WELLS Counter Point

Volume 8 Issue 1, January 2004

THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

Wide Range Air/Fuel Ratio Sensors

A new type of sensor has begun to appear. New diagnostic techniques are required.

A conventional zirconia oxygen sensor generates a very low voltage in response to changes in the oxygen content in the exhaust system. When it is operating properly, the oxygen sensor's output voltage ranges between 0 and 1 volt. The exhaust oxygen content, as measured by the oxygen sensor, theoretically indicates whether the engine is running rich or lean. If the oxygen sensor output voltage is high (close to 1 volt), the exhaust oxygen content is low and the engine is running rich. If the oxygen sensor output voltage is low (close to 0 volt), the exhaust oxygen content is high and the engine is running lean.

We've become accustomed to seeing the oxygen sensor's output voltage constantly range from high to low and back again. The extra oxygen present in the exhaust stream when the air/fuel ratio is slightly lean is used to recharge the catalytic converter with a fresh supply of oxygen molecules. This allows it to do a better job of oxidizing the HC, CO and NOx in the exhaust stream into harmless compounds.

A toggling air/fuel mixture works pretty well, but today's tighter emission control requirements can only be met through more precise control of the air/fuel ratio. These changes have necessitated the development of a new type of oxygen sensor. It is commonly called an air/fuel ratio sensor, or A/F sensor for short. It can currently be found on many late model Toyota and Honda models, and other manufacturers are certain to follow. The A/F sensor has the ability to accurately measure air/fuel ratios over a wider range than a conventional oxygen sensor. A conventional oxygen sensor is accurate near stoichiometric (14.7:1) only, but the A/F sensor is capable of measuring air/fuel ratios as lean as 23:1 and as rich as 11:1. This permits the PCM to more accurately meter the fuel, reducing emissions.

Though it may appear similar to a conventional oxygen sensor on the outside, the A/F sensor is constructed differently and has different operating characteristics. They are not interchangeable, although their harness connectors may look very similar. The A/F sensor operates at approximately 1200° F, which is much hotter than the conventional oxygen sensor's 600-750° F operating temperature. A more powerful internal heater is used to assure that the A/F sensor always operates in the necessary temperature range.

We'll discuss the operation and testing of the Toyota sensor here and will address other A/F sensors in future *Counter Point* issues. The most important difference between a conventional oxygen sensor and the Toyota A/F sensor is the way the A/F sensor signals the PCM when a change in the exhaust oxygen content occurs. Instead of the oxygen sensor's changes in signal voltage, the PCM watches the A/F sensor for changes in its current (amperage) output, relative to the amount of oxygen in the exhaust stream. A circuit in the PCM detects the change and strength of the current flow from the A/F sensor and generates a voltage signal proportional to the exhaust oxygen content. This allows the PCM to judge the exact A/F ratio under a wide range of conditions and quickly adjust the amount of fuel needed to reach the stoichiometric point.

This change in operating strategy means a big change in the way you diagnose and repair this A/F sensor. With a conventional oxygen sensor, it is possible to backprobe the sensor's signal wire and observe its signal to the PCM with a DVOM, oscilloscope or graphing multimeter. While it is still possible to backprobe the A/F sensor's signal wire, the information you receive by doing so may be of little use to you, especially if it is incorrectly interpreted.

The A/F sensor has two signal wires, not one. The PCM provides a set voltage on each of these wires; neither is a ground. One is set at 3.0 volts, the other at 3.3 volts. With the A/F sensor connected to the PCM, attaching the leads of a DVOM to these sensor's two wires would reveal little change. The reading should remain nearly constant at 0.3 volt (300 millivolts), regardless of any changes in the A/F ratio. As the A/F sensor changes its output in response to fluctuations in the A/F ratio, the PCM's detection circuit maintains the steady 300 millivolt output.

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 a 2001 Buick Century in the shop. It has 28,000 miles on it and is equipped with a 3.1L V-6 engine. The transmission was recently replaced. Now the Check Engine, ABS and Brake warning lights are all on constantly. My scan tool can't communicate with the brake or body controllers, but it can communicate with the Powertrain Control Module. I retrieved a Diagnostic Trouble Code (DTC) U1064. I can't find anything else wrong. Do you have any ideas?"

Tim Ross
Brough Exxon
Hasbrock Heights, NJ

A: As vehicles age and their electrical connections begin to deteriorate, you can expect to see more and more DTC U codes begin to pop up. A DTC U code indicates a communication problem between modules. An identification signal is normally sent between modules every two seconds. If no signal is received for five seconds, a DTC U1xxx will set. In most cases, it is caused by a wiring problem. Seeing as the transmission was recently replaced, I would suggest looking in that area first.

Results: After doing a closer visual inspection, Tim found two ground wires hanging loose over the top of the transmission. After he reattached them, communication was restored and the lights on the dash went out.

Diagnose The Problem - Update

An often overlooked key to a successful diagnosis involves asking the customer for a description of the problem. This may be the only way to get all of the facts. The problem presented in the previous *Counter Point* issue is a case in point. The vehicle in question is a 1998 Oldsmobile Delta 88 with a 3800 (VIN K) V-6 engine and 40,000 miles on it. The customer complained that it was often necessary to crank the engine for a long time before it would start, with black smoke from the tailpipe after startup.

The most important bit of information provided by the customer was the black smoke from the exhaust after startup. This only occurred when the engine was cold, after the vehicle sat for a long period of time. Starting and running characteristics were normal under all other conditions.

Black smoke indicates an engine that is running extremely rich. When you see this kind of indicator, your inclination might be to try to duplicate the problem. However, this may not be necessary or practical, especially when dealing with a cold start problem. To recreate the problem, the vehicle would have to sit overnight. Even then, there is no guarantee the problem will appear.

It's more effective to determine the source of the over-rich condition that is causing the black smoke. A good place to start is a fuel pressure test, which will tell us if the system is capable of building and holding a specified pressure. The fuel pressure specification is 48–55 psi. The test showed it could build 53 psi - well within the specs. However, the system pressure would immediately drop to zero when the ignition was turned off. As a rule of thumb, the system should maintain fuel pressure to within 10 psi of the specification for an indefinite period of time.

We needed to pinpoint the leak next. System pressure on this vehicle is regulated by the fuel pressure regulator, based on engine vacuum. At idle when engine vacuum is high and the demand for fuel is low, the fuel pressure regulator allows most of the fuel to return to the tank. Vacuum is low when the engine is accelerated and the regulator responds by blocking fuel return to the tank.

The engine was off when we checked fuel pressure, so the regulator did not have vacuum applied to it. This simulated an engine under a heavy load, and the fuel return to the tank should have been blocked. This meant the pressure leakdown we observed during our test had to be caused by the injector(s), fuel rail or pressure regulator.

The next step was to test the diaphragm in the pressure regulator. As we applied vacuum to the regulator, we noticed the vacuum hose was full of fuel. This indicated that the pressure regulator diaphragm had ruptured and vacuum from the intake manifold was drawing fuel from the rail. The excess fuel reached the combustion chambers, flooding the engine and causing black smoke when it finally started. After

Quality Points

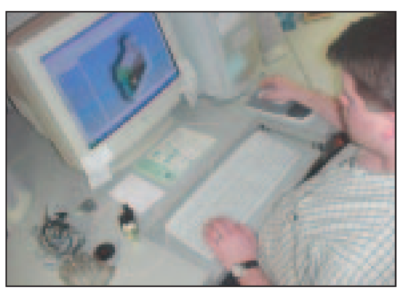
Computer-Assisted Design

The computer-assisted designer's job begins as soon as an engineer brings a component to be manufactured to the Wells computer-assisted design (CAD) department. The process begins by collecting all measurements. Non-critical, easily accessible measurements are taken by the CAD designer. All other measurements are collected by the quality assurance department (refer to *Counter Point* Volume 5, Issue 2, April 2001).

A three-dimensional model of the component is drawn by the CAD designer. This is not just a drawing of the outer shell; it is a 3-D drawing of the shell and all of the components. The CAD designer's 3-D solid model drawings can be rotated to any angle, taken apart piece by piece or sectioned anywhere through any surface.

The next step is to produce a Stereo Lithography model. This process uses lasers to carve an exact replica of the drawn component. This electrically non-functional replica is then mounted on a vehicle to check the fit with mating components and to assemble with obtainable components.

When the design has been finalized, the electronic cad file is sent to the mold maker in our tool room (refer to *Counter Point* Volume 6, Issue 2, May 2002). He will use three-dimensional computer-aided manufacturing (CAM) software to create the mold that will be used to make the final part. After the completion of the mold, it is injected with a clear material to make the first part. This clear part is used to check interaction between internal components. The final parts are then checked by our quality assurance department. After the molds receive final approval, stamping dies and other assembly tools are moved to the production floor.



CAD designer (your name here) uses *Solidworks* CAD software to prepare 3D drawings during the Wells part design process.

Our integrity and dedication are embedded in every component we manufacture. **WELLS** replacing the fuel pressure regulator, the problem was resolved.

I would like to thank our readers for your suggested solutions to this diagnostic problem. Most of the answers pointed to problems with the intake manifold. This vehicle incorporates an upper intake manifold that is manufactured with a composite material. This material has a tendency to degrade around the EGR stove pipe, which could result in a coolant leak near or under the throttle body area of the upper intake manifold (Oldsmobile Service Bulletin No. 01-06-01-007A).

This could cause symptoms very similar to the one described above. However, when antifreeze enters the combustion chamber and is used in the combustion process, it will usually cause whitish smoke from the tailpipe. Am I saying you don't need to check the intake manifold for leaks unless you see white smoke from the exhaust? Absolutely not! But in this case, it was the pressure regulator, not the intake manifold, which was the root of the problem. In either case, be sure to check the crankcase for gasoline accumulation and change the oil and filter if necessary.

The first correct e-mail or fax answer:
Matt Faw
Faw Motor Company
Cambridge, NE

The first correct postal answer received:
Rollin Nelson
Nelson 7607 Automotive Service
Ord, NE

Diagnose The Problem Win A Shirt

Q: "I am working on a 2000 Chevrolet Silverado with the 4.3L Vortec engine that has 46,000 miles on it. The Check Engine light comes on occasionally, but the owner has no driveability complaints. I connected a scan tool and retrieved two codes. The first was a P0171 - Fuel System Lean (Bank 1) and the second was a P0174 - Fuel System Lean (Bank 2). I also checked the fuel trim and long term was at 24.2%. I have checked it for vacuum and exhaust leaks and it looks okay. I have also checked fuel pump pressure and volume and they are both within specifications. The fuel pressure regulator also looks good. The voltage, resistance and amperage readings for the injector also were within specifications. What diagnostic step should I take next?"

Tim Marose
Tim's Truck Repair
Richmond, VA

continued from page 1

Wide Range Air/Fuel Ratio Sensors

To measure a four-wire A/F sensor's response using *voltage*, disconnect the sensor's four-wire connector, then attach jumper wires to maintain power to the sensor heater. Next, connect a scope or multimeter to the two *disconnected* sensor signal wires. When the A/F ratio is artificially richened or leaned, you'll see that the A/F sensor responds just like a conventional oxygen sensor. Its response swings between 0 and 1 volt, with 0 indicating a lean mixture and 1 indicating a rich mixture.

Figure 1: *After providing power to the A/F sensor heater, we attached a DVOM to the two other sensor leads. After starting the engine, the sensor responded like a conventional O_2 sensor.*

To measure a four-wire A/F sensor's response using *amperage*, install an ammeter *in series* with the PCM's 3.3 volt signal wire. The ammeter's negative (black) lead should be connected to the sensor lead and the positive (red) lead should be connected to the PCM wiring. The 3.0 volt signal wiring as well as the heater wires must remain connected (jumpered between connectors) during this test.

Imagine the A/F sensor as a tiny generator that is capable of changing polarity. A lean exhaust will cause the A/F sensor to produce a positive-going ammeter reading, while a rich exhaust will cause it to produce a negative-going ammeter reading. When the A/F ratio is at the stoichiometric point (Lambda), no current is generated and the ammeter shows 0 milliamps.

If you decide to forgo testing the A/F sensor directly at the sensor, always remember that the data you see on your scan tool has been processed and interpreted by the PCM. And in the case of the A/F ratio sensor, it's data that has been converted from a current reading into the voltage reading you see on the scanner.

If your scan tool is equipped with the necessary software, the PCM's voltage detection circuitry will produce the following readings on your scan tool for the A/F sensor parameter identification (PID):

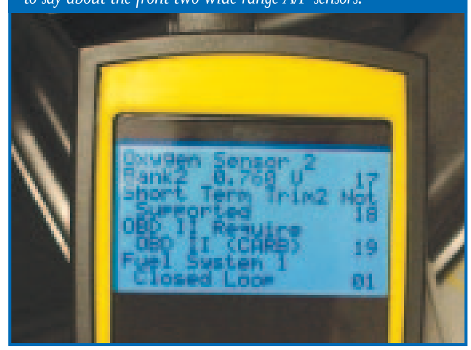
• A low exhaust oxygen content causes a negative current flow at the A/F sensor. The PCM detection circuit produces a voltage signal below 3.3 volts, indicating the air/fuel mixture is judged to be rich.

• Exhaust oxygen content at stoichiometry produces no current flow at the A/F sensor. The PCM detection circuit produces a voltage signal of 3.3 volts, indicating the air/fuel mixture is judged to be at 14.7:1.

• A high exhaust oxygen content causes a positive current flow at the A/F sensor. The PCM detection circuit produces a voltage signal above 3.3 volts, indicating the air/fuel mixture is judged to be lean.

Some scan tools are not equipped to read the data from the PCM's A/F sensor detection circuit. You may see no PID for the A/F sensor, which may lead you to believe the A/F sensor is faulty or the vehicle does not have an A/F sensor. Other scan tools apply a conversion factor to bring the A/F sensor PID into the more familiar 0 to 1 volt output range. This is accomplished by dividing the sensor detection circuit's original output by 5. So a stoichiometric reading of 3.3 volts becomes 0.66 volts on the scan tool. A 4.0 volt (lean) detection circuit reading becomes 0.8 volts on the scan tool. And a 2.5 volt detection circuit reading becomes 0.5 volts on the scan tool.

Figure 2: *Make sure your scan tool can handle data from a wide range A/F sensor. This generic OBD II scanner reported PIDs for both conventional rear O_2 sensors, but had nothing to say about the front two wide range A/F sensors.*



Everything seems fine until you notice that the A/F sensor voltage PID on your scan tool is exactly the opposite of what you're accustomed to seeing from a conventional oxygen sensor. The voltage output through the PCM's detection circuit and the interpreted PID on your scanner increases as the mixture goes lean and decreases as the mixture gets richer. Don't be fooled by your scanner.

During normal operation, the swings between rich and lean A/F ratios will be more subdued than you're accustomed to seeing. Don't look for the traditional toggle between very rich and very lean. The A/F ratio commanded by the PCM will remain fairly constant, unless there's a big change in engine speed or load. It's that consistency that helps the PCM deliver the cleanest possible emissions while retaining performance and driveability. **WELLS**

WELLS

WELLS MANUFACTURING CORP.
P.O. Box 70
Fond du Lac, WI 54936-0070

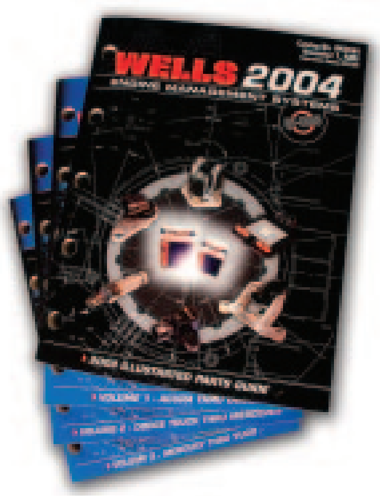
Hot off the Wire

2004 Catalogs

Wells Manufacturing Corp. is pleased to announce the publication of the **2004 Engine Management System Catalog** and the **2004 Illustrated Parts Guide.**

To maintain the high standards you have become accustomed to as a Wells customer, we have added more than 2,400 part numbers to our program and catalog this year. There are more than 24,500 numbers in the Wells line and always climbing.

Due to catalog rack restrictions, customer requests and the ever-growing number of parts needed to cover the entire engine management category, we have made two noteworthy changes to our catalogs. Applications are now divided into three separate volumes: Volume 1 covers Acura thru Dodge, Volume 2 covers Dodge Truck thru Mercedes and Volume 3 covers Mercury thru Yugo vehicles. We have also removed the OE to Wells interchange information from the back of the Illustrated Parts Guide. This information will be combined with other interchanges in a stand-alone book, which will be available late in the first quarter of 2004.



For coverage, availability and the right part the first time, choose Wells.

WELLS

Publisher's Information

Wells' President ....William Allen
Vice President of Sales....Gavin Spence
Technical Services Manager .. Mark Hicks
Newsletter Editor ....Karl Seyfert

Counter Point is a quarterly publication of Wells Manufacturing Corp., P.O. Box 70, Fond du Lac, WI 54936-0070. Letters and comments should be directed to: *Counter Point* Editor, c/o Wells Manufacturing Corp., P.O. Box 70, Fond du Lac, WI 54936-0070.