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PERFORMANCE AIR-COOLED CYLINDERS AND SLEEVES

UNDERSTANDING THE PCV AND AOS SYSTEMS

BY TONY CALLAS

Generally speaking, all Porsches 1978 and newer are equipped with a Positive Crankcase Ventilation (PCV) type emissions device, meaning the engine crankcase has a vacuum source supplied to it from the intake manifold. This is to collect and burn the residual combustion by-products known as “blow-by”. “Blow-by” is combustion forced past the pistons and piston rings into the crankcase. Blow-by in the crankcase is then consumed by running it through the engine again, in an effort to lower the overall vehicle emissions.

On the Mezger based flat 6 air cooled engines built from 1964-1998, these dry sump type oiling systems normally do not require an Air Oil Separator (AOS), but all water cooled naturally aspirated 9X6, 9X7 and 9X1 Sports-Cars equipped with the water-cooled M96, M97 and MA101 engines (1997-2017) require this device for AOS diagnostics (Except for the GT2’s, GT3’s and Turbo models). The AOS directly affects the engine crankcase atmosphere by applying a very small vacuum to it by the nature of its job; it should be named a vacuum-oil separator. In most situations when the AOS fails, intake vacuum in the engine crankcase rises to an unusually high value. More often than not, this high vacuum ends up drawing engine oil into the intake system causing excessive exhaust tailpipe smoke. This heavily laden oily air mixture can foul spark plugs, contaminate oxygen sensors, catalytic convertors and even possibly ruin various other sensitive engine management components, e.g. the Mass Air Flow sensor (MAF). Even when the PCV system or AOS is functioning correctly, valve guide and piston ring wear, as well as cylinder ovality, all contribute to oil consumption caused by excessive blowby. However, even a healthy engine might consume oil. Remember, Porsche states that one quart in approximately 600 miles is an acceptable level of oil consumption in a modern engine with low tension rings. There are several contributing factors including fuel dilution, however with modern oils volatility is the primary contributor to oil consumption and PCV/AOS failures.

Have you ever torn down a motor and seen oil in the intake manifold? How about an intake valve dirtier than an exhaust valve? Ever wondered why that is? The one word answer is “volatility.” This refers to how much vapor a motor oil releases when it gets hot. Just as how water vapors rise off a pot of water before it begins to boil, the same thing happens to motor oil inside your engine. As oil splashes onto the pistons and valve springs to keep them cool, the high temperature causes some of the oil to evaporate. Modern engines have a positive crankcase ventilation valve that vents these oil vapors into the intake manifold. The oil vapors condense in the cool air/fuel mixture, which leaves the oily deposits in the intake manifold and on the intake valve.

So what can you do? Using a lower volatility motor oil is the first line of defense. Fewer oil vapors mean not as many make it into the PCV system in the first place. More oil is then kept in the crankcase where it belongs. Secondly, not overfilling your engine and keeping the oil level closer to the min. fill level will further reduce windage in the crankcase, reducing load on the PCV system.

These two steps will reduce the amount of oil getting into the intake tract. Obviously a cleaner intake valve will flow better, providing more power and better fuel economy than a dirty valve. These steps also reduce oil consumption, which helps to protect O2 sensors and catalytic converters from damage due to excessive oil consumption. Specialty oils like Driven DT40, DI40, and DT50 feature a high quality base oil, reduce oil consumption AND contain more ZDDP for better engine protection. The O2 sensors and catalytic converters don’t know how much ZDDP is in the motor oil so it stays where it should – in the crankcase lubricating your engine. These oils can contain 50% more ZDDP since the volatility is 67% less than standard base oils. The higher quality base oil delivers better all around protection and performance.
Even with the right oil, faulty or dirty injectors can contribute to cylinder bore wash-down, further reducing ring seal, allowing for increased blowby and contamination of the engine oil, all which have a negative effect on performance. Regular use of Top Tier fuels, such as Shell V-Power, and fuel system cleaners like Lubro-Moly Jectron or Driven Injector Defender will protect your port injected engine from intake and combustion chamber deposits.

Direct injected engines, like those found in 2009 and later Boxster, Cayman, and 911 models as well as Cayenne models since 2008 and all Panamera models, do not have the benefit of port injection to keep intake ports and the intake valve clean. As a result, the use of a low-volatility oil is even more important. Driven DI40 is a specially formulated oil that is designed to have very low volatility, meaning you end up with less intake port and valve deposits. Like with most modern Audi, BMW, Mercedes, and Volkswagen engines with direct injection, expect to have your intake ports and valves cleaned using a process done by the dealership and independent technicians, whereby walnut shell media is used to blast and vacuum these deposits away. But again, using the right oil will minimize the buildup and extend the performance of your direct injected engine and continued use of Top Tier fuels and fuel system cleaners will ensure combustion chamber and piston deposits are minimized.

For modern Porsche engines utilizing an AOS, measuring the crankcase vacuum is an excellent way to test for overall engine health as well as for the condition of the AOS. The only way to definitively test the AOS is to measure the engine crankcase vacuum with a slack tube tester or Manometer (an ultrasensitive vacuum gauge). On the 9X6 and 9X7 Porsches, the engine crankcase vacuum reading is normally in the region of -4.0” to -6.0” H2O (Inches of water). When an oil separator fails, the crankcase vacuum can rise to -10.0” to -15.0” H2O, or even much worse (-40.0” H2O) depending on the extent of AOS failure.

On the 9X7.2 and 9X1 Porsches, the engine crankcase vacuum reading is normally in the region of -14.0" to -16.0" H2O (Inches of water). When an oil separator fails, the crankcase vacuum can rise to -20.0" to -25.0" H2O, or even much worse (-30 to -40.0" H2O) depending on the extent of AOS failure.

Normally vacuum is measured in inches of Hg (Inches of Mercury) but in this case we measure it in H2O (Inches of water). Water is much lighter that Mercury.
When the air oil separator starts to fail on a Boxster (986-987), you will generally start to see a substantial amount of tailpipe smoke on cold engine start-up. When the oil separator finally fails, the exhaust tailpipe smoke can reach epic proportions; almost like it is manufactured from an anti-mosquito smoke machine. On the 996's & 997's, when the oil separator fails, it usually doesn't create much exhaust tailpipe smoke, if any. It's almost like a silent killer or costly surprise. It is a good idea to check your vacuum reading at each engine service to monitor the health of your AOS.

However, there are instances other than tailpipe smoke that can indicate your AOS is going bad. Two such symptoms caused by an early failing non-symptomatic AOS are ignition misfire and fuel trim faults. On 2005 and older models the DME fuel trim monitor does not operate immediately from cold start-up but the misfire monitor typically does. If the AOS is in its early stages of failure, it can produce some very high vacuum values i.e. -40.0" H2O, but only for the first 3 minutes of cold engine operation, usually without any trace of tailpipe smoke. Hence the AOS can cause a lean running condition that can affect the fuel trim values but without any other symptoms. You can get misfire faults and the check engine light (CEL) will be illuminated but there are virtually no other symptoms. This is where having tools such as a Durametric along with the CR Tools AOS Analysis Tool can help you diagnose and catch an AOS failure before serious engine damage can occur.

Normally when an AOS fails, it can cause a lean running condition that will most likely illuminate the CEL. The only way to really know what's happening is to measure the crankcase vacuum and then monitor the fuel trim numbers in the Actual Values section of the Digital Motor Electronics (DME) with a high quality scan tool/tester to see exactly what's going on, otherwise you're just guessing. So what do the readings actually mean?

LOW VACUUM READING:

-Missing engine oil cap and or oil cap O-ring.

-Cracked or broken spark plug tubes, if applicable.

-Disconnected or broken dipstick tube, if applicable.

-Make sure the oil dipstick is fully seated, if applicable.

-Anything that can leak air can leak oil and vice versa.

-Torn AOS boot, broken or cracked oil filler tube, Dipstick and/or crankcase crossover accordion pipe.

Please note: These readings are at Sea-Level and at operating temperature. With elevation these readings should be lower in value due to thinner air.

SPORTS-CAR NOMINAL VACUUM READING:

M96 & M97 Nominal crankcase vacuum is -5.0" (-4.0" to -6.0") of H2O (not HG).

MA1 Nominal crankcase vacuum is -15.0" (-14.0" to -16.0") of H2O (not HG).

HIGH VACUUM READING:

The only thing that can cause an excessively high manometer vacuum reading is a faulty AOS and or sludge.
The result of a faulty AOS (with high vacuum readings) will sometimes cause the engine to make a honking like sound; this is caused by vacuum/air being forced backwards past the crankshaft seal(s). Note: this does not have to be accompanied by tailpipe smoke. More often than not it is non-symptomatic. A high vacuum reading is an internal vacuum leak and this causes a lean running condition usually leading to an illuminated check engine light (CEL).

A failed AOS (with high vacuum readings) can cause the engine oil pressure warning light to illuminate. This is usually from too low of engine idle, a cause and effect condition created by a faulty AOS.

If the AOS has a catastrophic failure and causes a hydraulic lock condition do not panic, remove all the spark plugs, turn engine over slowly by hand with wrench, get engine oil out of the cylinders slowly and gently. Perform engine leak down and compression tests on all cylinders to confirm engine condition and then replace spark plugs with new. Remove exhaust muffler(s) and drain engine oil from exhaust system. It is always recommended to remove central resonance tube from intake manifold to remove engine oil with a vacuum device (e. g. Mighty-Vac), complete assembly, replace faulty AOS and start engine. Run automobile at idle in a safe area until smoke subsides. Be forewarned, it will smoke a lot.

ABOUT THE AUTHOR:

Tony Callas grew up in his father's shop, Rennsport Porsche Works, in Sealy, Texas, and demonstrated mechanical talent at a very young age. At 10, he was servicing Porsches; at 16, he rebuilt his first engine; at 18, he went to the Porsche Factory School and began teching race cars on weekends. In Los Angeles, Tony mentored under Adrian Gang at Edelweiss Porsche, Alwin Springer of ANDIAL, and the renowned Vasek Polak. Then, in February of 1993, the dream of Callas Rennsport became a reality with the opening of a one-bay shop at 24714 Crenshaw Boulevard in the Skypark Shopping Center. Quickly outgrowing this location, Callas expanded to our Hawthorne Boulevard address on Car Row, where we continuing growing today.

The Callas legacy includes an international racing history with Roock, Seikel, Champion, Peterson White-Lightning, and wins at the 24 Hours of Daytona and Le Mans, where Tony was Mechanic of the Year for Porsche in 2001.

Today, in addition to our service work, Callas Rennsport restores classic collector cars, including vintage 914s and 356s, and is one of two premiere shops in the country that service the 959s. Tony has been recognized by Porsche Classic for his contributions to our community. Tony and his crew are proud of who they are and what they do and it shows in everything they do.

Callas Rennsport is an IMS Solution Certified Installer and Tony Callas is an instructor for The Knowledge Gruppe and SSF Auto Parts. Tony also runs the Porsche Assistance group for independent and dealer technicians, supporting those who live and work to maintain our Porsche vehicles. To learn more, please visit https://www.callasrennsport.com/