March 2008

The Oil Report

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How to Inspect Your Aircraft Oil Filter

By John Schwaner, Sacramento Sky Ranch

When we find metal in an oil sample, we often recommend you inspect the oil filter for metals. But how should you do it? And what, exactly, are you looking for? If you find metal, how can you tell what part it’s from? The following information comes courtesy of Sacramento Sky Ranch, www.sacskyranch.com. In addition to the information we’re reprinting here, they have many other informational articles on maintaining and troubleshooting aircraft engines.

Figure 1: Filter holder

Figure 2: Filter in a vice

1. Hold the oil filter, either in an oil filter holder shown in figure 1 or in a vise as shown in figure 2. The filter holder in photo 1 can be purchased at www.cancutter.com.

2. If you have a filter holder, it can be mounted in a vise or mounted to a work-bench: Drop the filter into the holder and the nut engages into the hex and locks it into position. If you’re using a vice to hold the oil filter, you need to really tighten the vise to prevent the oil filter from slipping sideways while you cut it open.

3. Squeeze and slightly rotate the can cutter to completely pierce the shell. Once pierced, rotate the cutter one time around the oil filter (Figure 3).

4. Lift the top off (Figure 4). Notice the nice chocolate brown color of the oil. We know from the color of this oil that the engine has good piston ring compression. If it didn't, the oil would be black—black like black lacquer paint. We also know that the engine has not operated for too long between oil changes as the oil would be darker than this.

5. Examine the metals. When I first started examining oil filters I would cut the can open and then cut out the paper filter media with a sharp knife. Aviation oil filters use thick, tough paper and I thought eventually I would cut off a finger trying to cut out the paper media. A better and safer method is to place the filter media into a coffee can with some solvent (Stoddard solvent, if you can find it) and shake well; This rinses the debris from the filter paper. Pour the solvent mixture through a coffee filter and let dry. Drag a magnet under the coffee filter to separate out the iron from the rest of the stuff on the coffee filter.

Figure 3: Cutting off the top

Figure 4: Taking a peek inside

Aircraft Oil Filter Media Condition

One inspection item that is often overlooked when inspecting the oil filter is inspecting the condition of the filter paper. As the filter media ages or is exposed to excessively hot temperatures, it gets dark and brittle. Normal filter media should retain its light yellow/tan color and not break apart when bent.

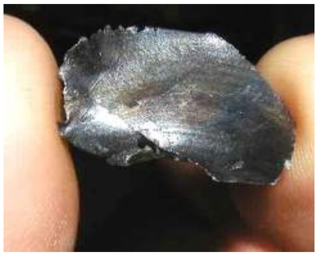
Non-turbocharged: Tan/yellow colored, small amounts of hard carbon. Filter paper should not be brittle. Dark filter media without significant hard carbon means the filter has not been changed often enough. Dark filter media with significant amounts of hard carbon indicate high oil temperatures. Suspect compression blow-by, or poor engine baffle.

Turbocharged: Tan/yellow to dark colored with more amounts of hard carbon. If filter media is brittle then filter should be changed more often or oil temperatures should be reduced.

Appearance of Metals in the Filter/Screen

Chunks

Dents and deformation indicate secondary damage has occurred when chunks wedged and jammed between moving engine parts. With secondary damage two or more separate damage sites may exist in engine. Evidence of fatigue markings indicates chunk originated from a primary failure point. Brittle fracture indicates impact failure from some other failed part. Any chunks larger than the oil filter pick-up screen will not be in the oil filter. Your oil filter is the second filter in the system.



You'd hate to find this in your oil filter or screen!

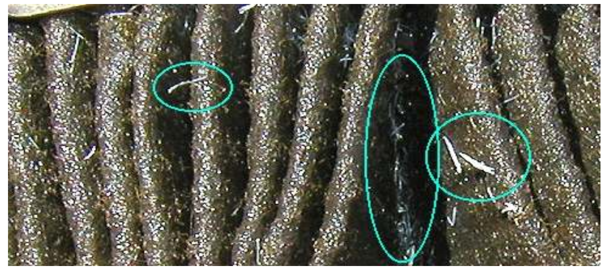
Melted
Melted aluminum globules indicate pre-ignition or detonation damage. The source is usually a piston.

Slivers
Small flat slivers are most likely tin or chrome, though they can also be aluminum (see the picture below). Probable source of tin is washers. Particularly on Continental engines, the rocker arm thrust washer is suspect. Usually this is not cause for concern. Cut and gouged slivers indicate metal on metal gouging, and the source should be identified. Large amounts of bronze slivers in Continental engines are most likely from starter adapter gear. Continental's IO-520-AE doesn't use a bronze starter adapter gear.

Platelets
Flat round steel slivers with possibly small cracks at the edges are from roller fatigue. The most probable source is camshaft lobes and camshaft followers. Chrome flaking off of chrome-plated cylinders is another source for platelets. Babbitt flaking off the bearings will also create platelets.

Carbon deposits
Carbon or varnish deposits indicate the source was in a high temperature.

Metallic
Very small metallic particles found in the oil are best seen in bright sunlight. Take an oil sample out into the sunlight. Any small metallic particles, such as microscopic particles of brass, will reflect sunlight. Indoors the same particles may be invisible.



Small aluminum slivers from the piston pin plugs on a Lycoming O-320-H2AD engine.

Identifying Particles

Aluminum
Sodium hydroxide dissolves aluminum. It fizzes! Sodium hydroxide doesn't react with steel, bronze, or tin. A good source for sodium hydroxide is Drano or Red Devil drain cleaner (the powder kind). I prefer Red Devil since it is 100% sodium hydroxide. If you mix some Drano in water and then place a drop on aluminum, the drop will sit there awhile while it works its way through the oil film on the aluminum. As soon as it contacts aluminum it will start to fizz. Since sodium hydroxide doesn't react with steel, bronze, chrome or tin, it is an excellent check for aluminum. I have even used it on an engine bearing and then watched through a microscope. If the little embedded particles start to fizz then they are aluminum particles embedded into the bearing.

Bronze or Copper
When mixed with nitric acid, these particles will react to form green liquid.

Chrome
Chrome is hard, brittle, and a plated material. Pieces of chrome are small and flat with broken edges. Chrome is usually seen as many small shiny particles. Hydrochloric acid reacts with chrome, usually making the liquid green. Nitric acid has no effect on chrome other than reducing the chemical reactivity of its surface.

Glass beads
These look like small round "fish egg" spheres when viewed under a magnifying glass.

Hard carbon
Breaks apart when squashed. Can be squashed between fingernails.

Inconel (an alloy of nickel, chrome, and iron)
Does not react with nitric acid.

Lead
Dissolves in nitric acid. These particles are often from leaded fuel and condense into small glass-like globules (metallic lead) in the exhaust system. Lead crystals will squish between your fingernails.

Plastic beads
These are abrasive beads used to strip paint from airplanes. They are sometimes used on some engine parts, such as crankcases. There are several types of plastic beads, and they have different appearances. They can have a white frosted appearance. Colored plastic is fractured, with smooth bright surfaces. Plastic beads will not scratch glass.

Lead crystals from leaded fuel
These glass-like crystals may be mistaken for glass beads. They will dissolve in water and are usually found in the exhaust port of cylinders on engines operating on leaded fuel.

Magnesium
When mixed in a solution of 25% hydrochloric acid and water, magnesium fizzes immediately on contact and forms a black deposit. 25% Nitric acid turns magnesium black.

Minerals
Small colored crystals with fractured surfaces. If found in engine, check the induction system carefully in the crooks and crannies. If found in

the induction system then source of minerals was through ingestion.

Monel (an alloy of copper and nickel)
Nitric acid turns metal blue-green. Steel rod rubbed in the solution will turn copper-colored.

Silica (sand)
Place between glass slides and rub together. Silica scratches the glass.

Silver
Mix with nitric acid. Slowly reacts to form whitish silver nitrate fog in acid.

Steel
Particles can be isolated with a magnet. Copper sulfate dissolved in dilute sulfuric acid. Turns steel copper color. Nitric acid in various concentrations etches steel. The higher the concentration of nitric acid the darker the reaction etch. Nitrided steel surfaces react very slowly.

Tin
Heat a knife to red hot and place against the particle. If it’s tin, it will melt. Hydrochloric acid immediately causes tin particles to fizz. Pieces of tin will float to the top of the bubble. Nitric acid causes tin to turn slightly dark with some bubbles attached. Hydrochloric acid turns tin into stannous chloride and hydrogen gas. Tin will not be attracted to a magnet.

Wire
Measure diameter. Small diameter wire may be from hoses. Wire with one fractured end and one rounded end is from wire wheel. Likely source is bits of safety wire left on workbench that finds its way into engines.

Where did the metals come from?

Possible sources of bronze and brass

- Starter adapter gear in Continental aircraft engines that use a starter adapter. An exception is the TSIO-520-AE, which uses an aluminum starter adapter spring.
- Bushings can be a source for bronze
- Very small, fine bronze bits in Continental engines, check the valve guides. If the engine has the older aluminum bronze exhaust guide (still common on the "E" series engines) and has chrome faced exhaust valves (not part number 626540) the chrome stem can gall the guide. Aluminum bronze guides look the same as the intake guides.
- Intake guide seal on "E" series engines.
- Brass bushing in oil pump on Continental "E" series engines such as the E185 and the E225 aircraft engine
- Lycoming's done it again—trying a bronze piston pin plugs. It didn't work too well the first time so if you see bronze shavings check the piston pin plugs. You about have to remove cylinders to inspect them.

Possible sources of chrome

- Cylinder walls. Check to see if you have chrome cylinder barrels. Borescope the cylinders. Chrome from cylinder walls can be caused by seizing of rings or piston onto the barrel, mechanical abrasion from failed piston assembly, or an excessively rough chrome surface. An excessively rough chrome surface will abrade a penny dragged across the surface. Rough chrome will lock the piston rings in place, preventing ring movement or rotation. There will be a fine dark line down the cylinder barrel where the ring gap was located against the barrel surface.
- Piston rings. Fatigue failure of ring surface will cause small flakes of chrome plating to separate from the ring surface. This failure is caused by an excessively rough or pitted cylinder barrel.
- Exhaust valve stem. Continental engines with Nitralloy exhaust valve guides will occasionally strip chrome from the valve stem. Note: Nitralloy exhaust guides have been discontinued in Continental engines and are not currently used although there are still many operating engines using these guides. High levels of chrome in aircraft oil samples is somewhat unusual. Chrome produces flakes that often don't end up in oil samples since they settle out in the oil sump.

Possible sources of aluminum

- Lycoming aircraft engines: Piston pin plugs are a typical source of aluminum.
- Continental’s IO-520-AE (only the AE): Aluminum starter adapter gear.
- Continental piston pin plugs in Ceramic chrome cylinders.
- Aluminum granules: Piston or cylinder head burning from pre-ignition.
- Chunks: Possibly piston ring land or piston skirt.
- All engines: A loose exhaust guide in the cylinder.
- Lycoming 540 series: Left magneto adapter bearing.
- Lycoming crankshaft idler gear (P/N LW-13796) shaft and the attaching hardware may be loose, allowing the shaft to rotate, wiggle, and elongate in the engine crankshaft hole.

Possible sources of steel
On Continental aircraft engines with a starter adapter, possibly the starter adapter spring has wound off the drum and is scoring the steel flange and creating cut shavings. Do not fly aircraft until the problem is identified and a determination of aircraft airworthiness is made.

Possible sources of long, brass slivers
A mixture of ground-up steel and long hair-like copper slivers is from the Continental starter adapter. Spring failure of the starter adapter allows the spring end to cut brass slivers from the starter adapter gear. The spring also cuts steel from the starter adapter housing cavity.

The purpose of this article is informational only. This is not meant to be an exhaustive troubleshooting list, and further identification of metals may be necessary to determine the airworthiness of the aircraft. Metals or filter pleats can be sent to Howard Fenton at 918/492-5844 for identification. Blackstone Laboratories assumes no responsibility for determining the airworthiness of any aircraft or for troubleshooting the metals found in an oil filter, screen, or oil samples.

Report of the Month

This is a sample from a Continental A-65. Metals read high -- but why? Take a guess, then look at the caption below to see if you're right.

(To learn where the various elements might be coming from, click here.)

Elements in Parts Per Million

		UNIT/ LOCATION AVERAGES					UNIVERSAL AVERAGES
MI/HR ON OIL	12		9	29			
MI/HR ON UNIT	649		637	628			
SAMPLE DATE	01/21/08		01/08/08	11/13/07			
ALUMINUM	9	27	**64**	8			10
CHROMIUM	88	224	556	27			17
IRON	59	114	**253**	**29**			62
COPPER	4	9	19	5			25
LEAD	446	1667	**1481**	**3074**			1331
TIN	6	16	43	0			4
MOLYBDENUM	0	0	0	0			0
NICKEL	1	2	4	1			1
POTASSIUM	0	0	0	0			0
BORON	0	0	0	0			0
SILICON	10	14	26	6			10
SODIUM	0	0	0	0			1
CALCIUM	0	1	3	0			2
MAGNESIUM	0	0	1	0			2
PHOSPHORUS	7	6	10	0			185
ZINC	0	0	0	0			4
BARIUM	0	0	0	0			1

PROPERTIES

		Values Should Be				
SUS Viscosity @ 210	91.0	86-105	97.4	91.0		
cST Viscosity @ 100C	18.23	17.0-21.8	19.74	18.21		
Flashpoint	515	>460	545	460		
Fuel %	<0.5	<1.0	<0.5	TR		
Antifreeze %	-	-	-	-		
Water %	0.0	0.0	0.0	0.0		
Insolubles %	**0.3**	<0.6	0.6	0.3		

You'd freak if you got numbers like these back in your analysis, right? But this is a prime example of how an aircraft engine can turn around. At the end of 2007, this engine went in to have some work done: namely, a cylinder was pulled due to a stuck valve. They reseated the valve with lapping compound but -- yikes! -- didn't get the lapping compound properly cleaned out of the engine. You can see the high metals that resulted from the abuse. But one oil change (and a thorough cleaning) later, the engine is on the road to recovery. With frequent flying, frequent oil changes, and a little TLC on the part of the operator, many problems can take care of themselves.