WELLS Counter Point

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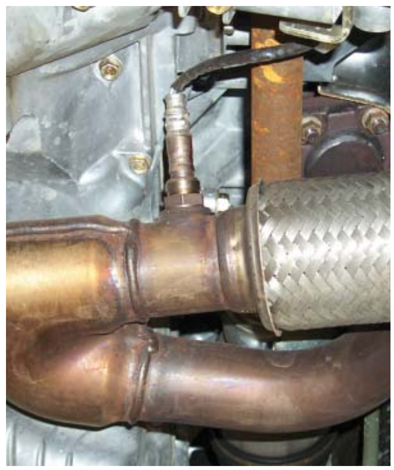
THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

OBD II...Monitors

We continue our OBD II overview with an examination of oxygen sensor heater and oxygen sensor monitors.



As described in the last *Counter Point*, some OBD II systems monitor the operation of the oxygen sensor heaters *indirectly* with a deductive test. The heater is used along with the oxygen sensor to permit the powertrain control module (PCM) to convert to closed loop operation as soon as possible after engine start-up. If the oxygen sensor begins producing a useable signal within the prescribed period after engine start-up, the oxygen sensor heater monitor is satisfied.

Other OBD II systems perform an active test to *directly* monitor the oxygen sensor heater operation. One such monitoring strategy involves measuring the current consumption of the oxygen sensor circuit while the engine is running. If the voltage drop is within specifications, the PCM assumes the heater is working properly. In other OBD II systems, the oxygen sensor heater circuit is checked by measuring the voltage drop in the oxygen sensor output circuit with the key off. The following are three examples of *active* oxygen sensor heater monitors.

Monitor Method One

This monitor method tests the integrity of the oxygen sensor's heater circuit in a very intuitive way. It will isolate the effect of the oxygen sensor heater element on the oxygen sensor output voltage from all other influences. The resistance in the oxygen sensor's output circuit is tested to verify heater function. After engine shut down, the PCM sends a 5 volt biased signal to the negative temperature coefficient oxygen sensor. This signal is sent at 1.6 second intervals lasting 35 ms each. Simultaneously, the PCM performs a voltage drop test from this 5 volt signal to determine oxygen sensor resistance. When the resistance in the oxygen sensor reaches a predetermined value the PCM energizes the Automatic Shutdown Relay (ASD) and applies voltage to the positive temperature coefficient oxygen sensor heater element. When the PCM senses the oxygen sensor has reached a predetermined resistance value within the required amount of time the oxygen sensor heater monitor passes. The integrity of the oxygen sensor wiring is also verified by testing the circuit in this manner.

If all the enabling criteria are met, the oxygen sensor heater elements are tested each time the engine is turned off. If the monitor fails, the PCM stores a pending DTC and freeze frame data is recorded. If two consecutive tests fail, a hard DTC is recorded and the Malfunction Indicator Lamp (MIL) is illuminated during the next key cycle.

The enabling criteria for this monitor are:
• engine run time of at least 5.1 minutes
• battery voltage of at least 10 volts
• sufficient oxygen sensor cool-down

The MIL is extinguished if the conditions that caused it to illuminate are not repeated during three consecutive warm-up cycles.

Monitor Method Two

The Method Two oxygen sensor heater monitor is similar to the Method One monitor, but it is run at a different time. Rather than running with the key off, this oxygen sensor heater monitor runs with the key on following a cold engine start. The outside temperature reported by the intake air temperature sensor (IAT) must be within 10° F of the temperature reported by the engine coolant temperature sensor and the coolant temperature must have dropped at least 50° F from its previous cycle.

If these conditions have been met, the PCM recognizes that the engine has experienced a cold soak and the oxygen sensor heater monitor begins. The PCM sends a 5 volt reference voltage to the oxygen sensor heater. The PCM then reads a voltage drop from that signal. When the voltage drop reaches a specified level (without excess) within a predetermined amount of time, the monitor passes. The voltage drop level indicates the oxygen sensor heater is using voltage and (in all probability) making heat.

Monitor Method Three

This oxygen sensor heater monitor is not activated until the engine is warm. To allow for any condensation in the exhaust system the delay before starting the monitor could be up to five minutes. The PCM will then switch the oxygen sensor heater(s) on and off in closed loop

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Fine Tuning

*Fine Tuning questions are answered by Mark Hicks, Technical Services Manager. Please send your questions to: Mark Hicks c/o **Wells Manufacturing Corp., P.O. Box 70, Fond du Lac, WI 54936-0070** or e-mail him at **technical@wellsmfgcorp.com.** We'll send you a Wells shirt if your question is published. So please include your shirt size with your question.*

Q: "We have a customer with an OBD II-compliant 1996 Ford Taurus (3.0L engine) that has set a diagnostic trouble code (DTC) P0420. The MIL light will also turn on, but go off after about a week of driving. The MIL then turns back on again after a while. Our service information tells us this code indicates that catalyst system efficiency has fallen below threshold limits. We have inspected the exhaust system for leaks, but found none. Am I correct in my understanding that a DTC P0420 means the converter(s) need to be replaced? How do I know the engine doesn't have another problem that destroyed the converters?"

Bob Wright
Wright Auto Repair
Detroit, MI

You are correct. A trouble code P0420 does indicate a catalytic converter problem. The parameters to set this DTC are as follows: the engine must be running in closed loop at a steady state for at least five minutes at highway speeds. Then, if the PCM detects a rear HO2S sensor switch rate frequency that is too high, DTC P0420 is set. This indicates a catalytic converter that is not doing its job.

A catalytic converter will very rarely fail on its own. Anything that increases catalytic converter temperatures will contribute to premature converter failure, however. Are there any other codes stored in the PCM? On this vehicle, for example, any DTC between P0300 and P0306 would indicate a cylinder misfire. These codes should be meticulously checked out and repaired before installing a new catalytic converter, as they would definitely contribute to repeat converter failure. Here is a short list of potential causes:

- Using leaded fuel
- Oil contamination
- Misfires
- Defective engine coolant temperature sensor (ECT)
- Excessive fuel pressure
- Damaged portion of the exhaust system
- Defective HO2S and/or wiring
- Defective fuel injector

One more thought comes to mind: Check to see if there is a trailer hitch on the vehicle. Excessive drag and engine overload could also cause this problem.

Results: After the converters were replaced a thorough check was performed and no other problems were found at this time. I will keep you informed if anything more develops.

The question from last quarter's *Counter Point* concerned a 1990 Jaguar XJ6 (4.0L engine) with an intermittent no-start. Here's the situation: when pushed into a warm garage, the injectors began to pulse and the engine had spark. But after sitting outside overnight, the same problem returned: no spark and no injector pulse.

Question: What components control both spark and fuel pulse on this vehicle?
Answer: The ECM (which was recently replaced) and the crankshaft position sensor.

I have three words to describe the key to this diagnosis: *amplitude, amplitude, amplitude.* If the crank sensor does not generate enough voltage to trip the transistor in the control module and/or ECM, nothing is going to happen. In this case the crank sensor was intermittent, and only generated enough voltage when it was warm. Conversely, we have seen crank sensors that became intermittent when heated. These sensors generated enough voltage when cold but failed at warmer temperatures.

The point is to test the sensor for both resistance and AC voltage. On most vehicles, the rule of thumb spec is that the crank sensor must produce *at least* .5 AC volts (while cranking). The crankshaft position sensor resistance specs vary greatly from one sensor to the next; check your repair manual or the Wells technical data sheet for specifications. Both the voltage output and resistance must be checked.

Results: When tested cold, the crankshaft position sensor only generated .4 volts. Replacing the crankshaft position sensor repaired the problem.

Patrick O'Reilly of Troy, NY submitted the first correct answer, and will receive a Wells golf shirt.

Diagnose The Problem Win A Shirt

Q: "Our shop has been working on a 1995 Chevrolet Lumina car with a 3.1L engine. The first time the customer came in, a code 77 was stored in the PCM's memory. I followed the diagnostic tree, which pointed to a bad EGR valve or connector. So far, we have replaced the digital EGR once with an aftermarket replacement and twice with an original equipment part, and the same problem still reoccurs. Every few weeks, the customer comes back with a code 77 stored in the PCM's memory. I have also replaced the connector and the PCM, but neither of those changes helped either.

The customer says the Check Engine light will illuminate when the vehicle is driven down a long decline. The light will stay on for a week or so, then go out again. Otherwise the vehicle runs perfectly. Do you have any ideas?"

James Sieglaff
Montgomery, AL

The first reader to respond with the most accurate answer via e-mail or fax, and the first reader to respond with the most accurate answer via snail-mail, will receive a Wells golf shirt. The answer will appear in the next issue.

Quality Points

Keys to Continued Success

To remain a leader in the always competitive automotive parts market, a manufacturer must strive to remain as basic as possible. What do we mean by 'basic,' you ask? Here's one example: Since our modest beginning in 1903, Wells Manufacturing has been committed to keeping as many of our manufacturing processes as possible 'in house.' This includes the manufacture of our own dies, die components, forms, inserts, fixtures, etc.

The machines needed to perform these tasks are computer numerical control (CNC) mills and fully-automated wire cutting electrical discharge machines (EDM), located in our state of the art tool room. The Wells EDMs have the ability to hold a tolerance of one ten thousandth of an inch (.0001). That's less than one hundredth the thickness of an average human hair. To maintain these tolerances, the EDMs are housed in a climate-controlled environment of 68° F, with a humidity level that never exceeds 40%.

Mike Turner monitors an EDM process in the Wells Tool Room.

In operation, the EDMs actually melt the metal away by sending a strong electrical current through a thin brass wire. The wire feed is fully automated as it moves from one start hole to the other. Once the program is set up on a computer and downloaded to the EDMs, the machines can run unattended for an entire work shift or longer. Jobs that formerly took days to complete now require just a few hours.

Since 1903, Wells has shown an unwavering commitment to consistently provide top quality and reasonably priced products. This commitment will not change.

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OBD II...Monitors

operation while monitoring the response time between the front and rear oxygen sensors. If an excessive response time occurs between the two sensors, the PCM will fail the test, activate the MIL and set a pending code.

Enabling Criteria:
• ambient air temperature
• engine coolant temperature
• MAP or MAF
• Crank Sensor
• TPS
• System voltage of at least 11 volts

This oxygen sensor heater monitor will not be run if there is a stored DTC for oxygen sensor operation. If the oxygen sensor heater monitor fails on two consecutive trips, a hard DTC will be stored and the MIL illuminated. The MIL will be extinguished if the conditions that caused the original DTC are not repeated during three consecutive trips. The DTC will be erased from memory if the monitor passes during 40 consecutive warm-up cycles.

Oxygen Sensor Monitor

If the oxygen sensor heaters have been doing their job, all of the oxygen sensors in the OBD II system should be up and reporting soon after engine startup. However, the OBD II system isn't satisfied with knowing that each oxygen sensor is working. It needs to know exactly how well the various oxygen sensors are working because each is critically important to OBD II operation.

The front heated oxygen sensor is used by the PCM to sense exhaust oxygen content and control fuel trim. The rear heated oxygen sensor reports the exhaust oxygen content after the catalytic converter to the PCM. The PCM will also use this information to determine catalytic converter efficiency. If the voltage level of the rear heated oxygen sensor stays above or below a 450 millivolt level for an extended period of time, the PCM uses this information to make slight fuel trim adjustments.

The oxygen sensor monitor evaluates the operation of all oxygen sensors in the system. The PCM tests the vehicle's oxygen sensors once per trip (if possible), and is always on the alert for failure or deterioration. The oxygen sensor monitor provides the PCM with the following information about oxygen sensor health:
• sensor response rate
• sensor voltage range
• sensor switching frequency (crosscounts)

The oxygen sensor response rate is the time required for the oxygen sensor to recognize a rich or lean condition. To determine response rate the PCM commands an abnormal air/fuel ratio (too rich or too lean), then calculates the time it takes the oxygen sensor voltage to move from 300 to 600 mV, or vice-versa. A good sensor will switch from lean-to-rich or rich-to-lean in less than 100 milliseconds. If the sensor(s) response time exceeds the oxygen sensor monitor's fail threshold on two consecutive trips, the PCM will turn on the MIL and store a hard DTC. Freeze frame data will also be recorded during the first failure (pending DTC). This monitor may be performed by the PCM up to seven times per trip.

Figure 1: *Lean to Rich Sensor Response Time*

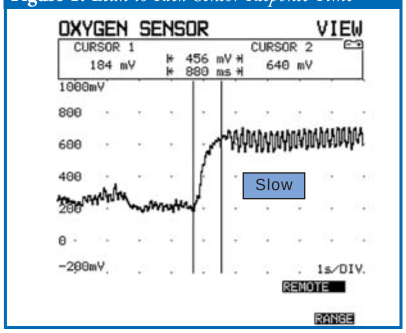
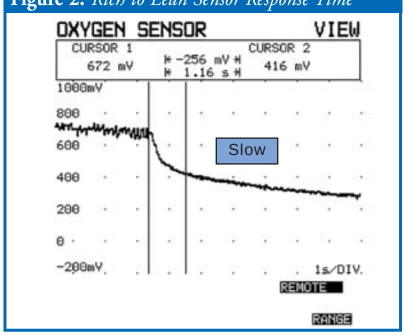


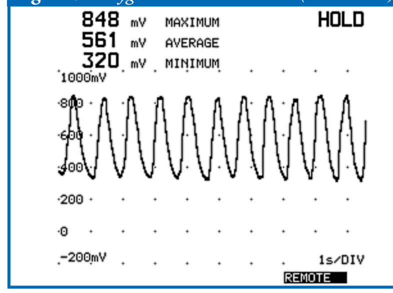
Figure 2: *Rich to Lean Sensor Response Time*



The oxygen sensor monitor also keeps track of minimum and maximum attainable oxygen sensor voltages and the sensor's switching frequency (crosscounts). During normal closed loop operation a good pre-catalyst oxygen sensor will produce voltage that rises above 600 millivolts when the mixture is rich, and drops below 300 millivolts when the mixture is lean. The voltage also should switch between these extremes five times per second or more (crosscounts) when the engine management system is in closed loop. If the oxygen sensor voltage is out of range, or doesn't cross the transition point of 450 millivolts frequently enough (low crosscounts), the oxygen sensor monitor will fail.

Some OBD II systems test the oxygen sensor response rate using other methods. The response rate may be evaluated by entering a special fuel control routine. This test drives the air/fuel ratio at a set frequency and magnitude, which should produce a predictable corresponding oxygen sensor

Figure 3: *Oxygen Sensor Crosscounts (biased lean)*



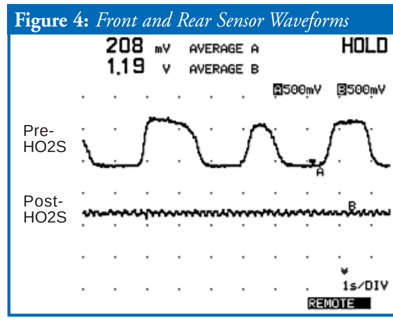
signal amplitude. If the oxygen sensor response has deteriorated, it will show reduced amplitude. If the calibrated frequency could not be obtained while running the test due to excessive purge vapors, the test will be run again.

Enabling criteria for the oxygen sensor monitor are:
• inputs from the CKP, ECT, IAT, TPS and MAF within required range
• fuel system and misfire monitors completed

Rear Oxygen Sensor

The operation of the rear (post-catalyst) oxygen sensor(s) is also tested during the oxygen sensor monitor. Due to its position after the catalyst, the normal rear HO2S waveform is different from the front (pre-catalyst) oxygen sensor waveform. The rear sensor waveform has lower peaks and valleys, and relatively low signal amplitude. The oxygen sensor monitor therefore looks for rear oxygen sensor voltage that exceeds the typical rich and lean thresholds during the test. If the voltages do not exceed the thresholds during the test, the air/fuel ratio may be driven rich or lean, forcing the rear sensor to switch. If the sensor does not exceed the rich and lean peak thresholds during this test, a DTC is stored indicating degraded heated rear oxygen sensor performance.

Figure 4: *Front and Rear Sensor Waveforms*



Catalyst Monitor

Once the OBD II system has determined that all of its oxygen sensors are functioning properly, it can rely on them for one of their most important jobs: monitoring the health and performance of the catalytic converter(s). In the next *Counter Point*, we'll explain the operation of the OBD II catalyst monitor.

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INSIDE: OBD II...Monitors

Hot off the Wire

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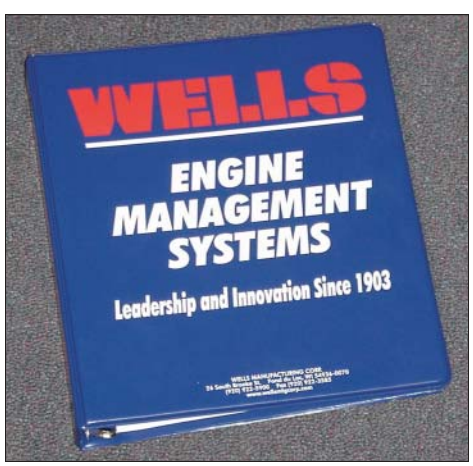

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