2003 Audi A4 testing

An Audi A4 equipped with a 1.8L AMB turbocharged engine was in for service. The owner had just received it back from his kid, indicating it was neglected, having few if any oil changes performed. The services requested were an oil change, checking the air bag system, and advising on the check engine lamp.

An oil & filter change was performed using oil meeting the VW specification. By the oil reminder, it was due for an oil service at 128, 582 miles or 8/2/2011. The mileage was 132,016 on 8/6/2012 when the LOF was performed. After the LOF, codes were pulled from the SRS and ECM. A 01218 side airbag igniter (N200) upper limit exceeded code was retrieved from the SRS. The ECM had 9 codes on the generic side, and 18 VAG codes. Below are images of the printouts of the codes and freeze frame.

VAG codes

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                 Address 01: Engine        Labels: None
Control Module Part Number: 8E0 909 518 AF    HW: 8E0 909 018 A
  Component and/or Version: 1.8L R4/5VT     G   0002
           Software Coding: 0016751
            Work Shop Code: WSC 63351 000 00000
                      VCID: 74EC706B14A00F4
18 Faults Found:

16684 - Random/Multiple Cylinder Misfire Detected
            P0300 - 002 -  - Intermittent
16685 - Cylinder 1
            P0301 - 002 - Misfire Detected - Intermittent
16686 - Cylinder 2
            P0302 - 002 - Misfire Detected - Intermittent
17887 - Brake Boost Vacuum System
            P1479 - 008 - Mechanical Failure - Intermittent
16687 - Cylinder 3
            P0303 - 002 - Misfire Detected - Intermittent
16688 - Cylinder 4
            P0304 - 002 - Misfire Detected - Intermittent
17544 - Fuel Trim: Bank 1 (Add)
            P1136 - 001 - System too Lean - MIL ON
16712 - Knock Sensor 1 (G61)
            P0328 - 001 - Signal too High - Intermittent
16891 - Idle Control System RPM
            P0507 - 001 - Higher than Expected. - Intermittent
16683 - Boost Pressure Regulation
            P0299 - 002 - Control Range Not Reached - MIL ON
17736 - Knock-Control: Cylinder 4
            P1328 - 001 - Regulation Limit Exceeded  - Intermittent
16717 - Knock Sensor 2 (G66)
            P0333 - 001 - Signal too High - Intermittent
17735 - Knock-Control: Cylinder 3
            P1327 - 001 - Regulation Limit Exceeded  - Intermittent
17734 - Knock-Control: Cylinder 2
            P1326 - 001 - Regulation Limit Exceeded  - Intermittent
17733 - Knock-Control: Cylinder 1
            P1325 - 001 - Regulation Limit Exceeded  - Intermittent
16395 - Bank 1: Camshaft A (Intake)
            P0011 - 002 - Retard Setpoint not Reached (Over-Advanced) - Intermittent
17978 - Engine Start Blocked by Immobilizer
            P1570 - 008 -  - Intermittent
17519 - Oxygen (Lambda) Sensor Regulation: Bank 1
            P1111 - 002 - System too Lean - MIL ON

Readiness: 0000 1001

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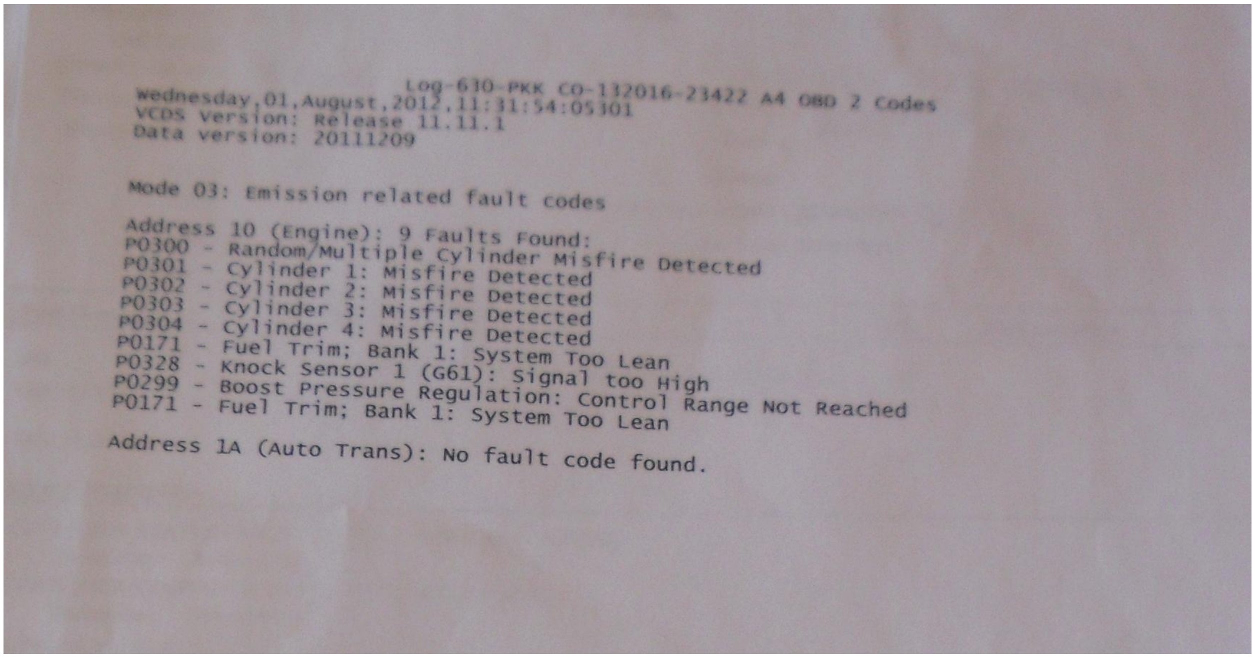
OBD codes



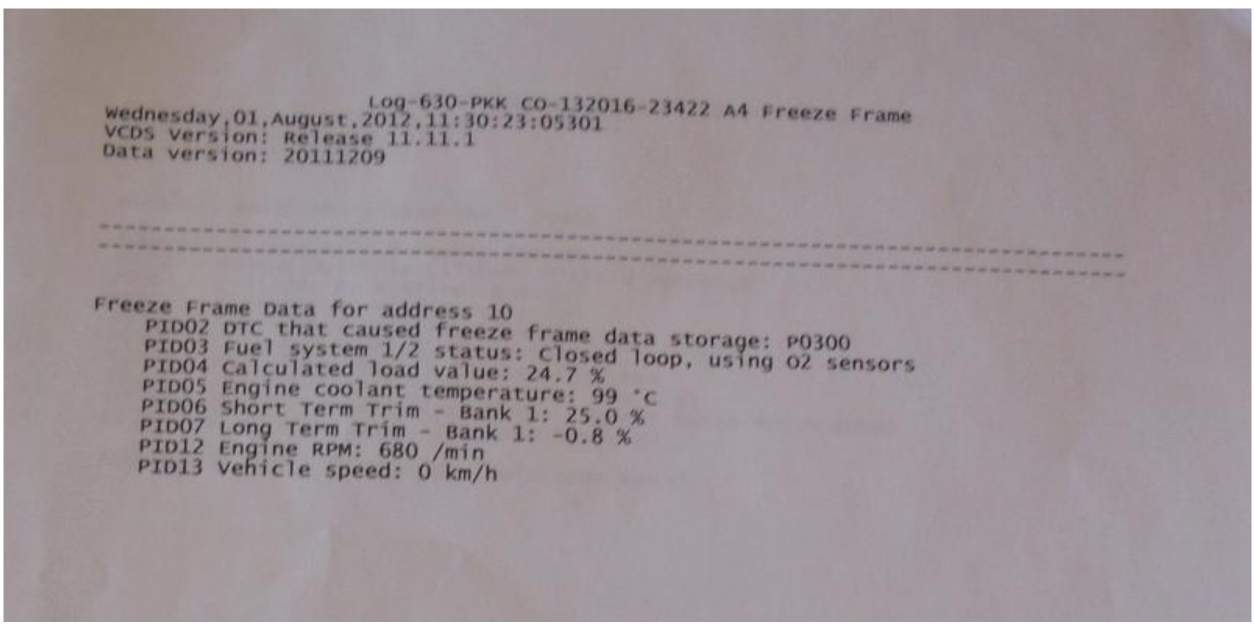
Log-630-PKK CO-132016-23422 A4 OBD 2 Codes
Wednesday,01,August,2012,11:31:54:05301
VCDS Version: Release 11.11.1
Data version: 20111209

Mode 03: Emission related fault codes

Address 10 (Engine): 9 Faults Found:
P0300 - Random/Multiple Cylinder Misfire Detected
P0301 - Cylinder 1: Misfire Detected
P0302 - Cylinder 2: Misfire Detected
P0303 - Cylinder 3: Misfire Detected
P0304 - Cylinder 4: Misfire Detected
P0171 - Fuel Trim; Bank 1: System Too Lean
P0328 - Knock Sensor 1 (G61): Signal too High
P0299 - Boost Pressure Regulation: Control Range Not Reached
P0171 - Fuel Trim; Bank 1: System Too Lean

Address 1A (Auto Trans): No fault code found.

Freeze frame



Log-630-PKK CO-132016-23422 A4 Freeze Frame
Wednesday,01,August,2012,11:30:23:05301
VCDS Version: Release 11.11.1
Data version: 20111209

Freeze Frame Data for address 10
PID02 DTC that caused freeze frame data storage: P0300
PID03 Fuel system 1/2 status: Closed loop, using O2 sensors
PID04 Calculated load value: 24.7 %
PID05 Engine coolant temperature: 99 °C
PID06 Short Term Trim - Bank 1: 25.0 %
PID07 Long Term Trim - Bank 1: -0.8 %
PID12 Engine RPM: 680 /min
PID13 Vehicle speed: 0 km/h

Testing started by clearing the SRS fault code, it returned immediately indicating a hard fault. Since, the air bag concern was only one code, testing focused on the engine fault codes. With 18 fault codes getting a clear direction on what to test can be difficult. I decided to do three things. First was clear the codes to see which returned, next was to try to run basic settings, and then take a look at the engine health with a pressure transducer.

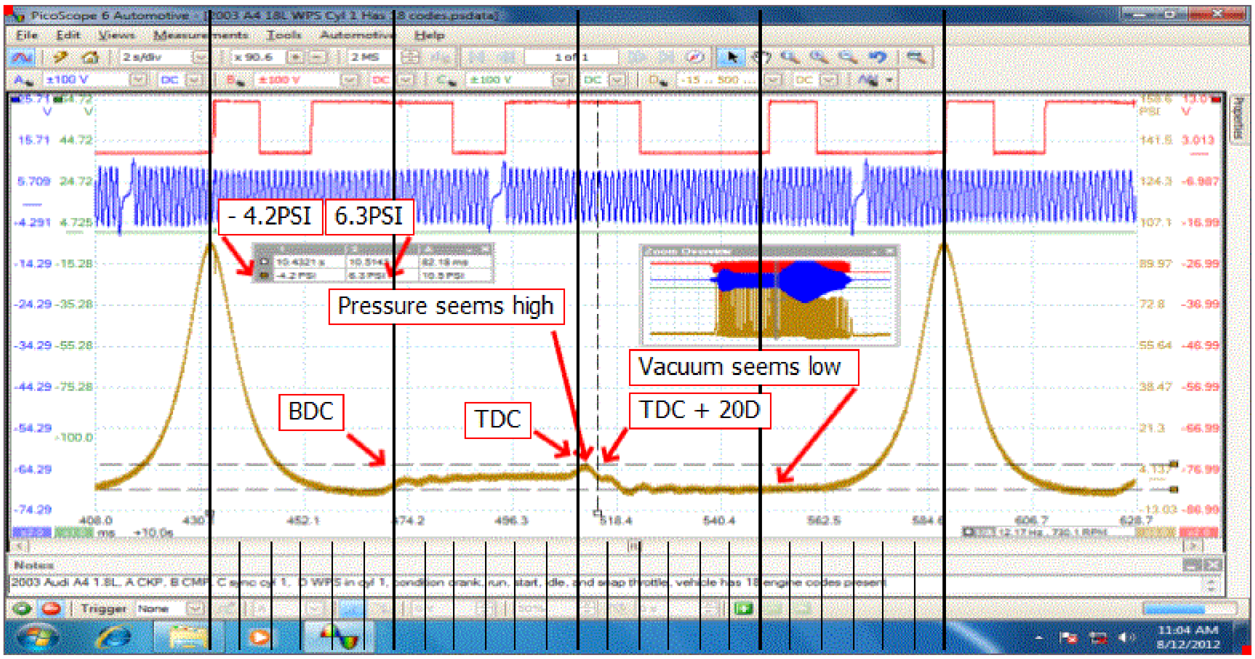
A test drive was performed, and the vehicle was very low on power. Two fault codes returned P1479/17887, and P0299/16683. In the bay fuel trim was observed at +25 at low speed. At higher throttle the correction was less. Revving the engine like this was performed a few more times. One time, the oil light started flashing. The engine was shut down then started again and the oil light was out now. The way the 1.8L is mounted the oil pickup is prone to becoming restricted.

Testing continued by clearing codes again and attempting to perform basic settings, the throttle body and kick down adaption worked. Next was entering 04/001, to proceed the engine needs to be warm, and the correction in a window of plus or minus 10 percent. The correction was at +25 checking the codes again a P1711/17519 oxygen sensor regulation fault was present.

Next, engine health was inspected by placing a pressure transducer in the place of the spark plug on cylinder one. A running compression test was performed. If the cam timing is out a large amount, this can be determined using software that marks the pressure peaks BDC, TDC and TDC + 20 degrees. This can be done without the software using some math. Measuring the time between the two peaks, and multiplying by .25 will indicate BDC. Multiplying the two peaks by .50 is TDC. TDC + 20 ((360+20)/720) it is not an exact number rounded up is .53 the markers for both BDC and TDC + 20 should be near the top of the transitions if the cam timing is good.

A lot more than cam timing is displayed in the waveform, in this case I saw two potential faults. The pressure rise before the intake seemed high. Also, the vacuum during the intake portion seemed low. In the Denver metro area, a good vacuum reading is in the 15 to 17"HG range, with an actual barometric pressure usually in the 24 to 25 "HG range. A traditional vacuum gauge was connected to the intake manifold. A reading of 8"HG was recorded. In addition the back pressure of the exhaust was tested with the upstream exhaust sensor removed. A peak reading between 14 and 18PSI was recorded. At this point I was not certain if back pressure testing on a turbo equipped vehicle was different than a traditional naturally aspirated engine. At this point, I posted a question on it in international technician network (IATN) in the technical theory forum. Below are images of testing.

Pressure transducer cylinder 1

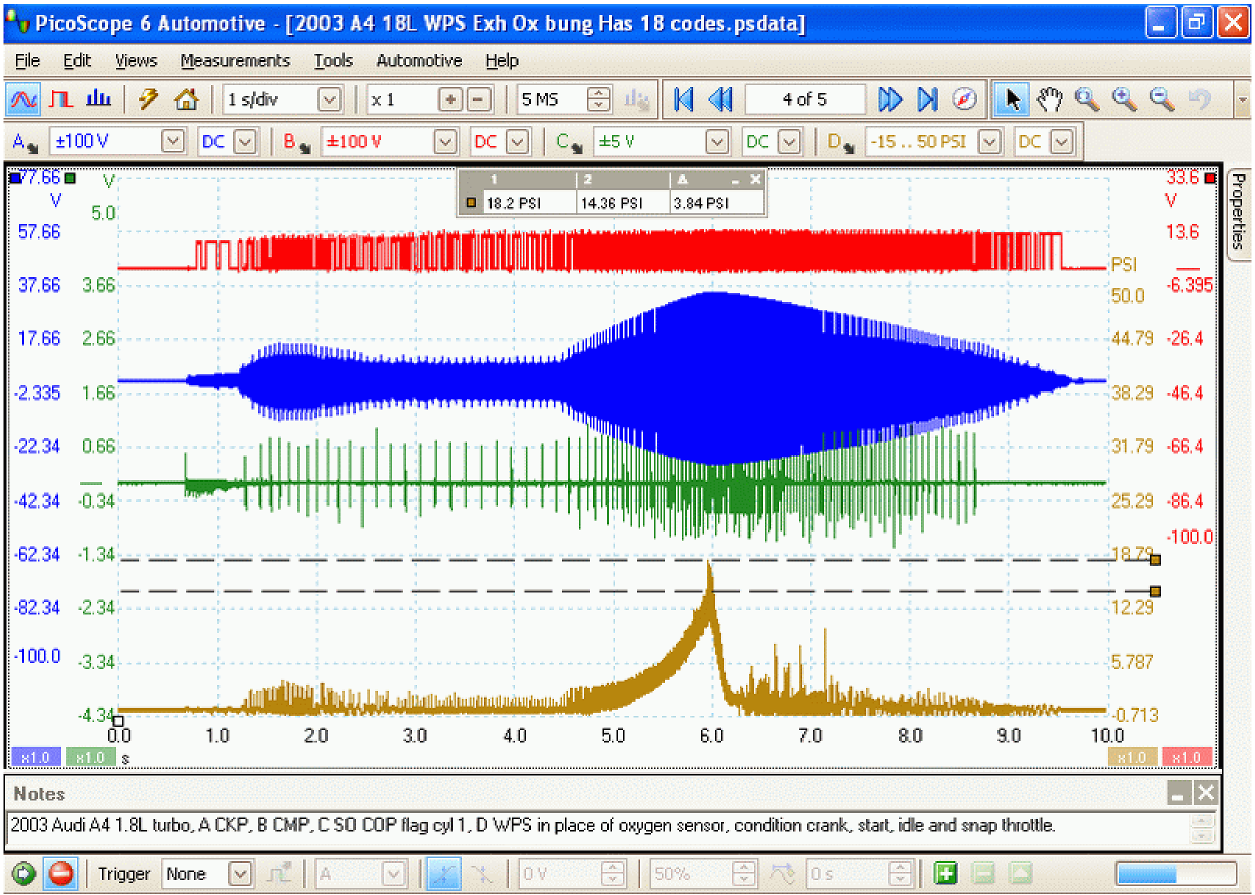


The test was to place a pressure transducer in cylinder one then crank, start, idle and then perform a snap throttle. Four channels are displayed yellow is the pressure sensor, red is the camshaft position sensor, blue is the crankshaft position sensor and green is an ignition sync to cylinder one. The wave form presented is at idle. In this image the BDC marker is typical of good exhaust camshaft timing. The TDC plus 20 is questionable, indicating a possible fault with the intake camshaft timing. The sync for cylinder one is not very clear, but it appears ignition spark is taking place after the compression event. This may also indicate a fault most gasoline engines have spark occur before the compression peak.

Vacuum gauge in intake

A vacuum gauge was tied in, using a tee at the front on the intake manifold. A good reading at sea level is 20'HG. Vacuum decreases as the altitude increases. A good reading at the elevation tested is 15 to 17"HG. The value recorded is definitely low.

Back pressure



This test was again crank, start, idle then snap throttle. The connection for blue, red and green remained the same capturing crank / cam sensor and cylinder one ignition. Yellow, is now the pressure transducer connected into the exhaust in place of the upstream exhaust sensor. This allows direct pressure testing of exhaust system.

At the same time the Audi was being tested, there was also a 2002 Volkswagen Beetle equipped with a 1.8L turbocharged engine in for service. This vehicle had the catalyst replaced some time back and should allow a known good back pressure test. The configurations are not identical. The Bug is a transverse mount while the Audi is a longitudinal mount. This creates a little bit off a difference in the exhaust routing. It still would be at least something to compare values. Below are images of the exhaust differences and the result of the back pressure test on the Beetle.

Audi exhaust

The catalyst is mounted directly after the turbocharger on the Audi.

Beetle exhaust

The catalyst on the Beetle is mounted further down than the Audi. This image also displays the pressure transducer used during testing and the test connections.

Beetle back pressure results

In this waveform only the exhaust back pressure and the battery voltage was recorded. The test conditions were the same crank, start idle and then a snap throttle. The peak exhaust back pressure was only 4.2PSI. The original test on the Audi the peak pressure was between 14 and 18PSI. At this point it was good idea to take a look at the front of the catalytic converter on the A4.

Cat inspection

This image is of the inside of the catalytic converter using a video inspection device connected to a monitor. The image is not perfectly clear on the monitor but does indicate a problem is present with the cat. A good cat will have a honeycomb shaped substrate. This cat appears to be damaged. A damaged cat can increase the backpressure present resulting in poor performance.

Cat inspection another view

Viewing the cat directly from the video inspection device is little more defined but the screen is much smaller. The catalyst was observed by removing the exhaust sensor and using the 90 degree camera.

Before selling a catalyst, authorization was received to remove the valve cover and inspect the engine top end. Due to the lack of service, and the oil lamp coming on, it was possible the engine was full of sludge. If the engine was full of sludge, it would be better to find out before the cat was replaced. The worst case scenario being if the engine was full of sludge it would likely need to be replaced.

Also, worth noting is the damage present on the cat is typical of misfires being present. There were codes for misfires present among the 18 codes present. At the time of testing the vehicle was not misfiring even though engine performance was poor. The spark plugs were inspected and there were signs of one ignition coil being replaced.

Top end inspection

The engine top end did not show signs of sludge building up. Since the top end was not full of sludge, an estimate was presented for the catalytic converter, and the exhaust sensors.

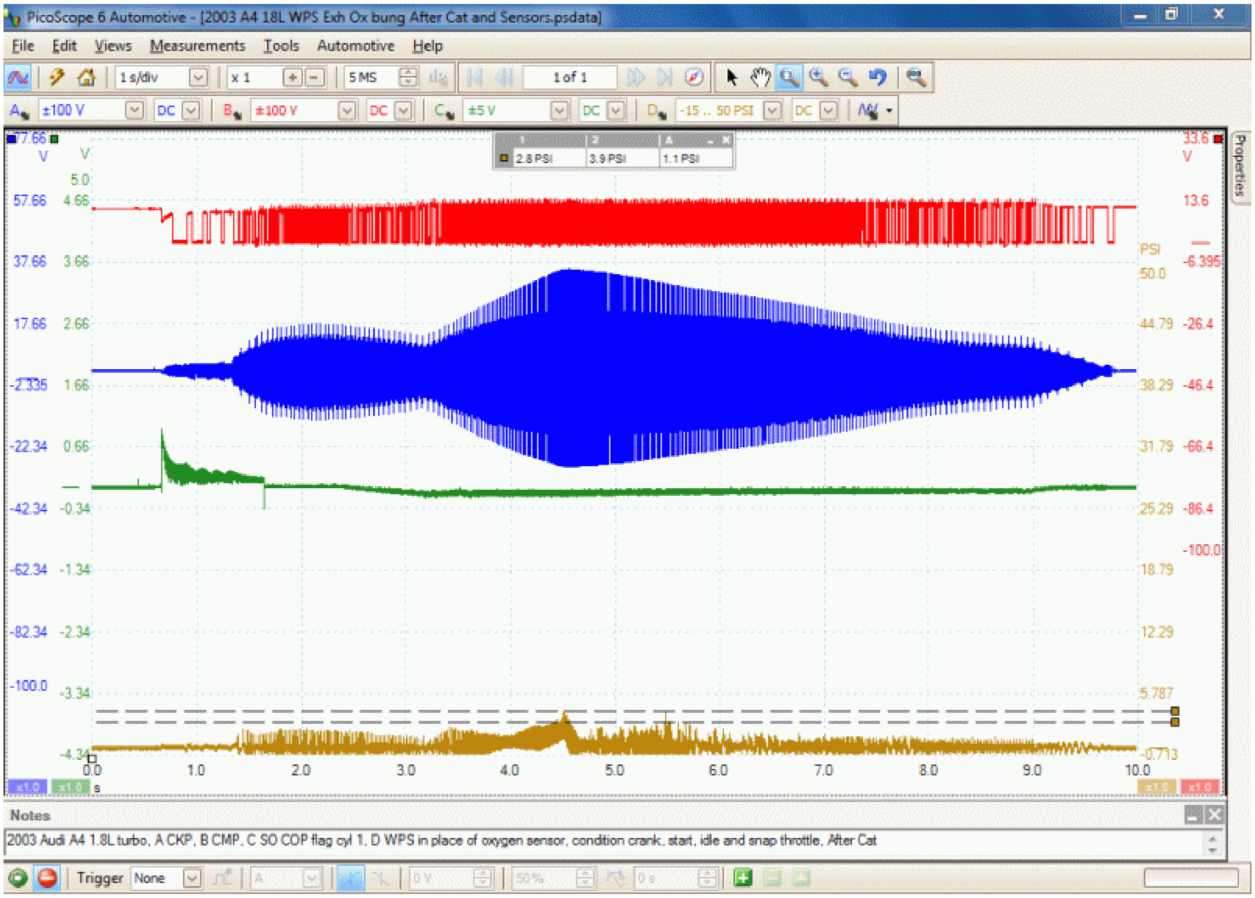
Cat inspection out of vehicle

With the cat out of the vehicle, the damage is easier to see. The image is of the front side of the cat. The back side of the cat had a typical honeycomb shaped substrate.

With the new cat and sensors installed, the in cylinder pressure test, the back pressure test, and vacuum gauge test were repeated. The back pressure was greatly reduced. The peak pressure was now 2.8 to 3.9PSI, and the engine did seem to run better. The in cylinder pressure test, still indicated low vacuum. This was also verified by the vacuum gauge.

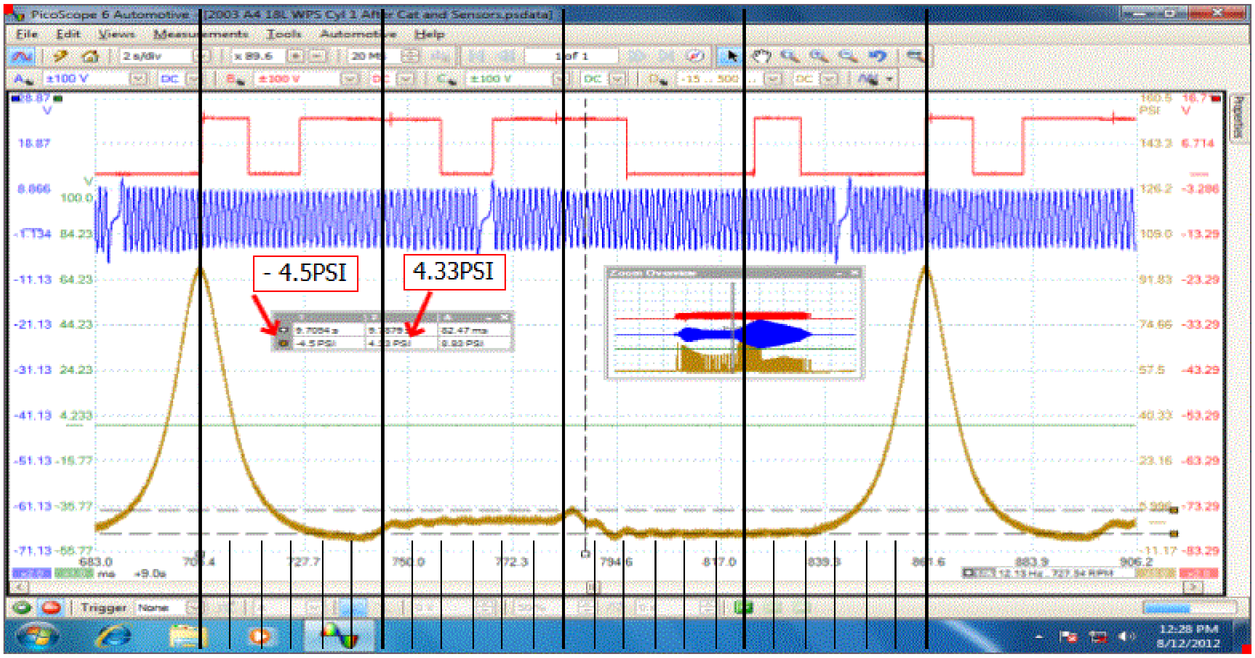
Previously the engine vacuum was 8"HG it was now 10"HG which is still low. Again an attempt to perform basic settings was attempted. The fuel trim correction was still at +25 and the code P1711/17519 returned. Further testing found 8"HG present in the crankcase indicating too much vacuum present in the crankcase. The crankcase ventilation system has several components on this vehicle and appears a little complicated. The VW parts department indicated usually they serviced the breather system by replacing most of the components.

Back pressure after cat replacement



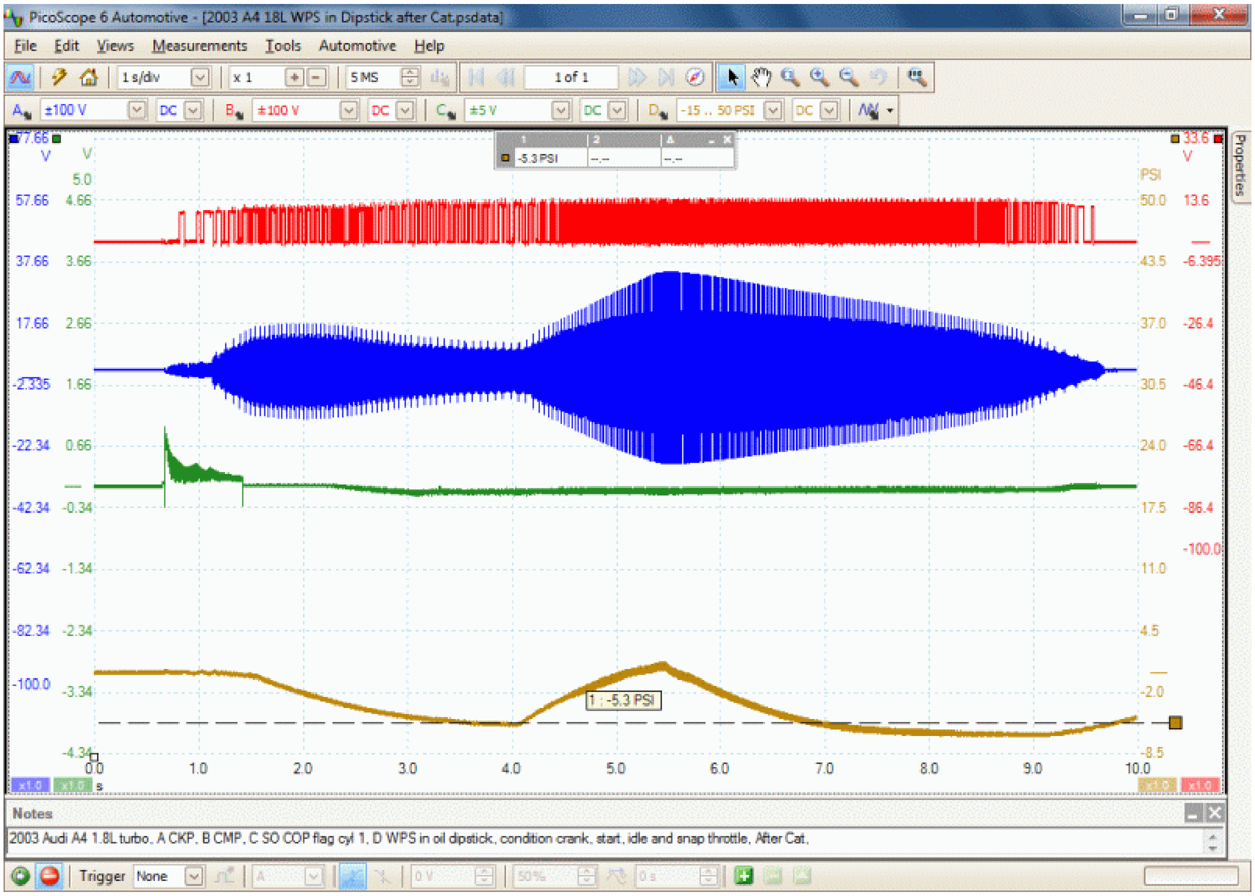
Peak back pressure is now 2.8 to 3.9PSI. Back pressure prior to cat replacement was 14 to 18PSI.

In cylinder pressure after cat replacement



While the back pressure was reduced, not a whole lot changed in the pressure waveform. The vacuum increased a small amount, but the pressure peak is still present prior to the intake stroke. The intake camshaft timing still appears questionable.

Crank case pressure

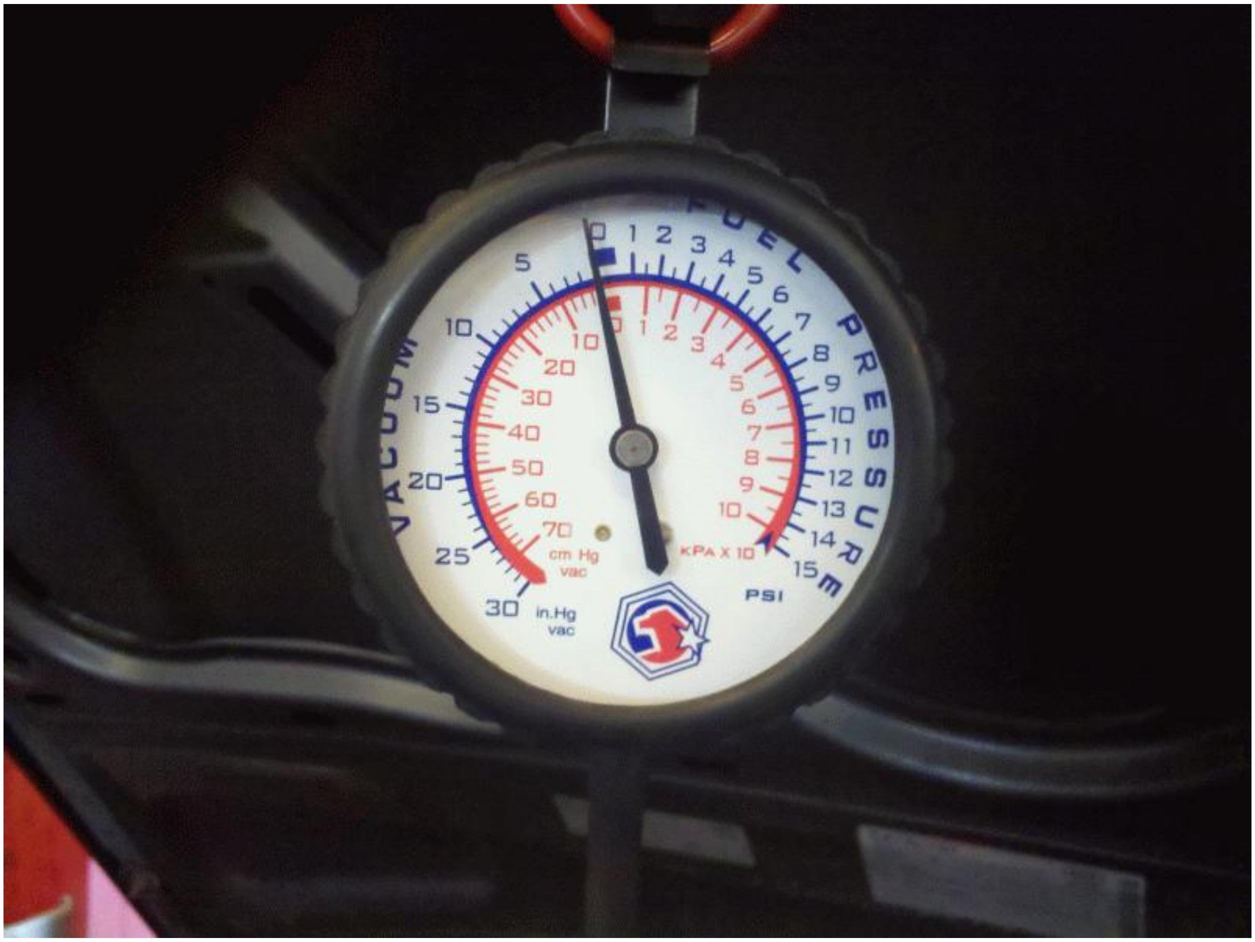


Test conditions crank, start, idle and snap throttle. Test point is at oil dipstick tube using WPS confirming vacuum gauge reading.

Crank case ventilation

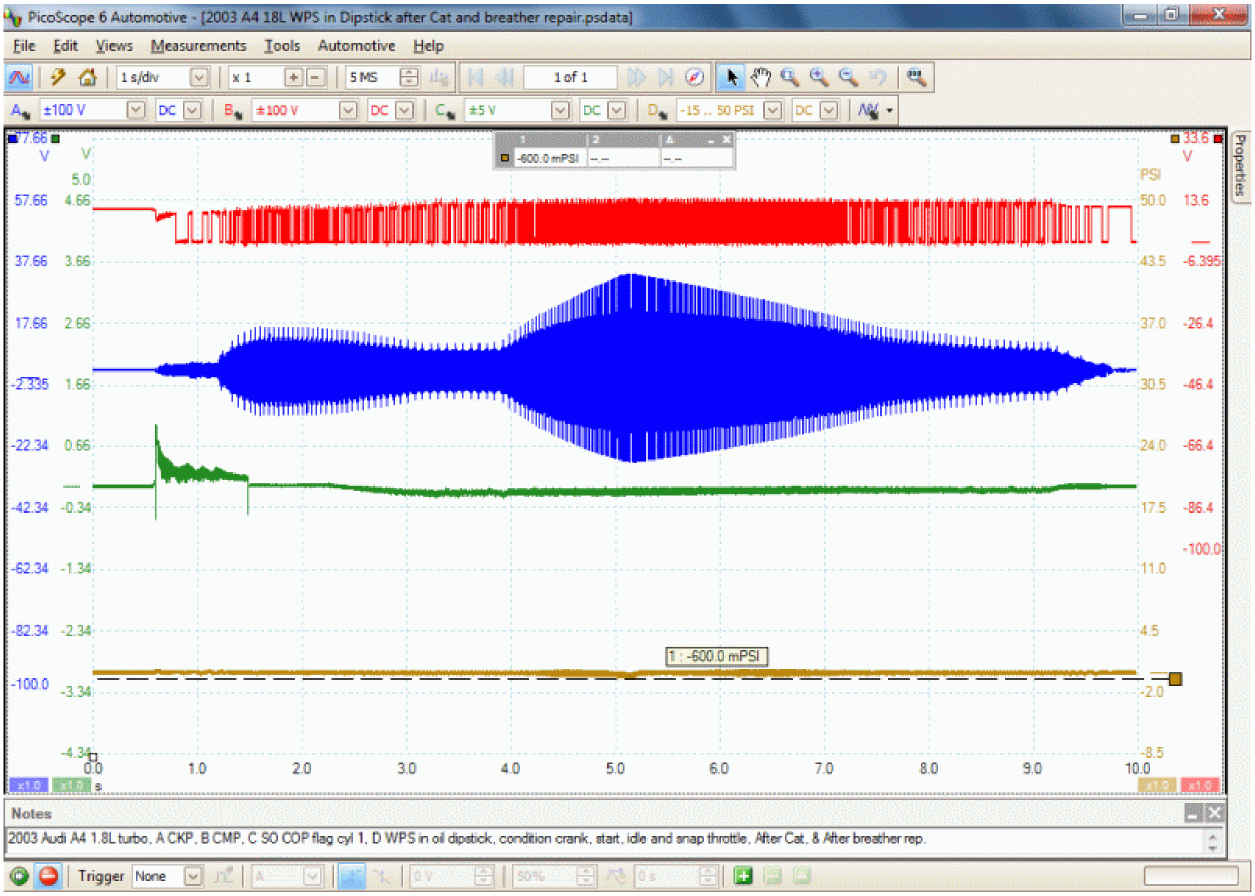
Above is most of what was suggested for repairing the breather system. It is a bit challenging to remove, and place all the components back in the same spot. With all these components replaced, the crank case pressure was tested again with a vacuum gauge, pressure sensor, and the in cylinder pressure test was performed again. The crank case pressure was less than 1"HG, measured by both the vacuum gauge, and WPS sensor. Engine vacuum was improved at 12"HG, but still not quite right. Again, it was attempted to perform basic settings. This time 04/001 did eventually enter the range of +/- 10 but the P1711/ 17519 still set. Clearing the code immediately returned the fuel correction to +25. After running a while the fuel correction again was in the +/- 10 percent range.

Crank case pressure vacuum gauge



An image of a vacuum gauge tied into the crank case via the oil dipstick. Prior to the breather system repair 8"HG of vacuum was present. After the repair less than 1"HG was present.

Crank case pressure WPS

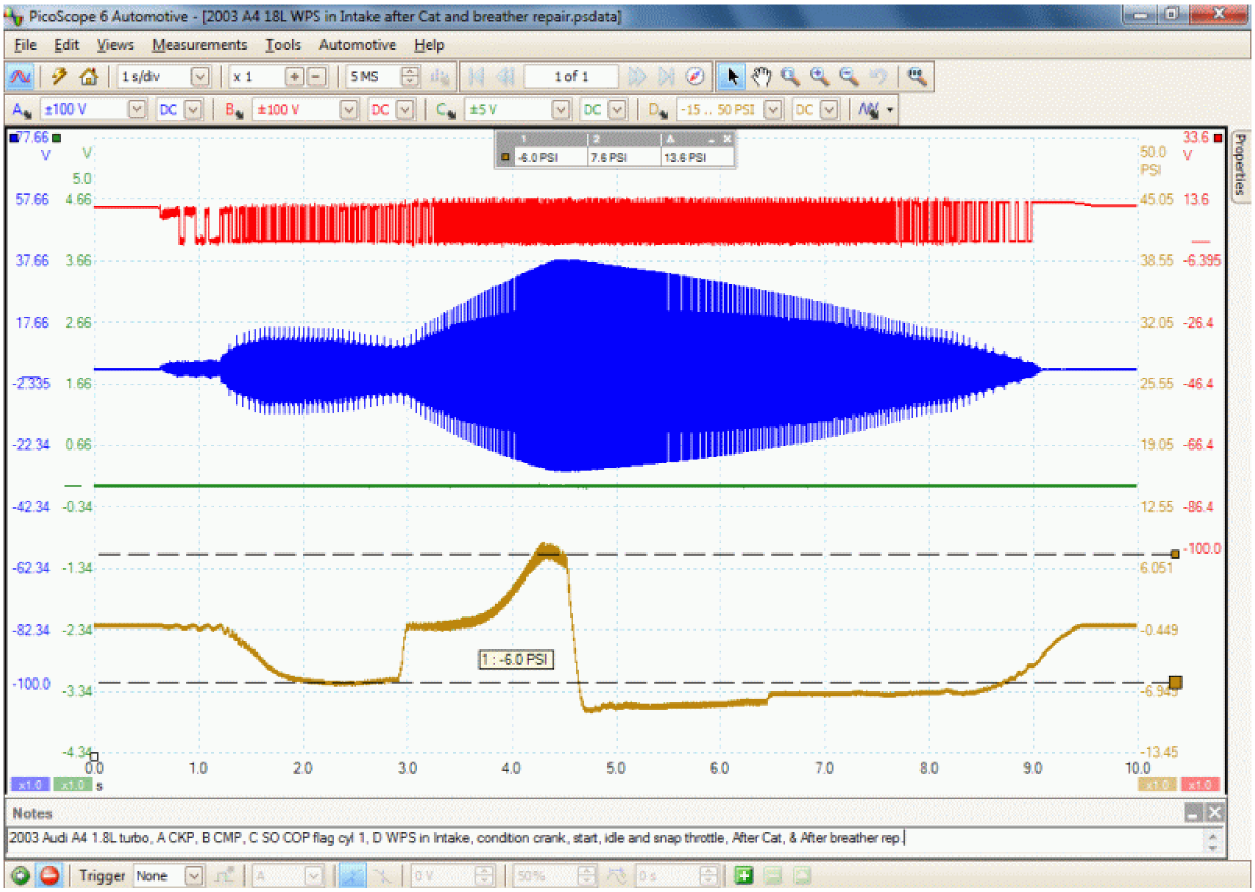


Crank case pressure after breather repair. There was an 8"HG vacuum present in crank case prior to repair.

Engine vacuum

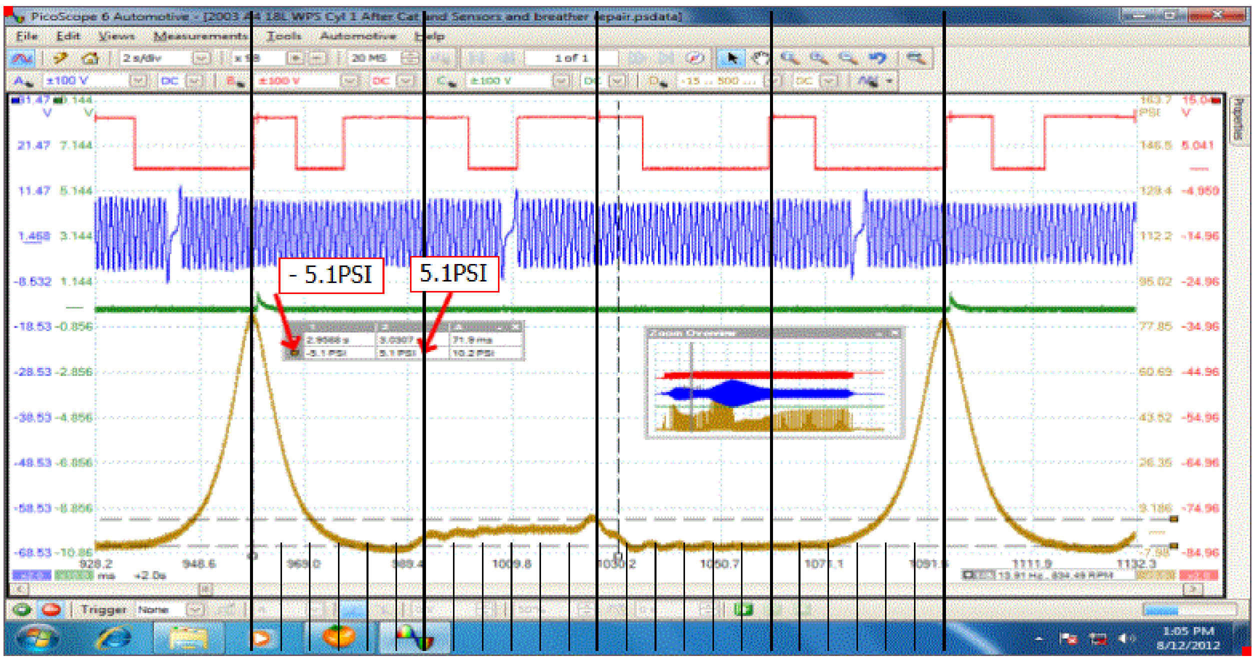
Engine vacuum after repairing the crank case ventilation system, the original vacuum was 8"HG. After replacing the catalyst the vacuum increased to 10"HG. In this image the vacuum increased to 12"HG but is still low.

Engine vacuum WPS



Engine vacuum improved but did not reach the normal range of 15 to 17"HG. The WPS readings are in PSI. A rough conversion from PSI to "HG is to multiply by 2.04. In this image, the vacuum is near identical to what was recorded on the traditional gauge. A snap throttle also created a boost condition from the turbo.

In cylinder pressure



The in cylinder pressure now has a much more defined transition to the intake stroke. Again based on where the markers are cam timing is suspect on the intake side.

Summary

Since, the oxygen sensor regulation code set each step of the way, but now the ECM was actually able to make some correction, the code was left alone and, an extensive test drive was performed, including driving on the highway. During the test drive, the power was improved from the original condition. It still did not feel right. Usually, vehicles equipped with the 1.8L turbo are very responsive, with very little turbo lag. Under part, and light throttle driving the power was decent. Full throttle seemed weak on power, with a significant amount of turbo lag. It also seemed to shift prematurely.

The codes present after the test drive were P1111/17519 oxygen sensor regulation, P1136/17544 system lean, and P1479/17887 brake booster fault. The brake booster fault code was intermittent in setting during testing, so not a lot of time was spent testing it.

The brake booster system appears to have some complexity as well. There are lines to the booster with an actual pressure sensor, and there is an electric vacuum pump. It would seem vacuum leaks would be the most common fault with the brake booster system. After overhauling the breather system I have not found any vacuum leaks. Engine vacuum is still low, and that could be the root cause of the brake booster fault code.

The cause of the low vacuum is not known, it could be a vacuum leak, or an engine mechanical fault (cam timing), or maybe something as simple as a bad air flow sensor. A cam timing concern has been possible, and suspected the whole time testing. There was a P0011 code present in the very beginning. It did not reset during testing. This engine uses a timing belt drive on the front of the engine and, a chain with a variable valve timing solenoid on the back of the engine.

If cam timing is off, there are a few possible scenarios. One is the timing belt is not aligned correctly on the front of the engine. This would have to be a small amount maybe one or two teeth since there is no cam/crank correlation fault codes. Another possibility is the mechanical timing is off on the chain on the back of the engine. The cam sensor is located on the front of the engine and, may not detect the timing off on the chain in the back. Another possibility is the variable valve timing solenoid is sticking, but just below the point of setting a fault code. One other possibility is damage to the cam or crank sprockets. This seems the least likely scenario.

At this point the customer decided to take the car and drive it for now. The plan is to bring it back in a week or two and see what all returns. That is understandable, due to the amount of repairs including needing the brakes serviced, and rotors on the front, and rear of the vehicle. It is a bit disappointing to not be able to fully repair the vehicle. On the other hand, it is equally frustrating to service a vehicle with a multitude of problems, and not being able to gain a clear testing direction right off.

Thanks to everyone that contributed online.

Testing was performed by Samuel Jarvis.