WELLS Counter Point
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THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

OBD II...Case Study

To improve your chances of OBD II diagnostic success, always develop and follow a diagnostic strategy.

In the two previous issues of *Counter Point*, we've given you an introduction to OBD II. As promised in our last issue, this issue contains a case study of an OBD II diagnosis and repair procedure. The vehicle in question is a 1995 Subaru Legacy, equipped with a 2.2 liter engine. Although regulations did not require all vehicles sold in the U.S. to be OBD II-compliant until the 1996 model year, Subaru got ahead of the game with the production of this vehicle and it was certified as fully OBD-II compliant in 1995.

Diagnostic Strategy

Diagnosing a problem on an OBD II-compliant vehicle is no different than the diagnosis and repair of any other vehicle problem. To improve your chances of diagnostic success, always develop and follow a diagnostic strategy. A basic diagnostic strategy can be broken down into six steps: communication, confirmation, inspection, evaluation, conclusion and verification.

Communication

Communication begins when the customer brings the vehicle in for repair. The service advisor or technician should interview the customer to gather as much pertinent data as possible. Ask when the failure occurred. What were the symptoms? If the vehicle failed an emissions test, ask the customer for a copy of the inspection report. The more information you collect at the start, the easier it will be to diagnose the problem.

In this case, the customer's complaint is an illuminated Malfunction Indicator Lamp (MIL) that is not flashing. Vehicle driveability has not been affected, and the customer hasn't noticed anything else unusual since the MIL first came on.

Confirm the Condition

Valuable diagnostic time can be wasted attempting to repair a problem that does not exist, or that is due to the customer's lack of understanding of the vehicle and its operation. After discussing the problem with the customer, attempt to duplicate the condition with a road test. Take the customer with you if necessary and have him (or her) drive the vehicle, especially if the problem only occurs under unusual circumstances. In the long run this procedure could save the customer costs and you a lot of frustration. Does the vehicle exhibit the symptoms the customer described?

Check the MIL status. If the MIL is on, it signals a condition which will cause an increase in emissions. If the MIL is flashing, it signals a condition which will cause imminent damage to the catalytic converter. The MIL will extinguish if three consecutive trips are completed without a repeat failure. If the MIL is off, there may still be pending DTCs (diagnostic trouble codes) in memory. These will be automatically erased if the problem doesn't repeat on the next 40 to 80 consecutive trips.

As described by our customer, the Legacy's MIL was illuminated. The vehicle operated normally in every other respect and the MIL remained illuminated throughout the road test.

Inspect the Vehicle

At this point, you should know whether or not there is an actual problem. Many seemingly complicated problems turn out to have relatively simple causes. Perform a visual vehicle inspection to look for loose grounds, damaged or misrouted vacuum hoses, chafed wires or other basic failures. There's no reason to drag out the heavy diagnostic artillery until it's really necessary. If the cause of the problem has not been found, connect a scan tool and/or take baseline tailpipe readings if the equipment is available.

Evaluate the Information

After attaching an OBD II-compliant scan tool to the data link connector (DLC), check for DTCs, monitor readiness status and parameter identifications (PIDs). If one or more DTCs have been stored, also check and record the related freeze frame data. Do not clear any stored DTCs at this time. Clearing DTCs removes all freeze frame data, as well as resetting the status of all monitors to Not Ready.

If a DTC is stored, adjust your scan tool to monitor only the PIDs that are related to the failure condition. Monitoring the entire generic scan data list will slow the scanner's update rate. There are several ways for a scan tool to

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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: "I am working on a 1993 Chrysler Concord with a 3.5L engine. The engine won't start because it does not have spark. There is no crank sensor signal. I have studied the wiring diagram and found PCM pin 7 feeds the 8-volt reference to the crank and cam sensors. I looked for voltage at pin 7 on the PCM. It should have 8 volts with the key on, but my meter reads 0. I probed all the feed terminals and have performed voltage drop tests on all the ground terminals to the PCM. All were found to be acceptable. I also replaced the PCM with a new one from the dealer. What could be wrong? Why am I still reading 0 volts at PCM pin 7?"

Scott Enzler

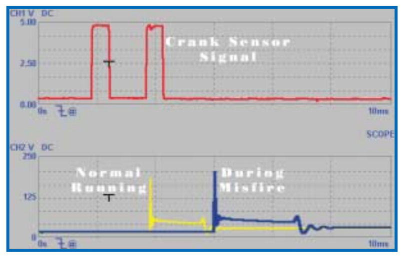
My suspicion is that a sensor is shorted to ground. If the crank or cam sensor is shorted directly to ground, you will read 0 volts at pin 7. No voltage can exist in a circuit that runs directly to ground. If there were only a partial short, you would see some voltage on your meter.

With your meter connected to PCM pin 7, disconnect each of the involved sensors one at a time. When your meter reads 8 volts, you have found the defective sensor.

Results: After testing the circuit as instructed, Scott found a shorted crank sensor. He replaced it and the engine started successfully.

I was very impressed with the number of responses we received to last issue's question. I felt certain this problem would have you stumped. It was a '93 Dodge Dakota that intermittently ran poorly and stalled at random. Nearly everything in the ignition system as well as the PCM had already been replaced with new parts.

I was able to obtain scope patterns from this vehicle (below). Two of them are superimposed to illustrate the cause of the problem. The top trace is the crank sensor pattern and the bottom trace is the secondary ignition pattern. The yellow secondary ignition trace was captured while the engine was running normally. Notice how it lines up with the crank signal trigger point. The blue trace was captured when the engine began to misfire.



The crank sensor on this engine is mounted on the bellhousing and produces its signal from the flywheel rotation. This signal should remain constant unless the crank sensor is defective or something happens to the flywheel to change the timing of the signal. After looking at the two patterns, I could see the ignition timing had changed under the same engine rpm and load. The computer, a defective crankshaft position sensor or something mechanical could cause this.

I found a Dodge technical service bulletin (TSB 18-08-93 Rev. A) in my reference material. The symptoms described in the bulletin were very similar to the problems this vehicle was having (warm engine surging, bucking and spark knock bursts).

The test procedure called for an inspection of the rotational movement of the rotor tip. The total movement should not exceed 3/16-inch. In this case, the rotor moved 1/2-inch or more. This indicated the oil pump drive gear, distributor drive gear and bushing were worn.

Results: After replacing the oil pump drive gear, bushing and distributor, the problem was solved. The hardest part was replacing the bushing. To do this job without removing and replacing the engine, you will need special tools C-3052 and C-3053.

Steve Svendsen, of Mechanicville, NY submitted the first correct answer received by fax or e-mail. The first correct answer by regular mail was sent by Chuck Seogwick, Firestone, Clute, TX. Both will receive Wells golf shirts.

Diagnose The Problem Win A Shirt

Q: "A 1990 Jaguar XJ6 with a 4.0L engine was recently towed to my shop with a no-start condition. I pushed it inside and checked for spark and fuel pulse width. The engine had spark at that time and the fuel system looked good. After replacing the spark plugs, the engine started. However it idled at a very low RPM and it would not respond when I attempted to increase the engine RPM with the accelerator pedal. As the engine began to warm, the RPM started to rise and it became more responsive. I found an old repair order in the glove compartment indicating the ECM had recently been replaced, so I am reasonably sure the ECM is not the problem.

"I decided to park the vehicle outside. The next morning the engine would not start. The cranking RPM was within specifications. I immediately checked for spark and fuel pulse width — it had neither. I checked the crankshaft position sensor resistance and it was within specs. What do you think it could be?"

Steve Ayers
Ayers Auto Electric
Howard, PA

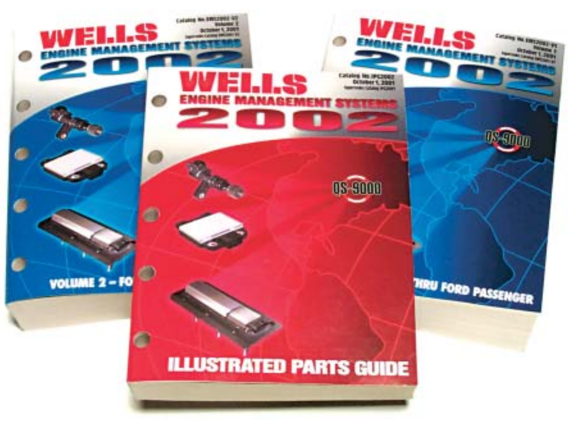
The first reader to respond with the most accurate answer via e-mail or fax, and the first reader to respond with the most accurate answer via snail-mail, will receive a Wells golf shirt. The answer will appear in the next issue.

Hot off the Wire

2002 Catalogs

Wells is proud to announce the publication of the *2002 Engine Management Systems Catalog* and *2002 Illustrated Parts Guide*. These publications include over 2600 new part numbers, covering vehicle applications through model year 2002.

Volume 1 of the application catalog covers Acura through Ford. Volume 2 covers Ford Truck through Yugo. Both volumes feature expanded Professional Gold listings. The *Illustrated Parts Guide* contains 1263 pages of information. New categories include Ignition Misfire Sensors, Fuel Tank Pressure Sensors, Horns, Flex Fuel Sensors, Oil Temp Sensors, Transmission Control Solenoids, Turbo Boost Solenoids, Fuel Tank Temp Sensors. Changes to our catalogs due to your input include dramatically expanded coverage in Circuit Breakers, Toggle Switches, Rocker Switches, Trailer Connectors and Industrial Solenoids.



To reduce lost sales, a dual listing system has been added for neutral safety switches and "clutch switches" on vehicles with manual transmissions. We have also incorporated a circuit breaker/ amperage reference chart.

To obtain copies of these publications, contact your nearest Wells distributor or representative.

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OBD II...Case Study

describe monitor status. Your scan tool may read Complete, OK or Done. It may indicate Incomplete, Pending or Not Ready for monitors that have not run. Remember, when the scan tool indicates that a monitor has run or completed, this does not necessarily mean that it has passed, only that it has run. Always check the readiness status of all monitors before beginning diagnosis of a no-code driveability problem.

Scanning for stored DTCs on our subject vehicle revealed a code P0141, which signals a rear oxygen sensor heater circuit malfunction. The monitor readiness status indicated that the Oxygen Sensor Heater Monitor was Incomplete. The freeze frame data indicated that when the fault occurred, the engine speed was @2500 RPM, the engine temperature was 140 degrees F and the vehicle speed was 34 MPH. Fuel status was Open Loop.

Reaching Conclusions

Does the vehicle have any stored DTCs? If so, consult your service information, follow its diagnostic recommendations to identify the cause of the failure, then make the necessary repairs. If no DTCs are found in memory, use the service information symptom chart to help identify the cause of failure. If a failure is found, make repairs.

Figure 1: *Oxygen Sensor Connector*

The factory service information available for our Subaru was only partially helpful. Most of the information assumed the use of the Select Monitor — the Subaru-specific scan tool. The Select Monitor allows access to enhanced scan tool data, including an amperage test of the heater element. We did not have the Select Monitor, but we used the manual's circuit diagram and normal resistance values for the oxygen sensor heater. After locating the oxygen sensor harness connector near the transmission (**Figure 1**), we verified a heater element open circuit. The normal resistance value for the heater element should be 30 ohms or less. In this case the resistance was infinite.

Verify the Repair

To ensure that the problem has been resolved, always verify the repair. Where Comprehensive Component failures are concerned, this can be accomplished by comparing before and after scan tool data. In the case of system failures, the vehicle should be operated through a drive cycle to allow the system to test itself.

This system runs the oxygen sensor heater monitor once per drive cycle. To run the oxygen sensor heater monitor, clear the DTC, then complete the engine warm-up cycle. Accelerate at 1/4 to 1/2 throttle opening to a speed of 30-40 mph. Drive at 35 mph for three minutes or until the monitor runs to completion. Have an assistant watch the scan tool during the road test.

After replacing the rear oxygen sensor, the Subaru oxygen sensor heater monitor ran to completion during a road test. Later scan tool inspection revealed that all other related monitors (oxygen sensor and catalyst efficiency) had also run to completion.

Oxygen Sensor Heater Monitor

One of the goals of OBD II is to minimize hydrocarbon and carbon monoxide emissions during engine warm-up. The most effective way to accomplish this is to get the engine management system into closed loop fuel control as quickly as possible. However, the system can't go into closed loop until it begins receiving a valid signal from the oxygen sensor(s). Oxygen sensors do not begin functioning properly until they are heated to 572-662 degrees F (300-350 degrees C). It may take several minutes for the engine exhaust to reach this temperature following a cold start.

To quickly reach and maintain an ideal operating temperature, oxygen sensors contain positive thermal coefficient (PTC) heating elements. When the PTC oxygen sensor heater receives voltage, its internal structure changes and the heater temperature increases. As the heater temperature increases, the internal resistance of the PTC heating element also increases. The increased resistance limits current flow through the heater. If the heater temperature drops, its resistance will drop and more current will flow – raising the heater temperature once again. This arrangement allows the heater to produce additional heat when necessary during engine operation, without the risk of burnout caused by excessive current flow. The PTC oxygen sensor heater, combined with the flow of hot exhaust around the sensor, assures that the oxygen sensor reaches and maintains an optimum operating temperature of approximately 1200 degrees F.

OBD II regulations state that the diagnostic system must monitor all heated oxygen sensors for proper operation. The regulations require the system to illuminate the MIL when a detected failure would cause an increase in emissions of 1.5 times any applicable Federal Test Procedure (FTP) standard. The oxygen sensor heater monitor verifies heater integrity using one of several methods. The heater circuit may be monitored at Key On or Key Off, depending on the vehicle manufacturer. Probably the simplest and most common method is the 'time to activity test.' This monitor measures the amount of time it takes before the oxygen sensor begins producing a valid signal following a cold engine start. If the time exceeds the programmed value for two consecutive trips, the monitor will fail and the PCM will set a hard DTC and turn on the MIL.

This type of oxygen sensor heater monitor is a deductive test, rather than a direct test of the oxygen sensor heater element. As long as the oxygen sensor starts sending a useable signal to the PCM within the prescribed time period, the monitor is satisfied. How this is accomplished (oxygen sensor heater, exhaust heat or both) is unimportant to the monitor. However, it's unlikely that the oxygen sensor would be able to repeatedly reach operating temperature within the prescribed time without the aid of the heater element, especially during colder ambient temperatures.

Some OBD II systems directly monitor the oxygen sensor heater operation. This may be accomplished by measuring the current level through the heater circuit while the engine is running. If the current level is within specifications, the PCM can assume the heater is working properly. In other OBD II systems, the heater circuit is checked by measuring the voltage drop in the output circuit. To run this monitor, the PCM sends a 5 volt biased signal through the sensor heater circuit and reads the circuit voltage drop.

The oxygen sensor heater monitor is a two-trip monitor. The monitor must detect a fault during two consecutive trips to activate the MIL and set a DTC. The front and rear oxygen sensors are used as diagnostic inputs by other monitors, such as catalyst efficiency and EGR, so a stored DTC for a failed oxygen sensor or oxygen sensor heater may keep the other monitors from running. Whenever multiple DTCs are stored, always start your diagnosis with the information received from the freeze frame data.

Next Issue

The next Wells *Counter Point* will further explain oxygen sensor heater monitor operation and explore other OBD II monitors and monitor strategies.

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INSIDE: OBD II CASE STUDY

Quality Points

Wells Testing Lab

The Wells testing labs are designed to meet QS9000 standards, and to ensure that every Wells part you purchase is a top quality part. This is not an easy task. Try going to the local hardware store to purchase a throttle position sensor (TPS) life tester. Obviously, this would not be possible.

That's why all of the test fixtures in our labs are designed by Wells engineers and lab technicians. The test fixtures are then fabricated and assembled by Wells tool and die makers in our tool room. These specialized test fixtures must accommodate many different part number characteristics and configurations. For example, one TPS part number may require a completely different mounting apparatus than the TPS that preceded it in the testing fixture.

Once mounted in the test fixtures, all tested parts must pass a full battery of tests. These tests include *Performance* (shock, high

Lab Technician Steve Wissink using a brake light switch fixture in one of the Wells Testing Labs.

temperature soak, corrosion/leakage, thermal shock, vibration) and *Life/Durability* (electrical life, test to failure).

Every part tested is subjected to these general tests. For each of the general test areas, there are also specific tests for each part category. For example, while a TPS is tested in the electrical life portion, both full rotation and dithering stroke tests are utilized.

The next time you sell or install a genuine Wells part, remember that one just like it has been rigorously tested to meet or exceed original equipment performance standards.

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