

# Off to a Good Start: PLANNING FOR YOUR FIRST ANNUAL



*Evaluate and maintain a new-to-you aircraft using all of the tools available today. By Dennis Wolter*

**SO,** it's been a year since the pre-purchase/annual inspection was completed and you have been the owner of this new-to-you airplane. As the months passed, every flight revealed more details about the condition and usefulness of your new flying partner.

You probably encountered a few issues that required immediate attention and many others that became line items on your to-do/wish list. (*In last month's Piper Flyer (November 2018), Dennis Wolter outlined best practices for preparing to tackle a renovation. —Ed.*)

With this list and your maintenance technician's familiarity with your new airplane, the arrival of annual inspection time presents the perfect opportunity to sit down with your mechanic and put together a schedule for the renovation of your airplane.

In the list that you put together when flying the airplane during previous months, it's important to include maintenance and performance issues that need to be discussed before starting that all-important first annual.

I definitely believe that you should read all applicable Airworthiness Directives and Service Bulletins and confirm that important issues are well-understood and properly completed. Just because an AD is signed off in the logbook doesn't mean that it was done properly or even that it was done at all. A couple of times a year at Air Mod, we find evidence that a signed-off AD was, in fact, never taken care of.

The point here is that between a thorough pre-purchase and the first annual, all issues are checked and verified, and your airplane should be off to a good start toward working its way to being a "good as new" machine.

From a safety standpoint, the condition of your airplane's engine is of major importance. You should take advantage of every technical process available for evaluation and maintenance in this area.

Back in the day, inspecting an oil filter for contaminants such as metal particles and performing a simple compression check were the two major engine evaluation processes that a technician used in determining the health of the piston engine.

Compared to my early days in this industry, we now have at our disposal far more inspection and diagnostic tools that make it possible to operate our engines longer with greater confidence.

## Determining engine health

A compression check is done to determine the health of the upper or power section of the engine where combustion takes place. Combustion exposes pistons, rings, cylinder walls, valves and valve guides to a lot of heat and combustion byproducts.

The time-tested compression check involves a technician using compressed air and air pressure gauges (Photo 01, Page 21) to determine if the cylinder and all of its parts are doing the job of sealing in the combustion gases in such a way as to efficiently produce the desired pressure of pushing the piston down to turn the crankshaft and rotate the propeller. Any leaking of these high-temperature gases past the valves or the piston and ring assemblies will cause heat buildup, a decrease in engine performance and increased wear on these critical components.

As good as the compression check was and is, it falls short of presenting all the information needed to fully evaluate the condition of the combustion components of a piston engine.

Beam-me-up-Scotty to 2018. Today, we have three diagnostic tools that bring engine condition tracking to a whole new level.

## Tool No. 1: Borescopes

The first implement I refer to here is the affordable, state-of-the-art borescope. What's that, you might ask? It is a 1/2-inch diameter, 18-inch-long fiber-optic tube that can be placed in an engine cylinder through a spark plug hole (Photo 02, Page 21). It will present a high-resolution color-correct image on a bright screen that allows a technician to evaluate the condition of the cylinder walls, piston crown, valves, etc.

Often, an engine that has good compression will have stress marks on the cylinder walls or discoloration on valves that can only be seen with a borescope. These anomalies can indicate a potential for future problems. The borescope allows a technician to address an issue before it becomes a failure. Also, most borescopes have a built-in digital camera, making it easy to email a picture of a problem to the customer. So much for the good old days!

Here is a great example of the value of this technology. I called a good friend, Adrian Eichhorn, who has done quite a bit of research into the use of this technology, to help identify cylinder components that are in the early stages of failure. He

*...between a thorough pre-purchase and the first annual... your airplane should be off to a good start...*

sent me a photograph of an exhaust valve that presented an uneven color pattern (Photo 03, Page 22), indicating that the valve was becoming too hot in one area and not sealing at that point on the edge of the valve.

If not corrected, the valve will eventually begin to deform and lead to serious and expensive valve failure. Eichhorn, in partnership with AOPA, came up with a chart showing various color patterns that indicate different types of potential valve failures. These charts have been distributed and used in the field with very positive results. Smart! (*A link to the PDF is available under Resources at the end of this column. —Ed.*)

These borescopes are miracle investigative tools that allow technicians to see into



inaccessible areas in various parts of the engine and airframe. I have a customer who recently used one to find a badly-corroded elevator component that was close to failure.

#### *Tool No. 2: Oil analysis*

Another important area to be evaluated is the bottom end of the engine—the crankshaft, connecting rods, oil pump, camshaft, etc. Back in the good old days, about the only diagnostic tool a technician had to help establish the condition of these components and their bearings was to hold a magnet in the oil as it drained out of the engine and look for magnetic or ferrous metal particles sticking to it. A technician could also cut open the full-flow oil filter, if the engine was equipped with one, and look for metal fragments in the filter.

Magnetic fragments mean a steel component is experiencing high wear; nonmagnetic fragments mean a nonmagnetic component such as a bushing is wearing, or something is rubbing the aluminum crankcase. Fragments don't always provide enough information to accurately diagnose a potential problem. Big pieces of metal indicate serious pre-failure issues.

The second engine diagnostic tool I'm going to discuss is oil analysis. It can vastly improve a mechanic's ability to assess an engine's health.

Here's how it works: as the technician is draining old oil out of the engine, a small cup is filled with an oil sample that is sent to a laboratory for analysis. After testing, the lab returns a report to the technician that indicates the percentage of metal residue found in the oil, measured in parts per million and listed by type of metal. Iron can indicate wear on the oil pump gears; silver can indicate wear on a plain bearing such as connecting rod or crankshaft main bearings; bronze can indicate wear on valve guides, and so on.

As the engine builds hours and additional oil samples are analyzed, a technician can track data and determine wear trends of the various internal engine components. If a high reading of a specific metal is noticed, the technician can use this information to identify a possible point of failure and initiate the appropriate maintenance action.

#### *Tool No. 3: Engine monitors*

The third 21st-century device that has revolutionized the monitoring of piston engine operation and maintenance is the digital engine monitor with data download capability (Photo 04, Page 22). The



*Technician using compressed air and air pressure gauges.*



*Borescope being placed in an engine cylinder.*

complexity of these systems can range from basic exhaust gas and cylinder head temperature monitors to systems that replace existing round engine instruments with a full screen that has multiple additional read outs for voltage, percentage of horsepower, fuel remaining and even outside air temperature.

These systems allow valuable information to be downloaded and analyzed by an owner, a technician or an online company, to track engine condition trends. Science fiction has become reality. We should take advantage of these contemporary tools to ensure the safe and efficient operation of an engine all the way to TBO. (See *Resources* for a list of PFA supporters. —Ed.)

#### **Other items to evaluate**

##### *Hoses*

An annual inspection item that I believe is sometimes not carefully looked

at is the age and condition of the fuel, oil and vacuum flex hoses. Many rubber flex hoses in service today have a service life of five years. Failure of an oil or fuel hose can definitely contribute to a bad day!

I highly recommend replacement of timed-out hoses with hoses fabricated with cost-effective, safety-enhancing orange fire-resistant sleeves, which protect the hose and its often-flammable contents in the event of an electrical or engine fire. The photo shows a typical black hose with a service life of five years as well as a stainless steel fitting, fire-sleeved silicon rubber, extended service life, top-of-the-line hose (Photo 05, Page 22).

#### *Engine accessories*

Moving beyond the engine itself, it's important to monitor the service life and condition of the engine accessories. A good pre-buy inspection should have clarified the times in service and inspec-



03



*Uneven color pattern on an exhaust valve indicates a possible problem.*

tion status of all the stuff that keeps the engine running.

An owner needs to be aware of the status of these components in order to prevent as many surprises as possible.

#### *Magnetos*

Let's focus now on a big item: magnetos. Most brands of magnetos require a 500-hour half-life inspection and a 1,000-hour overhaul or replacement. Experience has shown that scheduled maintenance and monitoring is very effective in increasing the reliability of these critical components.

#### *Vacuum pumps, propeller governors*

We know that dry vacuum pumps driving traditional gyros have a higher failure rate after 500 hours of operation. Propeller governors are best overhauled at engine change. The failure of a prop governor can send engine-damaging metal through the engine's lubrication system—that means big bucks to fix! The point here is to have a meeting with your maintenance tech and totally vet the status of all firewall-forward systems.

#### *Engine overhauls*

OK, I'm walking on thin ice here. No discussion about piston airplane engines would be complete without talking about the often-debated subject of time between overhauls (TBO). It seems like experts are all over the map as to when a seemingly great-running engine should be overhauled. Opinions range from "TBO is cast in stone" to "TBO is an arbitrary, money-making number set by the engine manufacturer." (See "Further Reading" in Resources for more on this topic and other topics discussed in this article. —Ed.)

Here's an 18-year-long anecdotal study I was unintentionally exposed to during the time Air Mod was located next to one of the more active field overhaulers in the country. Located by their hangar were two dumpsters. One contained rejected ferrous metal engine parts (crankshafts, connecting rods, gears, cams, etc.). The other contained rejected nonferrous aluminum parts (crankcases, cylinder heads, etc.). Most of the engines going through their facility were overhauled at or near TBO.

Based on the quantity of rejected parts that got hauled off to the recycling facility, I tend to think that the manufacturers base TBO numbers on experiences they've had tracking these engines for almost a century. Just remember, you can't write the check on the way down!

04



*Digital engine monitor with data download capability.*

05



*Extended service life hose on top, typical black hose below.*



If it's time for you to schedule that engine overhaul, tune in next time as we look at the options and process involved overhauling your trusted engine. Until then, fly safe. **PF**

*Industrial designer and aviation enthusiast Dennis Wolter is well-known for giving countless seminars and contributing his expertise about all phases of aircraft renovation in various publications. Wolter founded Air Mod in 1973 in order to offer private aircraft owners the same professional, high-quality work then only offered to corporate jet operators. Send questions or comments to editor@piperflyer.org.*

## RESOURCES >>>>>

ENGINE MONITORS  
– PFA SUPPORTERS

**Electronics International**  
buy-ei.com

**Insight Instrument Corp.**  
insightavionics.com

**J.P. Instruments Inc.**  
jpinstruments.com

AOPA FOUNDATION'S  
VALVE FAILURE CHART

**"Anatomy of a Valve Failure"**  
PiperFlyer.org/forum  
under "Magazine Extras"

## FURTHER READING

**"My engine is 50 hours from TBO...."**  
by Bill Ross  
Piper Flyer, September 2018

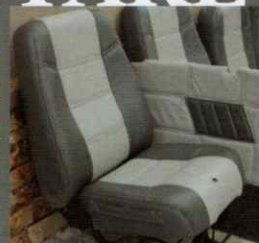
**"A Step-by-Step Guide to Overhauls"**  
By Jacqueline Shipe  
Piper Flyer, February 2018

**"Is Your Engine Worn Out?"**  
by Steve Ells  
Piper Flyer, October 2017

**"Dissecting a Dry Air Pump"**  
by Jacqueline Shipe  
Piper Flyer, June 2017

**"I Found This in my Oil"**  
by Jacqueline Shipe  
Piper Flyer, May 2017

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