WELLS Counter Point
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THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

Forming a Diagnostic Strategy

The first step in a successful diagnosis is to form a diagnostic strategy.

Chances are, a large percentage of your service customers come to you with a problem, not for just maintenance work. Perhaps the engine isn't running right or there's an unfamiliar noise when the brakes are applied. They rely on you to figure it out — for a fair price, with the least inconvenience and in a reasonable amount of time. To accomplish these simple goals, you must have a diagnostic strategy, which is nothing more than an orderly set of steps that help you determine what the problem is, its cause and how you are going to fix it.

For something simple like a flat tire, the diagnostic strategy has only a few steps. You look at the tire, determine what allowed the air to escape, then decide whether the damage can be repaired without compromising the integrity of the tire. If the tire is repairable, you make the repair, recheck it for leaks, put the tire back on the vehicle and you're done.

Things get more complicated if you're dealing with engine management or driveability problems. For any given problem, there could be any number of different causes. Each potential cause might involve the replacement of an expensive part and/or several hours of shop labor. A missed diagnosis, due to an incorrect or incomplete diagnostic strategy, costs your customer in the form of unnecessary or ineffective repairs, and costs you in the form of a tarnished reputation and the possibility of lost customers. That's why it's so important, for everyone involved, to get it right the first time.

For the past several issues of *Counter Point*, we've been discussing the tools and concepts that go into forming a successful diagnostic strategy. Improving your understanding of OBD II and five gas analysis are two recent examples. It's time to show you how that knowledge can be used to fix an actual vehicle. Recently, a shop in our area asked us to look at a vehicle that had been giving them diagnostic fits. Here are the specifics of the case:

• The vehicle is a 1997 Chevrolet Yukon – 5.7L engine with CSFI,
• Diagnostic Trouble Codes (DTCs) P0420 and P0430 were stored in PCM memory,
• The shop recently 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 before each catalyst to the signal from the oxygen sensor located after each catalyst. One of the main purposes of OBD II is to make sure the catalysts are working properly, since they play such a large role in assuring the vehicle meets the appropriate emissions standards. P0420 and P0430 would have to be considered *very important* DTCs.

By replacing the oxygen sensors and catalysts, the original shop addressed only *the effect*, without finding *the cause*. The catalysts were no doubt damaged. But something had to cause that damage, as we know catalysts rarely fail on their own without some outside cause. Lacking an outside failure cause, they will often last the life of the vehicle, without difficulty. Our job is to find that cause.

Where to begin? How about a list of possible causes for P0420 and P0430? These include (but are not necessarily limited to):

• Engine misfire,
• Ignition timing,
• Engine oil contaminated with HC,
• Front or rear oxygen sensor contaminated with fuel or moisture,
• Front or rear oxygen sensor loose in its mounting — causing an air leak,
• Air leaks at exhaust manifolds or pipes,
• High fuel pressure,
• Poor wiring connection.

Rather than running down this list of probable causes one item at a time until the real cause of the problem is found, it would be helpful to narrow the field somewhat. One quick way to do this is to look at the vehicle's scan data. A scanner equipped with the right software can provide you with a great deal of information about the vehicle, and it takes almost no time at all to get it with an OBD II-compliant vehicle.

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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 have been working on a 1993 Buick Skylark (3.3L engine) with no spark to cylinders 1 and 4 (verified with a timing light). I have replaced the ignition module, coil, ignition wires and spark plugs. I have performed voltage drop tests on the feed and ground wires to the ignition control module with very good results. What's next? Should I replace the PCM?"

Mike Lapp
Zoladz Tire
Alden, NY

A: The PCM is too expensive to replace without making a few more checks first. For example, is the module receiving a crankshaft position sensor (CKP) signal? Next, check the signal from the CKP to the ignition control module (ICM).

The CKP is a dual Hall Effect type. This means it creates a digital pattern from each side. Mike does not have a lab scope, so he used a DVOM on the duty cycle setting to see if he was getting a signal. He read a clear 50% duty cycle from the 18X side of the sensor. The 3X side normally creates a repeating, asymmetrical progressive duty cycle percentage, but he was getting an extremely erratic reading. Time to check the power and grounds to the crank sensor and replace it if they look good.

Mike called back to say the wiring looked good. He replaced the crank sensor but ended up with the same results. He had an erratic signal from the 3X side and cylinders 1 and 4 were still not firing. He had a known-good ICM, wiring and CKP, but no clean signal from the 3X side.

As the crankshaft rotates, the interrupter blades on the harmonic balancer alternately introduce and block a magnetic field to the circuit chips on the dual Hall Effect CKP. While the magnetic field is influencing the circuit chips, reference voltage from the ICM is passed through the sensor to ground. The ICM and PCM interpret this as an OFF signal. Conversely, when the interrupter blades move into the CKP, the magnetic field is blocked and the circuit chips switch the reference voltage from ground. The ICM and PCM interpret this as an ON or triggered signal.

As luck would have it, Mike noticed while testing the CKP that his screwdriver would stick to a portion of the interrupter ring. Somehow a section of the ring had become magnetized! Because it was magnetized in a specific position, the interrupter ring was unable to always fully block the magnetic field from the 3X circuit chip. The charge time to the primary coil windings for cylinders 1 and 4 was not long enough, causing them to misfire.

Results: This diagnosis produced more questions for us than answers. How could a stainless steel ring become magnetized? Could enough current have passed through it at just the right location to magnetize a section? Theoretically, a six cylinder engine will end up in three different positions after it is turned off. Could this customer's luck be so bad that it stopped in the same place too often and the crank sensor magnet magnetized the ring? Is the air gap specification for the crank sensor actually important? For a quick way to set the air gap, refer to "Fine Tuning" in *Counter Point,* Volume 5, Issue 4, October, 2001.

In the last *Counter Point*, we promised to devote more space to crank sensors — specifically what makes them tick and how to test them. A 1995 Olds Cutlass Supreme that came our way recently provided the opportunity to do just that. It was equipped with a 3.1L engine and had about 132,000 miles on the odometer. The owner complained that the engine would cut out and not exceed 2100 RPM. When this occurred, it felt like the rev limiter was kicking in to keep the engine from self-destructing, although the RPM was nowhere near the engine's rev limit.

This vehicle had been to several shops in the area and many ignition and emission components had been replaced. The tech working on the vehicle was able to demonstrate the problem for us. The description of the symptom was very accurate.

To determine whether the engine was losing spark or fuel, we connected a timing light to several of the ignition wires and attempted to raise the RPM above 2100. The timing light revealed that the engine was losing spark when it cut out. When this occurred, all cylinders were affected equally.

After studying the wiring diagram, we determined this engine management system incorporates two crankshaft position sensors. The 24X Hall effect sensor at the end of the crankshaft is triggered by an interrupter ring. The other 3X sensor is a magnetic reluctor design that's located on the back of the engine block.

The 24X sensor had already been replaced twice before, so we decided it would be wise to check the 3X sensor first. We tested it with an ohmmeter by tapping into the harness at the control module and the resistance was 207 ohms. The specification for this sensor is 750 to 1,250 ohms. Obviously, this sensor had a shorted winding and needed to be replaced. In the name of curiosity we also ran an operational test. We then switched the digital multimeter (DMM) to AC volts and cranked the engine. The sensor generated a 1 volt AC signal. The rule of thumb specification for output on this type of sensor is a minimum of 0.4 volts (400 millivolts) during cranking. A 1 volt output was well within those specs. Hmmm, the sensor had passed our first operational test.

Next, we reconnected the ignition module wiring, backprobed the wires leading to the crank sensor from the module, started the engine, then attempted to raise its speed above 2100 RPM. The amplitude and frequency of the crankshaft position sensor increased as the engine RPM increased, which is normal. But

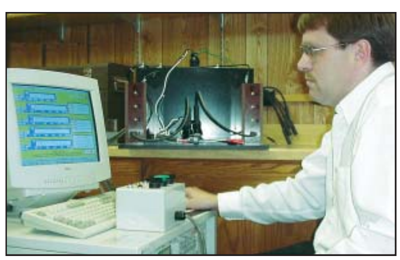
Quality Points

Wells Coil Testing System

Wells Manufacturing Corp. has always maintained very stringent product testing procedures. However, ignition and engine management systems have grown in complexity and precision at a much faster rate than many other systems on today's vehicles. As a result, Wells has further refined its already state-of-the-art ignition coil testing procedures to maintain its leadership position in product design and manufacturing technology.

During the new testing procedures, each coil type is mounted in a specifically designed cradle. It is then run through a battery of tests that simulate the operating conditions the coil would experience if it were running in your customer's vehicle.

The coil tester supplies the primary windings with a current pulse, while simultaneously monitoring the primary/secondary voltages and current flow. Over two million voltage measurements are recorded for each of the nine test parameters. The computer uses



Using the Wells coil testing system, Engineer Tom Schaefer simulates actual operating conditions.

these waveforms to determine coil quality. Next, the information collected during the coil test is stored in the computer's memory, right on the production floor. These waveforms and statistics are used by the quality contol engineer to evaluate product quality and to make production change recommendations.

These new coil testing procedures will continue to instill customer confidence and guarantee that every Wells coil meets and exceeds Original Equipment performance standards.

when the engine approached 2100 RPM, the sensor signal dropped below 400 mV and the engine began to cut out. The signal dropout and the engine cutout symptoms only grew worse as the engine temperature increased.

Diagnostic outcome: Many top technicians have been taught to look for an RPM signal on the scan tool when testing a magnetic reluctor crank sensor. This crank sensor test will work if it is unable to generate a signal above .4 volts because RPM won't register on the scan tool. However, if the problem is intermittent, both the voltage output and resistance need to be checked at different speeds and temperatures to make a complete diagnosis of the crank sensor.

Both correct answers to last issue's "Fine Tuning" question arrived via e-mail (no snail mail winner this time) in a dead heat — literally within minutes of each other. Each of our winners (below) will receive a Wells golf shirt.

Kevin Schmidt
Delphi Product & Service Solutions
Anderson, IN

Stephen Pirritano
Philadelphia, PA

Diagnose The Problem Win A Shirt

Q: "I service several late '90s Ford trucks and vans. The problem I have run into lately on these vehicles is misfires. Neither I nor my customers have actually felt the misfire, but the CEL will light and the PCM will have a P0301, P0304 and sometimes a P0306 stored in memory. The light will usually come on while the vehicle is cruising on the highway. If I clear the code(s), the light will go out but it will come back on in about a week. I have checked compression, fuel pressure, fuel volume and all are well within specifications. I have also replaced the spark plugs, ignition wires and coil with no improvement. I even had the PCM reflashed with an update. What could be wrong?"

George Pattee
Pattee's Garage
San Diego, CA

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.

Important Dates To Remember

The National Institute for Automotive Service Excellence (ASE) will offer certification tests for repair professionals and parts specialists on November 13, 18 and 20. The registration deadline for Fall testing is September 26, 2003. Be sure to register before the deadline, then mark your calendar with these important test dates. Wells Manufacturing Corp. encourages professionalism through technician certification.

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Forming a Diagnostic Strategy

When we retrieved the Yukon's scan data, everything looked pretty normal, except the short term (STFT) and long term (LTFT) fuel trim numbers for Bank 1 and 2. Both LTFT numbers (113 and 109) indicated the PCM was trying to force the fuel mixture lean by subtracting fuel. The STFT numbers (129 and 130) indicated the PCM was trying to force the fuel mixture slightly rich, only because the snap shot was taken at the beginning of a deceleration.

The PCM's most important fuel mixture inputs are the precatalyst oxygen sensors, and they are telling the PCM the mixture is too rich. The oxygen sensors know the mixture is rich, because there is an abnormally small percentage of oxygen present in the exhaust at that moment. Remember, the oxygen sensors can only measure the relative presence or absence of oxygen in the exhaust.

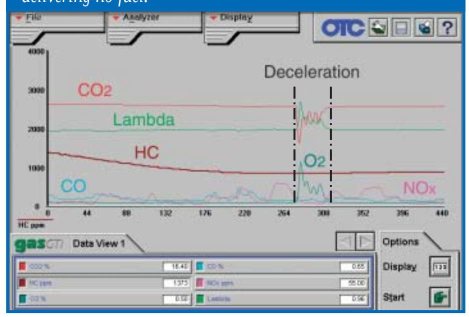
We now know the fuel mixture is too rich, which is probably what destroyed the first set of catalysts. Replacing the catalysts and the oxygen sensors didn't correct this problem. It only put an expensive and temporary band aid on it. And if the problem isn't found, the second set of catalysts will be destroyed in short order.

Other than the Check Engine light and the stored DTCs, the vehicle owner had reported no noticeable driveability problems. Where is the extra, unwanted fuel coming from? To find out more, we measured the post-catalyst exhaust emissions with a five gas exhaust analyzer, immediately after starting the engine cold. The results are shown in graph form in **Figure 1**.

Five gas readings in graph form may be new to you, so a brief explanation is in order. The scale at the bottom of the graph indicates time, so we are looking at a recording that's a little over seven minutes in duration. The numerical readings in the boxes at the bottom of the figure represent the readings at the very beginning of the recording. If we were viewing this graph on a laptop (instead of in paper form), we would be able to scroll the cursor to any point in the recording to see what the readings were at that precise moment.

HC starts out higher than normal and gradually declines. There was an abrupt deceleration between frames 264 and 308. Why is the engine running rich, especially if the PCM is trying to make it run lean? When this occurred, NO_x went down, O_2 went up, Lambda went up (more about Lambda next), CO_2 dipped and HC stayed about the same (still too high). All of these readings, except the high HC reading, are consistent with a lean mixture. We would expect to see a lean mixture at this time, 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 certainly seems impossible. In the next *Counter Point*, we'll explain how we finished our diagnosis and identified the fault.

Figure 1: *As this analyzer trace reveals, HC emissions remained high from cold startup, through acceleration and into closed throttle deceleration, when the injectors were delivering no fuel.*



What About Lambda?

Lambda is another word to add to your diagnostic vocabulary. It's the word for the Greek letter *L*, which also happens to be the first letter of the German word *Luftzahl*. That's "air number" or "air ratio" in English.

For diagnostic purposes, Lambda is a mathematical calculation that reflects an engine's air-fuel ratio (AFR) *before combustion*. Lambda is unaffected by fuel chemistry or the combustion process, so it can be very useful for diagnostic purposes. Many exhaust gas analyzers include a Lambda calculation, along with the conventional five gas and AFR numbers.

Numbers are meaningless without a reference point. We need to know what is "normal." When it comes to Lambda calculations, any AFR that has the ability to convert all carbon to carbon dioxide and all hydrogen to water is defined by the number 1. This is the ideal Lambda number because the AFR would produce perfect combustion. If the AFR is lean (too much oxygen), Lambda will be above 1, as seen in the five gas graph in **Figure 1**. If the AFR is too rich (too much fuel), Lambda will be below 1. For example, if the AFR is 5% lean, Lambda will be 1.05. If it is 5% rich, Lambda will be 0.95.

That's the skinny on Lambda. But don't worry, we haven't finished with it just yet. Upcoming *Counter Point* articles will explain how to work Lambda readings into your diagnostic strategies.

WELLS

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Hot off the Wire

National Catalog Managers' Award

Wells Manufacturing Corp. recently received the President's Award for Electronic Data Excellence at the National Catalog Managers Association (NCMA) annual conference in San Antonio, Texas. The award was presented to Wells Catalog Manager Dave Teifke, by NCMA President Chris Nierintz.

This award is given to the top companies supplying electronic data that is used in the electronic catalogs for Autozone, CCI/Triad, DST MacDonald and Wrenchead. Judging criteria include, but are not limited to:
• Information format,
• Compliance with Automotive Aftermarket Industry Association (AAIA) standards, established by the NCMA,
• Timeliness of data submission,
• Data accuracy,
• Ease of cross platform data transmission,
• Supersession and obsolescence information.

The 2002-2003 NCMA President's Award, presented to Wells Mfg. Corp. by AutoZone.

Wells Manufacturing Corp. has been a NCMA member since 1981 and has received nine President's Awards for Catalog Excellence for its paper catalogs (see *Counter Point* Volume 4 Issue 4, October 2000). We have earned more of these awards than any other ignition/emissions parts manufacturer. And now we have taken the next step by proving our ability to meet the highest standards in electronic data interfaces.

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