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Savvy Borescope Initiative: More Than 100,000 Images

Savvy Aviation's project to add borescope imagery to its database on cylinder condition has generated massive amounts of data and some interesting results.

by Rick Durden

Back in the January 2024 issue of *Aviation Consumer*, we reported on the rollout of Savvy Aviation's (www.savvyaviation.com) Borescope Initiative as the latest addition to its longtime engine analysis program. The goal was to add borescope imagery of engine cylinders and components taken according to a standardized protocol to its database to monitor cylinder condition. With machine learning/Artificial Intelligence (AI), the Savvy team would hone its ability to identify and diagnose cylinder issues earlier and more accurately. The two-fold goal was to reduce the number of engine failures due to burned valves and to reduce the number of perfectly good cylinders that are removed per outdated maintenance practices—of especial importance because removing and replacing a cylinder increases the risk of subsequent engine failure due to errors in cylinder installation in the field.

At no charge, Savvy provided users with a video showing how to take cylinder borescope imagery and set up a protocol stating what photos were to be taken and in what order. It also established a naming convention for the images. In doing so, it was following what has been a decades-long practice in the medical world for X-ray and other imagery. In our opinion, if nothing else, Savvy's Borescope Initiative has established an aviation industry standard for taking and identifying piston engine cylinder borescope images that will facilitate overall sharing and analysis of such imagery. We heartily applaud that action.

A&P Phil Weaver of Northern Air Airmotive on the Boundary County, Idaho, airport using a Vividia CS-4010i borescope to examine a cylinder on an Aeronca Champ's engine.

RESPONSE

The response was beyond anyone's estimates. In just over one year, more than 100,000 images were uploaded to Savvy's database by aircraft owners and shops.

According to the owner of Savvy Aviation, Mike Busch, of the over 100,000 images uploaded, users had Savvy's team analyze 70,000 of them. Of the images analyzed, some 7500 were of the heads of exhaust valves. (The Savvy borescope imagery protocol involves taking 11 photos inside each cylinder; one of those photos is of the head of the exhaust valve.)

The results of the analysis were a little startling: Busch told us that of those 7500 photos, between 7 and 8 percent exhibited signs of heat distress. Busch pointed out that he doesn't think that 7 to 8 percent of exhaust valves in the field have heat distress—it's his opinion that those who uploaded images and paid for analysis self-selected because they thought something might be wrong.

Of the image sets for the four or six cylinders of each engine, 25 percent had at least one exhaust valve with heat distress.

HEAT DISTRESS

Busch told us that, in his opinion, the data indicate to him that some 20 percent of engines in the piston-engine general aviation fleet have at least one exhaust valve in heat distress.

That's the bad news. The good

Four examples of burned exhaust valves from Savvy Aviation's imagery database. The green discoloration along one edge of each valve is a clear indication of a burned valve—a normal valve will show symmetrical bulls-eye heat signatures.

news is that Savvy rates the condition of exhaust valves as "normal," "early stage heat distress" and "late stage heat distress." Of the valves exhibiting heat distress, 85 percent were early stage. According to Busch, Savvy has had a nearly 100 percent success rate in fixing exhaust valves in early stage heat distress by lapping them in place.

VALVE LAPPING

Lapping in place is a roughly two-hour procedure that is done without removing the cylinder. It is described in detail on Savvy's website. It costs on the order of $250.

Removing, revalving and replacing a cylinder runs between $2000 and $4000.

Older maintenance guidelines focused on the differential compression test to determine the health of a cylinder and mechanics became spring-loaded to yank a cylinder anytime the compression was below some arbitrary level. Lycoming and Continental gave guidelines for acceptable compression levels. However, those have evolved. The engine manufacturers recommend less and less reliance on compression tests.

As of today, those in the industry who are heavily involved in engine maintenance state that the compression test is more art than science, often gives wildly different results on tests taken just a few minutes apart and simply does not generate valid results.

The problem is that the word hasn't gotten out to the piston-engine aircraft owner and maintenance community as it should. The result is that with some 20 percent of piston engines having at least one exhaust valve with heat distress, relying on compression tests means too many perfectly good cylinders are being removed, revalved and replaced. That means not only extra money spent, but an increase in risk of engine failure due to problems that develop from cylinder installation in the field.

CONTINENTAL GUIDELINES

Continental's service guidelines now call for a borescope inspection of cylinders *anytime* a compression test is done and point out that a cylinder should not be pulled for low compression alone.

Based on our review of NTSB accident reports that we have conducted monthly for over 30 years for our Used Aircraft Guide, it is our opinion that the accident data shows that removing and replacing a cylinder increases the subsequent risk of engine failure dramatically enough that a cylinder should never be pulled unless there is absolutely no other option.

Mike Busch and Savvy Aviation make the same statement about the increased risk of engine failure following cylinder removal and replacement in their website and publications.

Busch told us that more and more maintenance techs are recognizing that the old practice of routinely pulling cylinders is dangerous and that he wants to get the word out that the practice puts lives at risk. We agree.

GOLD STANDARD

Accordingly, we are of the opinion that Savvy Aviation is correct when it says that the borescope exam is the Gold Standard of cylinder inspection and maintenance. We are of the opinion that it should always be the primary tool for assessing engine health and that the compression test should only be a distant second.

We'll note here that a compression test usually only reflects an exhaust valve issue when it is in late stage heat distress and may be beyond saving. The borescope exam allows a problem to be caught early and repaired at what, in aviation terms, is a quite reasonable price.

That means, in our opinion, that an exhaust valve exhibiting early stage heat distress can almost certainly be repaired by lapping it in place. There is no reason to pull the cylinder and increase the risk of a subsequent engine failure.

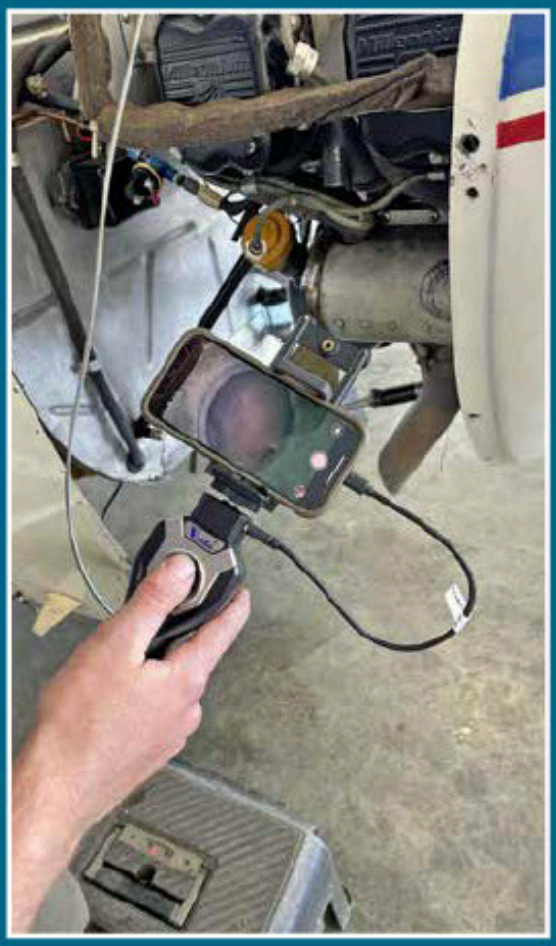
In our conversation with Busch he mentioned that he'd worked with at least one aircraft owner who had an exhaust valve that exhibited late stage heat distress. Mike said that the valves showed no evidence of cracking so a decision was made to try lapping

SAVVY BORESCOPE INITIATIVE: ONE SHOP'S EXPERIENCE

I base my airplane at a small airport, Boundary County Airport, in Bonners Ferry, Idaho. To give a feel for the population of the area and size of the airport, there are only 10,000 people in our county. The shop that I use is Northern Air Airmotive, which consists of two A&Ps, one with Inspection Authorization and one apprentice. It's a busy shop and works on the full range of piston-engine aircraft and I was curious to see what they knew about Savvy Aviation's Borescope Initiative. After all, every time I had my airplane in for its annual, shop owner and IA Phil Heisey would discuss what he's seen when he borescoped the cylinders, although I had never requested images.

I stopped in on an afternoon when both A&Ps were occupied but apprentice Tristan Thomas was able to take some time to talk with me. I first asked him whether he knew about Savvy's Borescope Initiative. He said that he did and that at least six of the shop's clients were making use of it.

He immediately walked me over to a computer and pulled up Savvy's webpage and started walking me through how things worked. He showed me the checklist on the website and explained that it called for taking 11 photos inside each cylinder. We went through the description of each image called out and how, in his opinion, they made logical sense. The image progression starts with a view of the piston crown; then goes to the head of the exhaust valve; followed by two more shots of the exhaust valve, the seat and face and the stem and guide; it then focuses on the intake valve with a head view, a seat and face view and a stem and guide view; finally there are four shots of the cylinder wall, at the 12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock view.



Thomas then told me that there is a naming convention for the images and files. He said that the first time he followed the checklist it took a little while to get the naming convention right, but after that the shop set up a copy and paste arrangement with their computer so that only the date needs to be input when collecting the photos.

Thomas next pulled up the video Savvy put together to show how to get the images and how to manipulate the borescope to get good quality images.

He said that the shop was offering to take the images and upload them to the Savvy website for a flat rate of two hours of shop time, which pretty closely matched the time involved.

On my next visit to the shop, A&P Phil Weaver immediately pulled out the shop's borescope, a Vividia CS-4010i, that had cost about $1000 when the shop bought it two years ago. He mentioned that the price had come down since then. (I looked it up; he was right.)

The borescope uses a joystick and Weaver immediately went to an Aeronca Champ that was in the shop and had the spark plugs out of the engine. In moments he had attached his cellphone to the borescope, activated the appropriate app, was maneuvering the camera around inside the cylinder and showing me what I thought were amazing quality images. That's one to the left. He explained that there are a number of options for imaging with the borescope, they can be displayed on a computer, tablet or smartphone, and can be stored, emailed and/or texted so an owner can immediately see what the mechanic is seeing and they can discuss the good, bad and questionable. Weaver said that once he'd memorized the Savvy protocol image sequence, it was easy to get the right shots in the right order and that the sequence, to him, made logical sense.

Shop owner Phil Heisey said that some owners simply want the images uploaded and they and Heisey look at them and do their own analysis. Some pay for Savvy to analyze them.

Most important, according to Heisey, is that putting up images at every annual or more frequently means that he is going to have a fast way to look at a collection over time and spot trends, something he considers important.

His bottom line: The borescope inspection is non-invasive and can spot developing problems early.

A portion of Savvy Aviation's DIY Cylinder Borescope Inspection Checklist showing what images should be made using a borescope and the order in which they should be taken. We expect that this protocol for cylinder borescope photography will become the industry standard. Image 2 shows a healthy exhaust valve with symmetrical bulls-eye heat signatures.

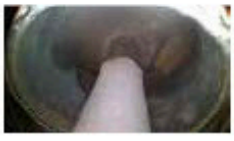
Cylinder Borescope Inspection Checklist (rev 1.2) — Savvy Aviation

1. ☐ **Piston Crown View**
(piston-crown)
Capture an image of the entire piston crown. Position piston at bottom-dead-center and position borescope camera just inside the top spark plug boss with the articulating tip set to 0° (straight ahead).

2. ☐ **Exhaust Valve—Head View**
(exhaust-valve-head)
Capture an image of the entire exhaust valve face. Position piston at bottom-dead-center and position borescope camera near piston crown with the articulating tip set to roughly 180° (looking toward cylinder head).

3. ☐ **Exhaust Valve—Seat+Face View**
(exhaust-valve-seat)
Capture an image of the exhaust valve seat and valve face (sealing surface). Position crankshaft so exhaust valve is fully open and position borescope camera just inside top spark plug boss with the articulating tip set to roughly 90° (looking sideways toward edge of open valve).

4. ☐ **Exhaust Valve—Stem+Guide View**
(exhaust-valve-stem)
Capture an image of the exhaust valve stem and guide. Position crankshaft so exhaust valve is fully open and position borescope camera between the open valve and the seat with the articulating tip set to roughly 120° to 150° (looking up through the seat toward the valve stem where it exits the valve guide).



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in place to see if the valves could be repaired. For $250 for the procedure and then a look through the borescope after a few hours of flight, it was a little like chicken soup—it can't hurt.

In those cases lapping in place did fix the affected exhaust valves.

We note that Savvy recommends that when lapping an exhaust valve that the rotocoil or rotator cap for the valve be replaced. Those relatively inexpensive components rotate the exhaust valve slightly each time it opens to spread the heat around. Their failure often causes a valve to burn.

We think the early results of Savvy's Borescope Initiative need to be widely circulated to let our community know not only that there is a significant proportion of exhaust valves with some level of heat distress, but that the problem can be fixed inexpensively when discovered early. Discovering it early is almost certainly not possible using only a compression check. The cylinder has to be borescoped.

WHAT'S INVOLVED

After expressing our support of Savvy's Borescope Initiative, the results it has generated and the need to do borescope exams, we'll look at exactly what's involved for an owner or a shop that wants to take and upload borescope images to Savvy's website.

Step one is to go to the website, roll your cursor over "resources" and click on "borescope initiative." Then download or print the Cylinder Borescope Inspection Checklist. It sets out the standard borescope inspection protocol recommended by Savvy and has good-quality sample photos showing each successive image. It then outlines the naming convention for the images and files. In our opinion, the photo succession and naming conventions are logical and easy to follow. We've said that we think this will become the industry standard and are glad that someone has taken the lead to create one.

After a review of the checklist, we recommend watching the half-hour video that is a clearly presented explanation as to how to do what's on the checklist. It also gives guidance on use of the borescope, and, importantly, how to take good quality images.

The video also explains how to upload the images to Savvy's image repository, noting that there is no charge to do so, and an owner who has a free Savvy account can upload borescope images and engine monitor data and then do his or her analysis on the website using the tools Savvy provides. The owner (or shop) can annotate the data that's been stored for future reference.

For someone who wants more background on the value of borescope imagery for determining cylinder health and the concern over the danger presented by unnecessary removal of cylinder, the borescope webpage includes a link to a webcast entitled "Ending the War on Jugs."

SAVVY SERVICES

Beyond the free stuff, Savvy offers a spectrum of maintenance management and analysis for what we feel are reasonable fees. In our opinion, the services are designed to provide assistance to aircraft owners at a level that is comfortable for each owner.

For the owner who is comfortable managing her or his own aircraft maintenance and analyzing engine monitor data and borescope imagery but has a desire for an expert pair of eyes to look things over, there is Savvy Basics. For $99 a year for a piston single and $149 annually (prices are current at press time) for a piston twin, Basics provides three report

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