

# Exhaust Valve Borescope Inspections

(What to look for, and how to interpret what you see.)

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## Quick Tips:

1. This information is applicable to Continental AND Lycoming AND Franklin engines (and maybe more.)
2. YOU can learn to use a borescope with confidence!

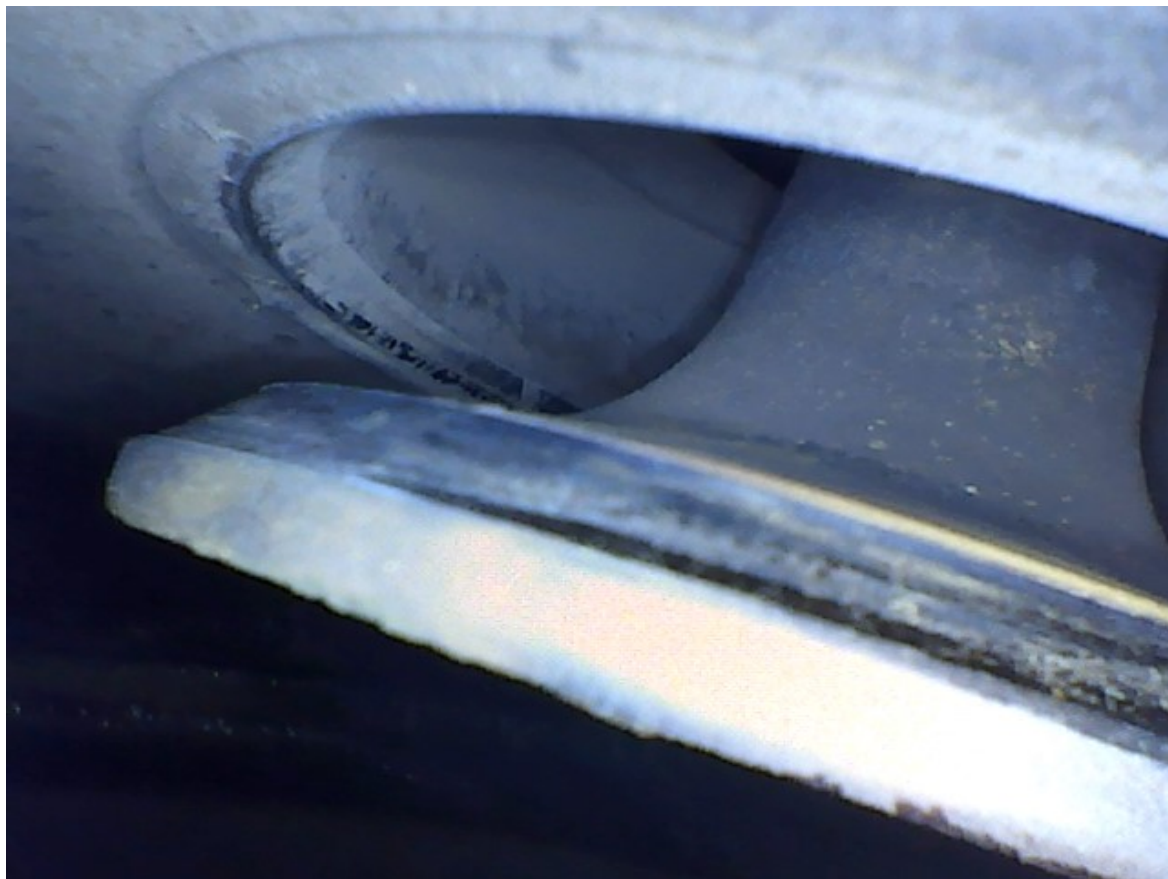
I've collected some case studies from real, flying airplanes.

If you study this guide, and practice using a borescope in your engine's cylinders, I am confident **YOU CAN QUICKLY BECOME SMARTER THAN MANY A&P'S** in the topic of exhaust valve borescope inspections.

## CASE STUDY #1: Beechcraft Turbo-Normalized A36 Bonanza



The previous picture is what I saw with the borescope in cylinder #6 during the annual inspection. The upper left side shows signs of significant burning, indicated by the greenish color. Burning means when the valve is closed, it does not seat well against the valve seat, which allows very hot exhaust gases to “leak” and flow around the edge of the valve. This burning effect is like a torch that burns the normal deposits off the surface of the valve. If the whole surface was like what we see from 2 o’clock to 8 o’clock, this valve would be just fine. But the greenish edge is a real problem, and we removed this cylinder for repair.



Although the structure of the valve still looked quite good, the seating area shows evidence of a poor seal, indicated by the hazy surfaces. A good seal will usually show a shiny, much wider band, both on the valve and the seat. Healthy valves have a

shiny band that is approximately 1/16 to 1/8 inch wide. However, I have also been amazed at how “rough” valves and seats can look, and still produce a compression test in the 70”s.

After removing cylinder #6:



Here's the same exhaust valve, from a different angle after removing the cylinder. This one needed to go!





In the previous picture, notice the edge on this side that looks rough and inconsistent. If we tipped the valve up to look at the other side, we would see the green edge where the hot spot and burning was happening.

Here's the same valve... notice the rough edge at the top where it was not sealing well, and the corresponding lack of orange-ish





color, that does not continue from about 10:30 to 1:30 o'clock. The orange-ish color is likely missing from the top edge because the hot exhaust gases have burned it off that area as they escaped around the edge of the valve.

## CASE STUDY #2: Diamond DA40

Burning exhaust valves only happen in Continental engines, right? Wrong!

I got a bit complacent after I noticed I very rarely found a burning exhaust valve in a Lycoming engine.

My thinking changed a few months ago when I found a surprise on a Lycoming engine.

The borescope inspection showed signs that two of the four exhaust valves were headed for trouble. Here's the first one:



The upper right side of this valve (about 12 to 1 o'clock) shows a small hot spot, and the normal deposits have been burned off the surface.

Here's the other valve:



Notice the very small hot spot to the left from about 8 to 9:30. Also notice the distinct band of shiny area on the valve seat. It's consistent, but a little thin. I should have gotten a picture of the seat area over on the burning side.

With these cylinders, we discussed the options, and almost removed both of them for repair. And then we changed course, and chose the less-invasive option - **lapping the valves with the cylinders in place**. This whole topic deserves a whole separate tutorial of its own, but let's just say this is a really good option if the conditions are right. You might call it "laparoscopic surgery" instead of traditional surgery.



Just remember, **there are certainly cases where the cylinder MUST be removed for repair.** Some of these cases, related to exhaust valves, are:

- If the valve is cracked.
- If the valve has a broken edge.
- If the valve has a green area on the surface.
- If the seating area is severely worn.
- And maybe some others I can't think of right now :)

In this case, with the Diamond DA40 engine, we were able to lap these two exhaust valves with significant success.

Both compressions improved remarkably, even with a cold compression test, immediately after the lapping procedure.

Notice the improvement of the seating area after lapping:





The valve grinding compound has restored a uniform band of sealing area both to the valve, and to the valve seat. It's hazy now, but over time as the engine runs, we're hopeful, a good, shiny seat will develop.

This procedure saved a significant amount of time and expense, and will hopefully extend the life of these two cylinders. This is a great option if a potential burning exhaust valve is detected early.

### CASE STUDY #3: Beechcraft A36 Bonanza

This one is by far the most startling thing I've ever seen when I poked the borescope in a cylinder.

I certainly did not see this one coming!

Keep in mind, the compression test on this cylinder was 61/80 and it only had 470 hours since cylinder overhaul!

In the “old days” this cylinder would have been considered “Airworthy” and sent out the door for another year of operation. And that would have been really bad.

Here’s what I saw:



(This picture was taken after removing the cylinder.)

Quite honestly, this shocked me when I saw it. I’ve looked at hundreds of exhaust valves, and I’ve never seen anything like this before. But one thing is for sure:



This discovery totally drives home the point in my mind:

***Whether you have a Continental engine or a Lycoming engine or a Franklin engine, a borescope inspection should be considered standard procedure for every annual inspection.***



The previous picture shows how it was able to produce a compression test of 61/80... even though there is a chunk missing from the edge of the valve, there is still enough seating area left to make a seal.

Compression testing alone is not enough! A borescope is a necessary tool in today's world of general aviation.

#### CASE STUDY #4: Cessna 182J

The previous owner of this airplane flew to so many fascinating places, and it would be awesome to have a book of his stories.

It's been a long time, but I think his destinations included places like Jackson Hole Wyoming, Central America, Bahamas, Florida, and many other places. This airplane could tell some stories.

One year, when he brought his 182 to Classic Aviation for the annual inspection, one of the cylinders had little to no compression. It quickly became obvious why. Here's the exhaust valve from that cylinder:



This valve was in serious trouble! Almost the whole surface is turning green. The only healthy looking portions are the two orange-red areas at the top and bottom.

Notice the scalloped looking edge at the left... big problem.

Also notice the vertical stress lines inboard of the angled green lines near the left and right sides. Who knows how long this one would have lasted until a large chunk broke off, rendering that cylinder useless in flight.



## CASE STUDY #5: The Classic Burning Exhaust Valve

In my experience, this next valve seems to be a typical indication that is seen when an exhaust valve is burning, (or not sealing well such that the hot exhaust gases are flowing around the edge, burning off the normal deposits that are found on the valve surface.)



The trouble on this valve is at about 1 o'clock. Notice the smooth brownish area near the edge. The surface is smooth due to the deposits being burned off in that area.

Perhaps this one could be a candidate for lapping, but that would need to be evaluated by the specific A&P or IA who needs to make the decision.

Also, if the decision is made to lap an exhaust valve without removing the cylinder, it is important to follow up at regular intervals with further borescope inspections and compression testing.

If the valve improves over time, you've just saved a chunk of money and hassle.

If the valve continues to deteriorate, it may need to be removed for repair.

## CASE STUDY #6: A Healthy Exhaust Valve



This is what you should hope to see when you look at your exhaust valves with a borescope. The reddish color is not a problem at all, and is totally normal. The concentric ring of deposits is an indication that all is well with this valve.



Keep in mind that some healthy exhaust valves will have even more deposits than this one. As long as they are consistent and in a circular pattern, it is not a problem.

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Thanks for taking the time to educate yourself about airplane piston engine exhaust valves. There is much more we could talk about, but this should be enough to get you going!

As I said earlier in this tutorial, (and I think it's worth repeating,)

***Whether you have a Continental engine or a Lycoming engine or a Franklin engine, a borescope inspection should be considered standard procedure for every annual inspection.***

Credits:

There are a few people I'd like to thank for the impact they've had on me and for what I've learned from them:

- Mike Busch: Before I attended Mike's Savvy Maintenance Seminar in 2008 at Norfolk, Virginia, I was clueless about borescoping exhaust valves. That seminar, along with Mike's writing and speaking, launched me into a fascinating journey of discovery

about borescoping and exhaust valves. Thanks Mike!  
You can find Mike at [SavvyAviation.com](http://SavvyAviation.com)

- Paul New: Like Mike, Paul is incredibly knowledgeable about this topic. Paul writes excellent articles about airplane maintenance, and I go back to them time and time again for great information. I had the privilege of visiting Paul's shop in Tennessee a couple years ago, and was very impressed. Thanks Paul! You can find Paul at [TennesseeAircraft.net](http://TennesseeAircraft.net)
  - Dave Pasquale: I discovered Dave through the American Bonanza Society (ABS.) Dave is very knowledgeable about borescoping and exhaust valve lapping. He has some excellent presentations on Facebook and YouTube. Dave's teaching has given me a much better grasp on the details of exhaust valve lapping and things to be aware of. My favorite lesson I learned from him is about how a Continental exhaust valve rotator works. It's like a miniature slinky sandwiched between two miniature frisbees... when the frisbees squeeze the slinky, and then release it, there is a rotational effect that happens... how cool! Analogies like this make it easy to understand. Thanks Dave! You can find Dave on Facebook and YouTube and at his shop in Pottstown, PA - Pasquale Aviation.
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***Dean Showalter loves both planes and people. He is the host of the Airplane Owner Maintenance Podcast.***

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***He is also the creator of the video training course,***

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***a course that trains airplane owners how to perform excellent safety wiring on their airplanes during preventive maintenance tasks.***

***Dean has been working as an A&P / IA, and pilot at Classic Aviation, LLC for almost 25 years, and he lives in the Shenandoah Valley of Virginia with his wife Maria, and three children.***