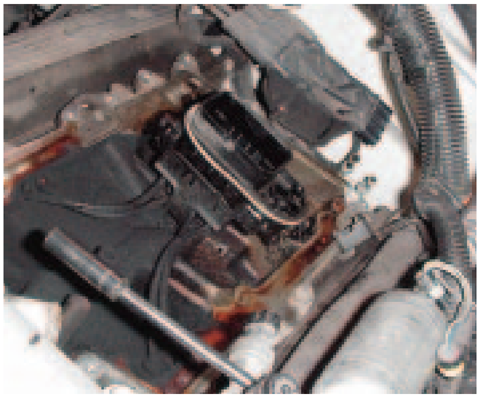
WELLS Counter Point
Volume 7 Issue 4, October 2003
THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

Forming a Diagnostic Strategy

Part Two



After collecting and analyzing the evidence, forming a hypothesis is next.

In the July, 2003 *Counter Point*, we described the early stages of a diagnosis on a 1997 GMC Yukon. In case you've forgotten the specifics, here's a refresher:

- 5.7L engine with CSFI,
- Diagnostic Trouble Codes (DTCs) P0420 and P0430 were stored in PCM memory,
- The shop replaced all of the oxygen sensors and both catalytic converters,
- Approximately one month after these parts were replaced, the customer returned with a DTC P0430 once again stored in memory.

DTCs P0420 and P0430 refer to low Bank 1 and Bank 2 catalyst efficiency. OBD II determines catalyst efficiency by comparing the signal from the oxygen sensor located upstream of each catalyst to the signal from the oxygen sensor located downstream of each catalyst.

More of the Story

We've welcomed many new *Counter Point* subscribers since July, so **Figure 1** (showing all five exhaust gases in graph form) is repeated on page 3. The graph begins with a cold engine start. HC is higher than normal in the early frames and gradually declines. There was an abrupt deceleration between frames 264 and 308. When this occurred, NO_x went down, O_2 went down, Lambda went up and CO_2 dipped (showing a lean mixture). HC reduced slightly but stayed about the same (still too high) and steadily declined.

All of the readings captured during the deceleration are consistent with a lean mixture, except the high HC reading. We would expect to see a lean mixture, because the injectors should be closed and all fuel should be cut during closed throttle deceleration. But the high HC reading indicates the presence of unburned fuel. This would seem to indicate that the engine was running rich and lean at the same time, which is impossible.

One possible explanation for this conflicting set of five gas readings was that the extra, unburned fuel (HC) was already in the exhaust before the engine was started. This would also explain why the HC reading gradually declined as the engine warmed up and burned off the extra fuel. But where was the extra fuel coming from and how could it be getting into the exhaust system before the engine was started?

Perhaps the injectors were leaking fuel into the intake ports after the engine was shut off. The Yukon has a central point fuel injection system with a set of injectors in a housing located in the valley between the cylinder heads. Flexible plastic fuel hoses link the injectors to small poppets near the intake valves. This is impossible to see without a little work, because everything is hidden by the intake manifold.

Based on our scan tool and five gas information, we decided it was time to remove the intake manifold and have a look. What we found is shown in **Figure 2** (also on page 3). As you can see, the rear half of the engine was wet with fuel, which may have been leaking from the central point unit, its hoses or the poppets. It appeared that number 5 cylinder hose or poppet was the source of the leak, but everything was so clean that we could not be absolutely sure. This extra fuel flooded the valley area, seeped past the O-rings around the poppets and found its way into the cylinders while the engine was off. When the engine was started, most of the extra fuel passed through unburned into the exhaust system. As the engine had an opportunity to run, the catalysts began to heat up and burn off the excess fuel. The extra heat in the catalysts was probably what destroyed them in the first place. Remember, the first shop had replaced both the cats and all four O_2 sensors.

Because we could not be absolutely certain which fuel system component was responsible for the leak, we replaced all of the CSFI components under the intake manifold. This wasn't a job that we wanted to do twice nor did we want to risk killing another cat. After everything was back together, we returned the vehicle to the customer. We allowed him to drive it for a while, then asked him to return so we could recheck the scan data and emissions. The long term fuel trim numbers were much closer to normal (124) and short term fuel trim for both banks were right on

continued on page 3

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 have been working on a 1997 Dodge Caravan SE. It has 80,000 miles on it and is equipped with a fuel injected 3.0L SOHC engine. The MIL is on and it has stored a diagnostic trouble code (DTC) PO204. I have checked the resistance and waveforms for the number 4 injector . I have swapped the number 4 and number 2 injectors and replaced the PCM twice. The vehicle does not display any driveability symptoms, but after running the engine for a short time the MIL comes back on and the same DTC is set. Do you have any idea what may be causing these symptoms?"

Mr. Bender
High Tech Tune
Fort Worth, TX

A: Let's begin by examining why this code sets. To verify fuel injector pintle movement, the PCM monitors the driver side of the injector winding. The PCM looks for the voltage spike created by pintle movement. If no voltage spike is detected, it will turn on the MIL and store a DTC for the injector in question. Seeing as you have tested, replaced or swapped all the components associated with this DTC, it is probably safe to assume they are okay.
If the injector driver wire could short to ground from time to time, the PCM would miss the voltage spike because either the injector pintle would not move or the ground circuit would absorb the voltage spike. If this were to happen, the fuse probably would not blow either.

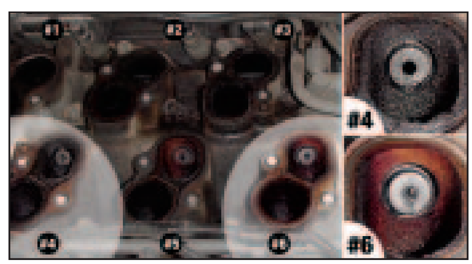
Results: Tom removed the intake plenum and found the injector wiring harness insulation had flaked off. This allowed the wires to intermittently short to each other. He replaced the wires and the MIL has remained off since.

We recently encountered a 1997 Ford Windstar 3.8L with a problem that was very similar to the problem described in the July, 2003 *Counter Point*. The engine would misfire consistently while cruising down the road at 30 mph or more. At this time, it would normally set a diagnostic trouble code (DTC) PO304 (cylinder number 4 misfire), but occasionally DTC PO301 (cylinder number 1 misfire) would also set.

An effective way to begin a diagnosis is by trying to recreate the problem. So after connecting a scan tool, a timing light to the number 4 ignition wire, a lab scope to the number 4 fuel injector and a five gas analyzer in the tailpipe, down the road we went. Sure enough, just as we began to cruise at about 45 mph, the scan tool validated a misfire in the number 4 cylinder. As the misfire occurred, I watched the timing light flash and it never missed a beat. I was also watching the lab scope and never once did a glitch occur in the fuel injector circuit. With this information, we could be somewhat sure the ignition or fuel systems were not the cause of the problem.

We returned to the shop, and then performed a running compression test on the number 1 and 4 cylinders. They both checked out perfectly. Things were starting to go against the grain. Three things are needed to create combustion in an internal combustion engine: good fuel, quality spark and adequate compression. It appeared we had all of these elements, but we still had a misfire. We next looked at the five gas trace, which showed a little higher than normal CO content and extremely high NO_x levels.

Let's take a moment to review. The misfire occurs while cruising down the highway at a steady throttle. What else happens during this period of time? The lockup converter in the transmission turns on and the EGR opens. Could either of these events cause a misfire in the same two cylinders? The torque converter lockup influences all cylinders equally, so it should not be a factor. So with the engine running, we carefully opened the EGR with a screwdriver. Shazam! The engine didn't die, but cylinders 1 and 4 started to misfire.



Several EGR ports on this Ford Windstar 3.8L V-6 were clogged. Consequently, all flow was directed to #1 and #4.

The photo above shows what we found after removing the upper intake manifold. The EGR port orifices leading to cylinders 2, 3, 5 and 6 were plugged. As the EGR opened at or near cruising speed, all of the exhaust flow went to cylinders 1 and 4 because they were the only ones with open EGR orifice ports. This caused the air/fuel ratio for these cylinders to become an incombustible matter.

While we had found the cause of the misfire, we still needed to find the reason why the EGR orifice ports had become clogged with carbon. The higher than normal CO reading on

Quality Points

Life-Cycle Testing

One of our fundamental goals at Wells Manufacturing Corp. is to construct the highest quality components possible. Among the many processes that help us attain that goal is evaluation life-cycle testing, which takes place during development and manufacturing. With over 26,000 part numbers in our catalog, this is not an easy undertaking.

To ensure the highest product quality and to manage production costs, our engineering department has developed automated life-cycle test stations. When a product is undergoing life-cycle testing, either during development or when a sample is taken from the production line, the process can take days or even weeks to complete, depending upon the component.

The process begins by placing the component (in this case a digital EGR valve) in an environmental chamber. For this particular component, the chamber cycles the temperature from -40 to +257 degrees F (-40 to +125 degrees C). These are the temperature extremes this component will be exposed to when in service due to the combination of environmental conditions and engine heat.

An environmental chamber, dedicated software and other specialized test equipment are used during Wells' component life-cycle testing.

Next, the component is connected to a lab scope and a laptop computer. While the component is thermally cycled, it is activated with a pulsewidth signal to simulate actual operation. At the completion of the test, this component will have been cycled 1,000,000 times, which equates to approximately 100,000 miles of service on the vehicle. The component is monitored and recorded through the entire life-cycle test. The laptop will alert the engineer of any component failures or discrepancies in the scope pattern, and corrective actions are taken. Again, Wells completes the objective and sets a benchmark. **WELLS** the five gas was a clue. A high CO level in the exhaust indicates a rich running engine. Before reinstalling the upper intake manifold, we decided to perform a quick fuel pressure test. The pressure was good, but the gauge would slowly leak down. We removed the injectors from the lower intake manifold but left them connected to the rail. We again energized the fuel pump to pressurize the fuel system. Sure enough, we could see the number 6 injector was leaking a little. This would cause an excessive amount of CO in the exhaust, which over time was the probable cause for the carbon buildup blocking the EGR orifice ports.

Results: After making the necessary repairs, the engine ran great and the NO_x and CO levels in the exhaust returned to normal.

The first correct e-mail or fax answer:
Jimmy Bohannon
Joplin School District
Joplin, MO

The first correct postal answer received:
Tom Carlson
All Imports and Domestics Auto Service
Blaine, MN

Diagnose The Problem Win A Shirt

Q: "I own a 1998 Oldsmobile Delta 88 with a 3800 V-6 engine (VIN K) that has 40,000 miles on it. After the vehicle sits for an extended period of time (usually overnight), the engine is very hard to start. I have to crank it over for an extended period before it will finally start, then it runs rough for a few seconds with black smoke coming out of the tail pipe. This problem happens frequently, but not every day. I have taken it to the dealer and several independent repair facilities. All sensors, as well as the ignition system have been checked, but nothing unusual has been found. Can you help?"

John Bartell
Topeka, KS

Editor's Note: We're going to try something a little different this time. If you think you know the solution to this problem, great! When you send us your answer, be sure to include a brief description of the diagnostic procedure you would use to attack this problem.

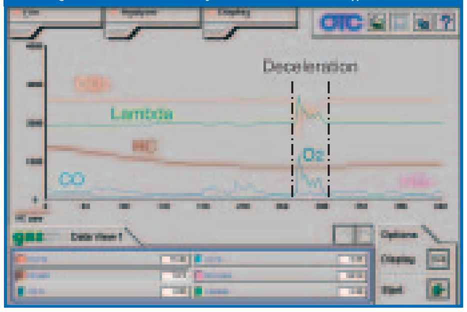
Of course, there are usually several different ways to come up with a solution to a problem. In the next Counter Point, *we will print the correct answer along with some of the procedures that our readers use to solve tough problems like this one. We look forward to hearing from you. The first reader 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.* WELLS

continued from page 1

Forming a Diagnostic Strategy

the money (128). A final check of the exhaust emissions showed an HC reading of 0. All of the other readings were also within normal ranges. Problem solved… we thought.

Figure 1: *Before repairs, HC emissions remained high from cold startup, through acceleration and into closed throttle deceleration. The fuel had to be coming from someplace else during decel because the injectors were turned off.*



"Ever Since You Worked On My Car…"

Perhaps you have had a service experience that goes something like this: After knocking yourself out on a tough diagnostic problem, you finally crack the case. The vehicle's running great and you happily return it to the customer. It's finally done and out of your hair. What a relief! Then a week or two later, the customer returns. The vehicle has a new problem, one that doesn't appear to be related to the original problem. Yet in the customer's mind, it must be related. After all, you just finished working on the vehicle a short time ago.

Problems like these can be a challenge to explain to a customer if they involve the malfunction indicator lamp (MIL). To the customer, a glowing lamp on the dashboard means only one thing: his vehicle has a problem. He doesn't care if the light is on because a DTC P0420 or a P0174 is stored in memory. Either way, it's a problem, and one he thinks he has already paid you to fix.

That's the position we found ourselves in a short time after we finished work on our customer's Yukon. He returned with an illuminated MIL and a DTC P0174 stored in memory. This DTC indicates that the fuel system's Bank Two was running too lean for conditions at cruising speed for a period of at least 120 seconds. During that period, the PCM attempted to richen the mixture by adding fuel but reached its correction limit.

After collecting the freeze frame data that was stored along with the DTC, we decided to compare the Bank One and Bank Two O_2 sensor waveforms. While Bank One looked normal, the Bank Two O_2 sensor waveform looked slower than normal, with relatively few crosscounts and reduced signal amplitude. A visual inspection revealed a new O_2 sensor, but something didn't look quite right about the installation.

Following the Yukon's fuel leakage and rich running episode, the owner decided to replace the O_2 sensors again. Certainly, all that raw fuel and the ensuing heat in the exhaust system could not have done the O_2 sensors any good. After all, it had cooked both catalytic converters, hadn't it? Everything went fine until he got to the Bank Two (right side) O_2. Its position in the exhaust system gave him very little room to work and he had inadvertently cross-threaded the new sensor during installation. The cross-threaded sensor was not able to fully seat against its washer, which allowed outside air to enter the exhaust and dilute its contents. Not only that, an overzealous application of torque during the installation had damaged the sensor's internal ceramic thimble, causing the feeble crosscounts.

To confirm our diagnosis, we repaired the slightly damaged exhaust system threads with a proper-sized tap, then swapped the O_2 sensors from side to side. Sure enough, the DTC and low cross counts swapped sides right along with the sensors. After installing a new O_2 sensor, the vehicle ran as it should and no DTCs were stored in memory.

Figure 2: *The rear of the engine was wet with fuel, either due to a leak at the #5 poppet or at the CSFI unit. Everything was either resealed or replaced to prevent further problems.*

This one may not have been our fault, but it's easy enough to get caught up in the euphoria when a problem vehicle finally seems to be fixed. Make sure it's completely fixed before returning it to the customer. And if it's an OBD II vehicle, try to make all the monitors run to completion at least once after you've made your repairs.

In some cases, an OBD II fault in one area may suspend certain monitors. Once you've repaired the original problem, those monitors will finally get a chance to run. If there's a fault in an area covered by one of the monitors, it's finally going to get a chance to tell somebody about it by possibly illuminating the MIL. Just make sure it's you who sees it, and not the customer on his ride home, after he's just picked up the vehicle from your shop. WELLS

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Wells Manufacturing Corp. is the only full-line supplier of engine management components in the aftermarket to have all its facilities fully QS9000 certified. Once again, Wells leads the automotive parts industry by gearing up for compliance with the ISO/TS 16949:2002 standard.

The quality standards for the automotive industry are being raised another notch with the introduction of ISO/TS16949:2002, which is much more than an update to QS 9000; it is a totally new standard. ISO/TS16949:2002 is a Technical Specification for the automotive industry developed by the International Automotive Task Force (IATF) and the Japanese Automobile Manufacturers Association (JAMA).

DaimlerChrysler, Ford Motor Company, General Motors and several European automakers require ISO/TS16949:2002 compliance of their suppliers. Wells Manufacturing Corp. was included in a group of 48 companies invited by the IATF to conduct audits to ISO/TS16949:2002. The group was selected from the 173 current QS9000-compliant companies.

In 1903 Robert Wells looked into the future. One hundred years later, Wells Manufacturing Corp. is designing the future. WELLS

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