

WELLS Counter Point

Volume 2 Issue 3, September 1998

THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

Making Sense Of Oxygen Sensors

Today's computerized engine control systems rely on input from a variety of sensors to regulate engine performance, emissions and other important functions.



These sensors must provide accurate information otherwise driveability problems, increased fuel consumption and emission failures can result.

One of the key sensors in this system is the oxygen (O₂) sensor. The O₂ sensor is mounted in the exhaust manifold to monitor unburned oxygen in the exhaust. The O₂ sensor tells the computer if the fuel mixture is burning rich (less oxygen) or lean (more oxygen). The computer then uses the sensor's voltage signal to alter the fuel mixture, creating a feedback loop that constantly rebalances the fuel mixture.

When the engine is first started, the computer is in "open loop" and does not use the signal from the O₂ sensor. The fuel mixture is set to run rich and stays that way until the system goes into "closed loop" and starts using the O₂ sensor signal to vary the fuel mixture. Most late-model O₂ sensors are "heated" so they will warm up and reach operating temperature sooner to reduce emissions. Heated O₂ sensors typically have three or four wires. Older single-wire O₂ sensors do not have heaters.

An O₂ sensor failure or a problem in the sensor's wiring circuit will prevent the system from going into closed loop causing a rich-fuel condition, increased emissions (particularly carbon monoxide) and fuel consumption. Keep in mind that a bad coolant temperature sensor can also prevent the system from going into closed loop.

HOW THE O₂ SENSOR WORKS

The O₂ sensor used in most vehicles is a voltage generating sensor. The tip of the sensor has a zirconium ceramic bulb coated on the inside and outside with porous platinum, which serve as the electrodes. Inside the bulb are two platinum electrodes. The inside of the bulb is vented through the sensor housing to the outside atmosphere.

When the bulb is exposed to hot exhaust, the difference in oxygen levels across the bulb creates a voltage. The sensor will generate up to about 0.9 volts when the fuel mixture is rich. When the mixture is lean, the sensor's output voltage can drop as low as 0.1 volts. When the air/fuel mixture is balanced (about 14.7:1), the sensor will generate around 0.45 volts.

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Counter Point Commemorates Its First Year!

With this issue, WELLS Counter Point newsletter marks the conclusion of its well-received first year of publication, a year in which more than 20,000 subscription requests were received.

"The favorable response from technicians and others involved in automotive repair has been even more than we expected," said Gavin Spence, Vice President of Sales for WELLS Manufacturing Corp.

"Our goal from the start has been to make Counter Point a valuable automotive diagnostic resource, presented in a straightforward, easy-to-read style. We're pleased that so many technicians have told us we achieved that. We'll work to make Counter Point even more useful in the future."

Despite the tremendous response already, we will continue to honor subscription requests. Please mail them to WELLS, P.O. Box 70, Fond du Lac, WI 54936-0070. We also welcome your comments and technical questions.

One quick note: we've changed the publication date for this issue from August to September, to put us on a calendar-year quarterly schedule. Because of many requests, we'll also three-hole drill Counter Point so you can save the issues in a binder.

Once again, thank you for your support. We at WELLS look forward to being a valuable diagnostic and driveability resource to you for many years to come.

Making Sense Of Oxygen Sensors

When the engine is running in closed loop, a good O2 sensor will produce a voltage signal that is constantly changing back and forth from rich to lean. The transition rate is slowest on engines with feedback carburetors, typically one per second at 2500 rpm. Engines with throttle-body injection are somewhat faster (two or three times per second at 2500rpm), while engines with multiport injection are the fastest (five to seven times per second at 2500 rpm).

OBD II = MORE O2 SENSORS

On late model vehicles equipped with OBD II, the number of oxygen sensors used has doubled. A second oxygen sensor mounted behind the catalytic converter is used to monitor converter operating efficiency. The OBD II system does this by comparing the fore and aft O2 sensor readings. Little or no change in oxygen readings between both sides of the converter can mean the converter isn't doing anything. This may cause the Malfunction Indicator Lamp (MIL) to come on.

O2 SENSOR DIAGNOSIS

O2 sensor performance diminishes with age as contaminants accumulate on the sensor tip and gradually reduce its ability to produce voltage. The sensor becomes sluggish and takes longer to react to oxygen changes in the exhaust causing emissions and fuel consumption to go up. The effect is most noticeable on engines with multiport fuel injection (MFI) because the fuel ratio changes more rapidly than on the throttle-body or feedback carburetor applications. If the O2 sensor fails, the computer may go into open loop operation. Contaminants include lead, silicone (from internal coolant leaks or the wrong type of RTV sealant), phosphorus (from oil burning), and sulfur.

The operation of the O2 sensor should be checked any time there's an emissions or engine performance problem. The sensor should also be checked when the spark plugs are replaced. Some vehicles (imports mostly) have a maintenance reminder light for checking the O2 sensor.

Reading the O2 sensor's output voltage while the engine is running (at normal temperature) with a scan tool or digital voltmeter will tell you if the sensor is producing a signal, but not if the signal is a good one because the numbers jump around so much. A high-impedance analog voltmeter is better for viewing transitions, but may not respond quickly enough on systems with higher transition rates. So the best instrument for observing the O2 sensor's voltage output is a digital storage oscilloscope (DSO). A scope will display the sensor's voltage output as a wavy line that shows both its amplitude (minimum and maximum voltage) as well as its frequency (transition rate from rich to lean).

Fine Tuning



Fine Tuning questions are answered by Jim Bates, Technical Services Director. Please send your questions to: Jim Bates 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 1988 Pontiac LeMans that is hard to start during rainy, damp weather. Replaced the spark plugs and plug wires which help somewhat, but problem still occurs. What's up?"

Charley Meyers, Ft. Wayne, IN

Hard starting can be caused by condensation on the inner and outer surfaces of the distributor cap. Moisture drains off the ignition voltage and weakens the spark making the engine difficult or impossible to start. The buildup of moisture on the cap on this car can be made worse by the plastic-bag style splash shield that covers the cap on vehicles built before VIN JB372711. Discard the splash shield, then remove the cap, wipe it dry and carefully inspect it for wear, burning, cracks or carbon tracks. Replace the cap and rotor if any defects are found.



Q: "A 1987 Ford Thunderbird with a 3.8L engine idles rough and sometimes stalls. Checked intake vacuum, spark plugs, ignition timing, fuel pressure and compression. All are okay."

Jose Raffiel, San Diego, CA

An erratic idle, rough running and stalling on this car may be caused by chafing of the MAP sensor wires. The wires may rub against the engine-ground strap, creating a short, which may also set a code 22. Loosen the engine ground-strap attaching screw and rotate the eyelet to a downward position so the strap does not make contact with the MAP sensor wires. Tighten the ground-strap screw and repair the insulation on the MAP sensor wiring.

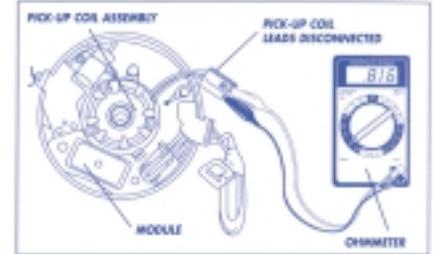


Q: "A 1991 Chevy Caprice with HEI ignition dies and won't restart (no spark). Replaced ignition module. Engine ran fine for several days, then died (again, no spark)."

Jeff Steiner, Columbus, OH

Don't be too quick to blame the module. The problem may be a faulty pick-up coil connector. The pick-up coil produces a small current that the module uses to switch the ignition coil on and off. If a poor connection exists in the pick-up coil circuit, the module may lose the trigger signal causing the engine to die because of no spark. Repositioning the pick-up terminal leads when the module is replaced may temporarily restore the

connection. But if the female connectors on the ends of the pick-up coil wires are loose or corroded, the problem will soon reappear.



Disconnect the green and white pick-up coil wires from the HEI module in the distributor. Check the continuity of the pick-up coil windings by connecting an ohmmeter across the two terminals. A good winding with tightly crimped terminals will produce a reading between 500 and 1500 ohms.

Recrimping the connectors on the wires and/or soldering the connectors to the wires will help assure good contact. Also, make sure the pick-up coil-wire female connectors fit the spades on the HEI module tightly. Apply dielectric grease to the terminal connections to prevent oxidation.



Q: "A 1995 Honda Civic misfires badly when accelerating. One spark plug was found to be wet. Replaced spark plugs. Condition improved but still misfires occasionally under load."

Wade Jackson, Lubbock, TX

Check the spark plug wires. Excessive resistance in the plug wires can increase the firing voltage requirements to the point where the spark may not be able to jump the electrode gap when the engine is under load.

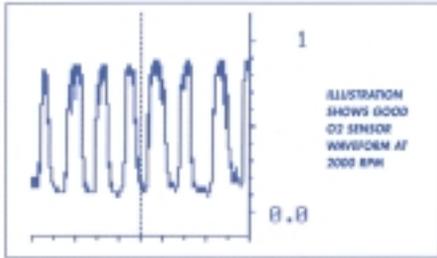


Loose-fitting spark plug boots or damaged insulation on the plug wires may also provide paths where the spark can escape to ground. Good plug wires should generally have less than 8,000 ohms per foot resistance. If resistance exceeds specifications, or the plug wires are found to be damaged, replace the wires.

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Making Sense Of Oxygen Sensors

A good O₂ sensor should produce an oscillating waveform at idle that makes voltage transitions from minimum (0.3v or less) to maximum (0.8v or higher).



Making the fuel mixture artificially rich by feeding propane into the intake manifold should cause the sensor to respond almost immediately (within 100 milliseconds) and go to maximum (above 0.8v) output. Creating a lean mixture by opening a vacuum line should cause the sensor's output to drop to its minimum (0.3v or less) value. If the O₂ sensor voltage does not change back and forth quickly enough, it needs to be replaced.

A sluggish O₂ sensor often won't set a fault code, so don't assume the O₂ sensor is okay if there is no code.

A SIMPLE WAY TO TEST AN O₂ SENSOR

The O₂ sensor can also be checked by removing it from the vehicle, connecting a digital voltmeter to the sensor and using a propane torch to heat the sensor element.

With a zirconia O₂ sensor, connect the positive test lead to the O₂ sensors lead wire, and the negative test lead to the sensor housing or shell (ground).

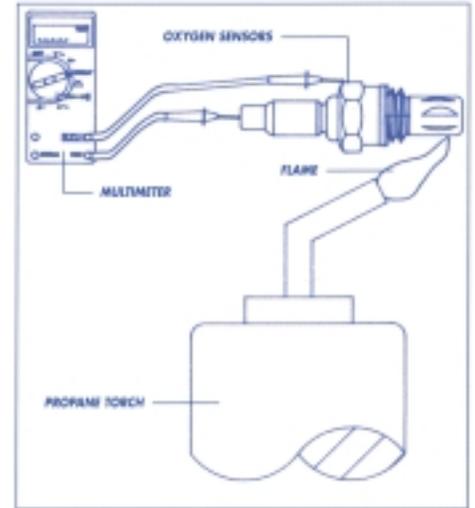
Hold the sensor with pliers, then use the propane torch to heat the sensing element. The flame consumes most of the oxygen, so the sensor should generate a "rich" voltage signal of about 0.9 volts within 60 seconds or less.

Next, remove the flame while observing the voltmeter. The sensor reading should drop to less than 0.1 volt within three seconds if the sensor is good.

To test the sensor's heater circuit, connect an ohmmeter (set on low scale) across the sensor's two heater wires. If the heater circuit is okay, the meter will register a resistance reading. The actual reading is not important so long as the meter registers something other than an open circuit.

HOW TO TEST A TITANIA O₂ SENSOR

Some vehicles (Jeep & Toyota) have "titania" O₂ sensors that change resistance rather than produce a voltage. This type of O₂ sensor can be tested with an ohmmeter and propane torch.



Set the ohmmeter on the 200K scale, and connect it across the black and gray sensor leads. Use the torch to heat the tip of the sensor as before, and note the ohmmeter reading. A good sensor should show some resistance (the reading will vary with flame temperature).

Next, remove the flame and note the reading again. A good sensor should go back to infinity.

Quality Points

WELLS Premium Spark Plug Wire Sets: The Perfect Replacement For OEM

Unlike many aftermarket spark plug wire sets, WELLS Premium Wire Sets are a perfect replacement for OEM wire sets. WELLS wire sets duplicate the appearance, fit and performance of all OEM wire sets in every way. Wire lengths are the same as the original, and some sets even include two different lengths of coil wire so that there are no compromises.

The same high-quality, high-temperature materials are used in WELLS Premium Wire Sets for the conductor, insulation, jacketing and boots as the OEM wires -- and the boots are designed to not only duplicate the look and fit of the OEM boots but also their performance.

For example, the WELLS QW942 replacement wire set for the 1994-95 Ford Explorer with 4.0L V6 and DIS ignition have the same pinkish-orange high temperature silicone boots as the original wire set.

Many aftermarket wire sets do not have special high temperature boots for applications that require them. Yet many late-model Ford and Chrysler applications have wire sets that require them. On Ford, black silicone boots provide protection up to 450 degrees, gray boots are for applications that require up to 550 degrees, and the pinkish-orange boots are for ones that must withstand up to 600 degrees.

WELLS Premium Wire Sets are backed by a lifetime limited warranty.

When should plug wires be replaced? New wires are needed if the wires have been damaged by mishandling or the wires are shorting, arcing, chaffing or burning. Wires should also be replaced if the resistance per foot exceeds the OEM specifications for the application, generally no more than 8,000 ohms per foot.

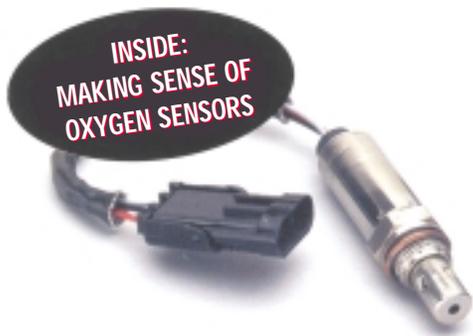
Plug wires should always be inspected anytime an ignition or driveability problem is experienced, and every time the spark plugs are replaced.

When replacing wires, start with the longest wire first. It's important to make sure the spark plug terminal is snap-locked in place (listen for an audible "click") to prevent arcing which could lead to premature failure of the wire as well as the ignition coil. Wires must also be routed the same as before to prevent crossfire or electromagnetic interference, and properly supported to prevent vibration, chaffing or contact with hot exhaust manifolds.



WELLS

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Hot off the Wire

WELLS' Website Has Isolation Diagnostic Charts

If you're looking for tips on how to test various kinds of sensors and other ignition parts, check out the technical tips on WELLS' website at www.wellsmfgcorp.com.

Here you will find diagrams showing how to isolate faults in oxygen sensors, ignition coils,

hall effect sensors, temperature sensors, throttle position sensors, mass air flow sensors, frequency generating MAP sensors and knock sensors.

Each chart shows how to hook up test equipment and check the component.



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