WELLS Counter Point

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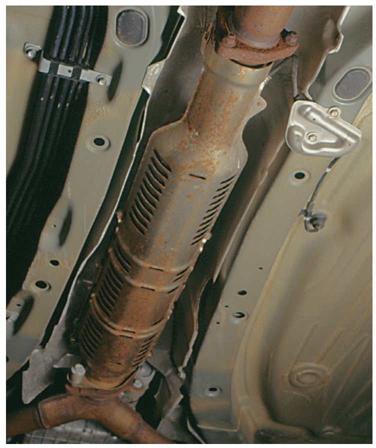
THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

OBD II...Catalyst Monitors

One of the OBD II system's most important jobs is to monitor the health and performance of the catalytic converter(s).



So how does OBD II monitor catalyst efficiency? In the last *Counter Point*, we discussed the operation of the OBD II oxygen sensor monitor. All OBD II vehicles have at least two heated oxygen sensors (HO2S) – one in the exhaust stream before each catalytic converter and one after each catalytic converter. We already know the engine management system uses information from the upstream HO2S to determine the correct air/fuel ratio. The OBD II system also uses information from the upstream and downstream HO2S to infer catalyst efficiency, based on the oxygen storage capacity of the catalyst.

Several different rear HO2S locations may be necessary, depending on the vehicle's exhaust system design. For example, many V-engines are monitored by each individual cylinder bank. A rear HO2S sensor is used along with the front, fuel-control HO2S sensor for each bank. So a total of four sensors are used. Some V-engines have exhaust banks that combine into a single catalyst and are referred to as Y-pipe systems. They use only one rear HO2S sensor along with the two front fuel-control HO2S sensors. TheseY-pipe systems use three sensors in all. Other numbers and combinations of front and rear sensors are used, depending on the manufacturer. The important point to remember is that OBD II must be able to monitor exhaust oxygen content before and after the catalyst.

Three-way catalysts (TWC's) contain one or more precious metals (palladium, platinum and rhodium), which are used to catalyze the unburned hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NO_X) resulting from the combustion of gasoline. When the catalyst is working properly, the unburned hydrocarbons are oxidized by combining with oxygen to form water vapor (H_2O). Carbon monoxide is also oxidized to carbon dioxide (CO_2), and oxides of nitrogen are reduced to nitrogen and oxygen.
Under normal closed-loop fuel conditions, TWC's have a very high oxygen storage capacity. To accomplish this, most modern TWC's also contain the base metal cerium, which attracts and holds excess oxygen in the exhaust stream. This stabilizes the operation of the catalyst and enhances the effectiveness of the precious metals in converting the byproducts of combustion into harmless gasses. As a catalyst becomes less effective in promoting chemical reactions, its capacity to store oxygen generally degrades as well. The OBD II catalyst monitor is based on an observed correlation between conversion efficiency and oxygen storage capacity.

Backprobing at the PCM, a good catalyst (one that approaches 95% hydrocarbon conversion efficiency) will show a relatively flat output voltage on the downstream HO2S under most driving conditions. The switching frequency of the rear HO2S will also be slow when compared to the switching frequency and amplitude of the front HO2S (*Figures 1&2 on page 3*). The flow of unused oxygen that is expelled by the catalyst remains fairly low and nearly constant, although rear HO2S frequency and amplitude may increase at higher engine load and RPM (*Figure 3*).

A degraded catalyst (65% or less hydrocarbon conversion) will cause greater peaks and valleys in the downstream HO2S output voltage, because the catalyst has lost some of its ability to store oxygen and properly process the exhaust gases. More oxygen will be expelled by the catalyst, and the post-catalyst HO2S signal will switch more rapidly with increased amplitude. Its waveform will begin to look very similar to the switching frequency and amplitude of the pre-catalyst HO2S.

The powertrain control module (PCM) uses this information to infer the oxygen storage capacity of the catalyst. A high oxygen storage capacity indicates a good catalyst; low oxygen storage capacity indicates a catalyst that is failing.

Monitor Requirements

The OBD II catalyst efficiency monitor is tested once per trip, rather than a continuous monitor. Before the monitor will run, certain enabling criteria must be met. The engine must be warm, the throttle must be open, the engine must be in closed loop, the engine rpm must be within a specified range and the MAP voltage must be at a specified level. Even if these enabling criteria are met, the catalyst monitor

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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: "My wife's 1997 Mitsubishi Gallant has about 75,000 miles on it, and it has had a driveability problem for the last 25,000 miles. The problem is intermittent, but seems to occur most often on the highway at 65 mph with the cruise on. The Gallant's 2.4L engine begins to surge a short time after the cruise is engaged.

"The vehicle has been to a dealership and several independent shops, but no one has been able to diagnose this problem. The fuel and ignition system have been tested and found to be in good shape. The airflow sensor has been replaced, the powertrain control module has been relearned and there are no codes stored in memory. All of the shops have agreed that the problem is in the engine and not the cruise control. Have you heard of this problem or do you have any ideas?"

Marty Shackleton
TASCO
Charlotte, NC

One of my goals as a technician is to spend as little time as possible repairing a vehicle. And when it comes to driveability problems, most of the time is spent diagnosing the cause of the problem. So before second-guessing what may or may not have been done to this vehicle, let's start by confirming the basics. Have the ignition and fuel system been checked and found to be within specifications? If so, maybe we can determine what was overlooked.

Today, I always check TSBs on any extraordinary problem before I dive in and start replacing unnecessary parts. Up to several years ago, I would have assumed that if a vehicle received service at a dealership, all relevant technical service bulletins would have been checked. But I have learned that dealership technicians are humans just like you and me. I try not to assume anything.

I checked the TSBs for this vehicle, and there it was — surging at highway speeds. The Mitsubishi TSB (97-15-001) referred to the alignment between the intake manifold and throttle body. Misalignment may cause turbulence of the incoming air, which causes the air flow sensor to operate incorrectly and create a surge at highways speeds.

Results: Marty returned the vehicle to the dealership with TSB in hand. The gasket was replaced and the throttle body and intake manifold realigned. Marty's wife has been driving the vehicle for over 350 miles without a problem.

The question from the last *Counter Point* concerned a 1995 Chevrolet Lumina with a 3.1L engine. It was storing a code 77 and the EGR valve had been replaced three times — two new OE units and one from the aftermarket. The PCM had also been replaced. The vehicle appeared to be okay after replacing the EGR and clearing the code, but the MIL still illuminated after driving the vehicle on a long downhill stretch of road.

Before answering this question, I would like to say "thank you" for your many responses. This question generated the most responses we have received to date, and nearly all were correct. It is a pleasure writing to such a fine group of professionals.

The parameters necessary to set a code 77 on this vehicle are as follows:
• Engine speed between 1400 and 2000 RPM
• Manifold Absolute Pressure sensor between 20 and 30 kPa
• Throttle Position sensor angle at 0%

When these values are consistent, the PCM runs a function test on the EGR system. As the PCM energizes each of the EGR valve solenoids, it looks for a change in the MAP voltage. When it does not see a change in the MAP after three consecutive tries, the PCM will illuminate the MIL.

On most vehicles of this type, the MIL will turn off following engine shut down and will not illuminate with the next start-up. However, codes 75, 76 or 77 will be stored in the computer's history memory. This test is very similar to the way an OBD II system runs its monitor tests. It changes something in the system and watches for a reaction through another sensor.

The diagnostic tree associated with code 77 recommends an inspection of the electrical circuit related to the EGR. No mention is made of the need to check the integrity of the EGR passages in the intake manifold. In this case the EGR passage had a partial restriction. The EGR solenoid responded correctly when the PCM commanded it to move the pintle, but the PCM did not see a change in the MAP sensor voltage due to the blockage of carbon in the passage.

Results: Since clearing the carbon buildup in the passage, the MIL has not illuminated. A thorough check of the ignition, fuel and emissions system was also performed to help prevent a reoccurrence of carbon buildup in the EGR passages.

Refer to the October 1999 Wells Counter Point *for conclusive on- and off-the-car testing procedures for digital EGR valves.*

The first correct answer received by e-mail or fax was from:
Joe Powers
Broad-Elm Auto Center
Hamburg, NY

The first correct answer received by post was from:
Ralph Davis
Westfield, PA

Diagnose The Problem Win A Shirt

Q: "About a week ago, a 1992 Chevrolet K-1500 (5.7L engine) was towed in with a no-start problem. I determined it had no spark, due to a bad ignition control module and pick-up assembly. I replaced these parts and the vehicle seemed to run fine, so I returned it to the customer.

"It's back in the shop again, but now it's running rough and dying out. I thoroughly checked the ignition, engine management computer and engine mechanical systems, including the timing chain, and found no problem. I did notice that the ignition base timing was slightly retarded, even though I know I set it to specs a week ago. Do you have any ideas or suggestions?"

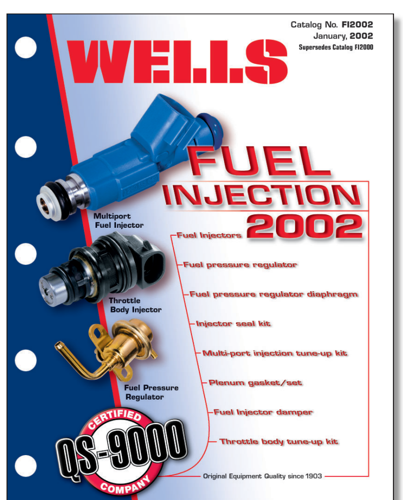
Scott Enzler
Dorsey's Auto Repair
Ukiah, CA

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.

Hot off the Wire

2002 Fuel Injection Application Catalog

Wells Manufacturing Corp. is pleased to announce the availability of its 2002 Fuel Injection Application Catalog. Over 170 new part numbers have been added to the Wells Fuel injection component line since the publication of the previous application catalog. A new product category — Fuel Injection Dampers — has also been added to this edition of the catalog. For more information about the Wells Manufacturing Corp. line of fuel injection components, contact your Wells parts supplier.



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OBD II...Catalyst Monitors

still may not run if certain conditions exist that would cause the test to fail or provide inaccurate results. These conditions could include:

- a misfire DTC is stored,
- an HO2S DTC is stored,
- an upstream or downstream HO2S rationality DTC is stored,
- a downstream HO2S heater DTC is stored,
- a Fuel Monitor Rich or Lean DTC is stored,
- the vehicle has stored a component DTC that caused it to operate in limp-home mode.

The catalyst monitor also will not run if the PCM determines that any of the following conflicts exist:

- the EGR monitor is in progress, or has not run,
- a fuel system intrusive test is in progress,
- the evaporative emissions purge monitor is in progress,
- the PCM timer indicates that the engine has not been running long enough.

A conflict will also be present if there is a maturing code in memory for:

- misfire,
- O2 sensor monitor,
  - upstream or downstream O2 sensor heater,
  - fuel system rich or lean.

Catalyst Monitor Measurement Methods

Assuming all of the conditions listed above have been met, the catalyst monitor is ready to assess catalyst oxygen storage capacity. If the engine is warmed-up and the inferred catalyst temperature is within limits, the monitor begins to count front and rear HO2S switches (crosscounts) during part-throttle, closed-loop fuel conditions.

When the required number of front switches have accumulated, the total number of rear switches is divided by the total number of front switches to compute a switch ratio. For example, if the upstream HO2S switches 100 times, and the downstream HO2S switches just 7 times, the efficiency ratio is 7 divided by 100, or 0.07. A switch ratio near 0.00 indicates the catalyst has high oxygen storage capacity and high HC conversion efficiency.

If the upstream HO2S switches 100 times and the downstream HO2S switches 95 times, the switch ratio is 0.95. A switch ratio near 1.0 indicates the catalyst has low oxygen storage capacity and low HC conversion efficiency. If the actual switch ratio exceeds the threshold switch ratio, the catalyst will be considered nonfunctional.

For Y-pipe systems, the two front HO2S sensor signals are combined into a single inferred front HO2S signal. The inferred front HO2S signal and the actual rear HO2S signal are then used to calculate the switch ratio.

To avoid a false catalyst monitor failure, all test results are processed by a mathematical formula called an exponentially weighted moving average (EWMA) as a final step. This formula allows the PCM to factor in abnormal conditions, which may cause the catalyst to temporarily underperform. During normal customer driving, a malfunction will illuminate the MIL, on average, in three to six driving cycles. By reseting the keep alive memory (KAM) in the PCM a malfunction may cause the MIL to illuminate in just two driving cycles.

Catalyst Monitor Failure Causes

If a catalyst monitor DTC sets, the cause of the failure must be determined. Catalytic converters generally do not wear out. However, several factors can damage the converter or contribute to a failure of the catalyst monitor. These include exhaust damage or leaks, catalyst contamination, catalyst overheating caused by engine misfire, rich or lean exhaust, replacement parts quality and alternate fuels/fuel composition.

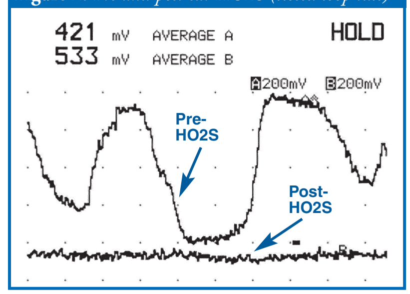
Figure 1: *Backprobing wiring harness at PCM to capture dual trace HO2S waveforms*

Relatively small exhaust leaks allow ambient oxygen to enter the exhaust stream. Depending on their size and location, they may:

- prevent a degraded catalyst from failing the catalyst monitor diagnostic.
- cause a false failure of a functioning catalyst.
- prevent the diagnostic test from running at all.

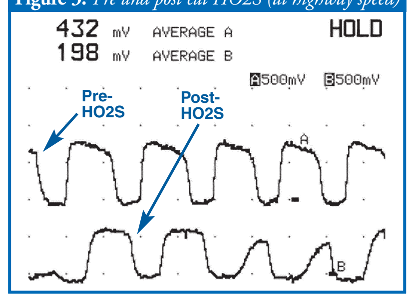
Substances found in fuel, engine oil or coolant that may contaminate the catalyst include phosphorus, lead, silica and sulfur. They coat the catalyst material, keep the converter from functioning properly and can affect the relationship between the catalyst's oxygen storage capacity and emission performance. Oil and antifreeze from a failed head gasket, cracked engine castings, leaking rings and valve guides are likely causes of contamination. The cost of repairing a blown head gasket on an OBD II vehicle may include new pre- and post-catalyst oxygen sensors, as well as a new converter.

Figure 2: *Pre and post cat HO2S (closed loop idle)*



Engine misfire allows unburned fuel to enter the exhaust system. When it reaches the converter, the catalytic effect allows it to continue burning. The converter was not designed to handle the added heat caused by this process. If it is allowed to continue, the converter will suffer overheating and permanent damage.

Figure 3: *Pre and post cat HO2S (at highway speed)*



For proper OBD II performance, the design and quality of all replacement parts must meet or exceed the specifications established by the vehicle manufacturer. For example, a replacement H02S sensor's performance characteristics may be different from the original equipment manufacturer sensor, which may lead to either a false pass or a false fail of the catalyst monitor diagnostic test. Similarly, if a replacement catalyst does not contain the same amount of cerium as the original part, the correlation between oxygen storage and conversion efficiency may be sufficiently altered to set a false DTC. Poorly engineered ignition modules and ignition wires may cause excessive carbon monoxide and/or hydrocarbons, leading to possible catalyst damage, as well as other OBD II-related failures and associated DTC's.

Although it is less likely to cause a failure of the catalyst, the composition of alternate fuels should also be considered. Some fuels are intentionally "oxygenated" to reduce vehicle emissions levels. Most modern fuel systems have been designed to accommodate the use of these fuels and their OBD II systems should be able to handle them without difficulty.

Next time: We'l look at long and short term fuel trim, and explain what this data reveals about engine management system health.

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

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INSIDE: Catalyst Monitors

Quality Points

Siemens High Speed Placement System

Automotive electronic components are getting smaller, yet they require a growing number of integrated circuits (IC's) and internal electronic chips to accomplish increasingly difficult tasks. Have you ever wondered how electronic components are assembled and the IC's and tiny chips are placed onto printed circuit boards (PCB's) with consistently high precision? To accomplish this feat, Wells has integrated two new Siemens high speed placement systems into its manufacturing processes.

The first stop in the PCB substrate assembly process is at the Siemens placement system. To ensure repeat accuracy, the PCB is placed on the transport the same way every time. For maximum speed and range, the Siemens system includes two revolver heads — each on a different gantry. Each head may have up to 12 vacuum-operated nozzles. When the PCB is ready to be populated, it and the feeders never move — the revolving heads do all the work.

A film carrier feeds the components to the system, using film that is similar to 8 mm movie film, but an electronic component takes the place of an image in each frame. After the component is cut from the film, a vacuum nozzle on one of the revolving heads collects it. To determine if the component is squarely placed on the nozzle, a digital picture is taken after the head has rotated 180 degrees from the component pickup point. At the next increment in its rotation, the nozzle rotates the component to a programmed placement angle. The computer uses this information to make adjustments to actions performed by the nozzles. After the PCB is populated, another camera photographs the PCB to ensure correct component placement.

Dave McDermid checks operation of the Siemens placement system. The revolver heads can be seen in the enlarged inset.

The entire substrate assembly process is a carefully choreographed electronic ballet that takes a blink of the eye, and is perfectly repeated with the next PCB.

Publisher's Information

Wells' President ....William Allen
Vice President of Sales....Gavin Spence
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