oils don't have those additives, so they can't have TANs and TBNs. "Aircraft oils really are different beasts," Ryan said.

aviation, two for all other samples) each of which cost more than a luxury car. The staff treats them with the respect they deserve. I spoke with Justin, the lab manager, as he tweaked one of the machines.

“This the most important test in the lab. It tells us the elements, in parts per million, of chrome, steel and aluminum,” he explained. “If I could only run one test, this would be it. I can get by with a one mill sample of oil.”

The machines are highly automated and aren’t hard to operate, but they do take some babysitting.

“Sometimes they get out of calibration,” he explained. “Generally you could go a whole day without calibration, but we check [the calibration] every twelve samples. That way, if the system goes out of line, we don't have that many samples to rerun.”

Luke inserts the samples into the centrifuge system which spins them at 2,000 rpm to separate the particulates from the oily liquid. These particles as so small they are not captured by a traditional oil filter. Subsequent spectrographic analysis determines the composition of the residues which helps with diagnostics.

The insolubles test uses a centrifuge as large as a home clothes washer but many times more heavy, which was being loaded by Luke.

“It spins at about 2000 rpm,” Luke explained as he placed racks of tiny test tubes into the machine. “We take five milliliters of the sample oil and mix it

with five milliliters of petroleum ether, which is a solvent. You shake it up, spin it, see what solids settle out." For example, lead forms a gray sludge at the bottom of the test tube.

Stark also showed me a new service for their customers: oil filter analysis. Healthy engine oil filters shouldn't contain anything but oil. But Stark showed me a scary example: the pleats of the filter were lined with metals. It's a messy job but can provide a mechanic with powerful insights into the health of the engine.

Report Writers

Blackstone hides their report writers in an undisclosed secure location (behind an old restaurant kitchen) because they are the "secret sauce" of Blackstone's success. The report writers translate the arcane lab results into information into short, simple words even a pilot can understand. That means, first and foremost, they are all writers.

Summer works on one of her analyses. There are about a dozen report writers at Blackstone who have (a) the technical skills to interpret the oil analyses and (b) the writing skills to make those findings understandable. Each of these people were hired for the writing skills. They endure months of technical training to learn the chemical and mechanical aspects of oil analysis. Summer started her career in construction, moved to Hawaii, and then came to Fort Wayne to enjoy the winters.

The analysts have diverse backgrounds. Brian spent time in both the Marine Corps and the restaurant industry. Brett has a master's in poetry and works a side-hustle as a college professor. Summer worked in Colorado and Hawaii while Arryn was a screenwriter in California. Brianna majored in writing at Indiana Westland. Master Analyst Anna has a bachelor's degree in history and was lured to Blackstone by “the siren call of good writing.”

Not all the report writers are based in Fort Wayne. Amanda is in Illinois and Samir is in Montana. “We’re flexible. We want to keep our highly-trained people even if their husbands or significant others need to move,” Stark said. “They can stay with their family and we can still keep ’em on.” Report writing is the perfect “remote work” job because all of the analytical data is in digital form. A sample of a Blackstone report is dissected in the sidebar with this article.

Anna and Stark do most of the training, which is expensive and time-consuming. About a month of classroom time is required before a new writer is ready to test their wings on automotive reports. There’s a second round of training before they graduate into aircraft applications.

Blackstone also offers their employees an unusual corporate perk: pilot training. “We helped Amanda get her pilot's license. She got her instrument and commercial, and now she's working on her instructor ticket,” Stark said. “We’ll pay half of the costs. Plus, some of our customers call the office and like to talk to a fellow pilot.”

The Long View

Mike Busch is highly supportive of oil analysis and particularly fond of Blackstone. “We steer our customers to Blackstone,” he said. “They seem to do a more comprehensive job.”

With kudos like that and business booming, I asked Stark about the future of Blackstone; what were his plans; what did he wish for? His surprising answer: he'd just like to know the punchline.

"We'll call a mechanic and tell him, hey, this engine's making a lot of metal, check it out. Maybe we've seen copper, brass, or aluminum. Maybe some bearing material, which can fail quickly," he said. "That call gets their attention, which is what they want; and they'll say thanks. But then they don't call us back. We don't get any feedback at all. I wish they'd call us once in a while and tell us how the story ended."

About the Author

Mike Jones is a 4,000 hour commercial-rated pilot who has more than 50 aircraft types in his logbook. His pride and joy is a Cessna T210, which has carried him to every corner of the U.S. and Canada for more than twenty years. He's always accessible at PilotMike2012@gmail.com.