A Better Valve Poster

by David Pasquale

Years ago when I started performing cylinder inspections, the only guidance on the subject was Continental's SB03-3. The borescope I used at the time was a Lenox Autoscope, which was a rigid optical borescope that couldn't take pictures. As expected, the quality of my cylinder inspections back then didn't come close to what I can accomplish today.

Things started to change when I bought my first digital borescope around 2014. It was a dental borescope that looked somewhat like a pregnancy test, only with a camera at the tip. I had to carve the housing of the scope in order to get it in the spark plug hole and it only provided viewing at a 90-degree angle. The field of view wasn't wide enough to see the whole exhaust valve in one photo.

Not long after getting my first digital scope, Adrian Eichhorn, together with AOPA, published the Anatomy of a Valve Failure poster. Search Google for "AOPA Anatomy of a Valve Failure" and you will find it on AOPA's website. That poster, and my first Ablescope VA-400, which I purchased in early 2015, really changed the way I did cylinder inspections. I started capturing images of every cylinder that came through my door during an annual inspection. I also started making reports and comparing sets of images to track trends in the appearance of the exhaust valves.

Through this process it quickly became apparent that many exhaust valves did not look like the normal valve examples in the poster, but they did not look like the numbered failure examples in the poster either. What I know now is many of these valves had early and mid-stage uneven heat signatures. At the time there were no publicly available examples of these valves. I resorted to closely monitoring valves to see what would happen. I now have thousands of exhaust valve images and have enough trend data to show the progression a valve typically takes on its path to failure. I also have been able to lap valves in place to stop that progression.

Earlier this year a colleague of mine at Savvy Aviation sent a link to the Anatomy of a Valve Failure poster to a shop he was working with for a client. I had not looked at the poster in a long time. What I realized is that all the numbered valve examples in the poster are what I would consider late-stage valves. Two of the six examples appear to be warped valves from operation above redline CHT. The remainder, with bell-shaped heat signatures, look like typical rotator-based valve failures. This made me realize that it would be helpful to have an updated poster that reflects what we have learned in the years since the AOPA published the first poster. My goal with this new poster is to aid mechanics and owners in interpreting the results of cylinder inspections by being able to identify failing valves sooner.

I encourage interested parties to watch the two cylinder inspection videos I produced for ABS, available free in the Maintenance section of the ABS Online Learning Center.

Exhaust Valve Failure

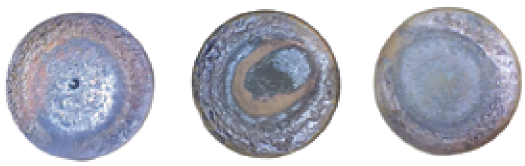
Mode and Sequence Identification

By Dave Pasquale

Normal Heat Signature

Normal heat signatures have a bulls eye pattern. Deposits can be thick or thin. Lean operation can make deposits hard to see. Rich operation will make thicker deposits. Color can vary from black,to grey or red.

Early Stage Uneven Heat Signature



Early stage uneven heat signatures still have rings. The outer ring develops a gap at the hot spot. The center of the bullseye becomes elongated in the direction of the hot spot. Valves in this stage can typically be lapped in place to restore valve seating. Heat signature takes approx 30hrs to return to normal after valve is lapped.

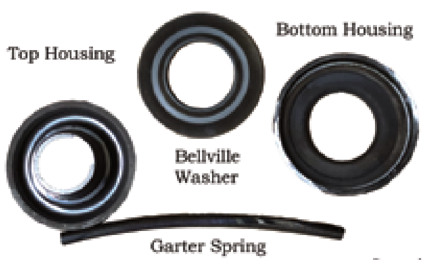
Late Stage Uneven Heat Signature

Late stage valves typically have U shaped or bell curve shaped deposits. The hot spot is in the center of the U or bell curve. Valve edges sometimes turn green at the hot spot. Late stage valves should be removed from service.

Burned Valve From Above Redline CHT

These valves had known operation in excess of redline CHT. High CHT typically results in two hot spots 180 degrees apart. Left and center photos are the same valve taken 47hrs apart. The uneven heat signature and head crack were not present right after the CHT event. Damage was not immediately apparent!

Valve Rotator Parts



The rotator shown is a garter spring type found in most Continental engines. Most uneven heat signatures occur when the rotator stops working.When the valve stops rotating, the wear is concentrated in one spot on the edge of the valve. This leads to reduced heat transfer into the cylinder head and a subsequent hot spot.

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