WELLS Counter Point

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THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

Evaporative Emissions Systems

As emission standards get tighter, keeping vehicles in compliance may also get tougher.

Ever-tightening standards force vehicle manufacturers to constantly look for new ways to reduce the emissions their vehicles produce. That means not just what comes out the tailpipe, but everything else the vehicle might emit, even when it's standing still with the engine off.

The biggest contributor to what might be called passive vehicle emissions is fuel evaporation. Given the opportunity, gasoline in liquid form will easily convert to a vapor. Leave the cap off a gas can, and you can be certain there will be less gas in the can a week later. The same thing will happen to fuel in a vehicle fuel tank, unless precautions are taken.

The one thing that will make fuel evaporate faster than anything else is heat. Heat surrounds fuel in the fuel system almost from the moment it leaves the tank. From there, it's pumped through the lines to the engine, where it passes through the fuel rail on the engine—picking up heat as it goes. The hotter it gets, the more it wants to turn to vapor. And any fuel vapor that is allowed to escape to the atmosphere contributes to the vehicle's total hydrocarbon emissions.

That's why all vehicles produced for sale in this country are now equipped with evaporative emissions systems, to trap fuel vapors that might otherwise escape to the atmosphere. The fuel system is a completely closed system that is designed to keep all fuel (both liquid and vapor) contained until it can be converted to energy by the engine. On late model vehicles equipped with onboard refueling vapor recovery (ORVR) systems, even the vapors that might otherwise be allowed to escape via the fuel filler neck during refueling are contained until they can be used. These onboard systems supplement the vapor recovery systems built into the gas station's refueling pump nozzle system, because it may be broken or malfunctioning due to careless use.

Early evaporative emissions systems were totally unmonitored. Once installed on the vehicle, it was relatively difficult to determine how well a system was doing its job. The advent of OBD II brought active evaporative emissions system testing. These tests gave the OBD II system the ability to routinely test the system, making sure it was performing up to par. Tests are conducted in the background and should be completely unnoticed by the driver. If a vehicle fails an evaporative emissions test, the OBD II system can turn on the MIL and store a diagnostic trouble code (DTC), alerting the driver and technician of a problem that could have a negative effect on evaporative emissions.

System Operation

Let's back up a few steps and briefly describe how a typical evaporative emissions system works. Early systems had only a few key parts. These included the charcoal canister, vapor lines between the tank and canister and a purge valve. Fuel vapors were routed from the fuel tank to the canister, where they were held by the charcoal element until they could be directed to the intake manifold and burned as fuel. Very primitive systems used a manifold vacuum port to determine when the vapors were allowed to reach the manifold, and to block all flow at idle and high vacuum cycles. A temperature-controlled vacuum switch usually blocked the flow of vapors until the engine reached operating temperature to limit the effect of the extra fuel on driveability and emissions.

Things have gotten a little more complicated since then. Fuel vapor management is now monitored and controlled by the powertrain control module (PCM). The same basic parts are used, with the addition of PCM-controlled purge and vent valves. The fuel cap continues to perform an important function, as it must maintain a leak-free seal on the fuel filler neck. For testing purposes, most systems also include a fuel tank pressure sensor. Evap system testing is only conducted when certain parameters are met. One important parameter to be met before testing is fuel level, so the PCM must be able to monitor that information as well. This is accomplished via the same fuel level sensor used by the gas gauge. A system service port with a green cap is located in the hose between the canister and the purge solenoid. The port contains a Schrader valve, allowing the connection of diagnostic tools.

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 2001 Chevy 1/2-ton Express for the past month or two. The engine intermittently will not start. I have checked for fuel and spark when the problem occurs. The fuel pressure, volume and quality are perfect, so I am sure it is not a fuel problem. When I checked it for spark, it didn't have any. The engine had spark after I replaced the control module and checked the distributor cap and rotor. It also started and ran great.

The no-spark condition returned about five days later, so I replaced the cap, rotor, coil, ignition wires and control module. That was about two weeks ago. Today, my customer called to let me know the truck would not start. I went to his place of business and installed another control module and Hall effect sensor. After that, it started and ran great (again).

There doesn't seem to be any consistency to the no-start pattern. At times the vehicle can go for weeks before the problem occurs. I noticed as I was replacing the cap and rotor that both were discolored. The rotor seemed to have a yellowish haze to it, and the distributor cap had a brownish tint on the inside. Could something else be damaging these control modules?

Ken Topp
Quality Auto Repair
Queens, NY

A: The most common cause for ignition control module (ICM) failure is high secondary resistance. You have already replaced all of the secondary ignition components, so we will rule them out as a possibility for now. Another cause for ICM failure is a bad grounding circuit. Perform a voltage drop test between battery negative and the grounding point of the ICM. With the engine running, the reading on your voltmeter should be .2 volts or less. Another cause for ICM failure is AC current from the charging system. Every charging system will emit some AC current. However, too much will eventually ruin the ICM. To verify, connect an AC voltmeter to the battery and start the engine. If the meter reads more than .5 AC volts, the alternator needs to be replaced or repaired.

Your last comment about the discoloration of the distributor cap and rotor gave me the feeling the module is not at the root of the no-start problem. Chevrolet Technical Service Bulletin (TSB) number 03-06-04-041 is related to the symptoms you describe. The TSB states: "This condition may be due to high levels of internal corrosion in the distributor, causing spark to go to the wrong cylinder. This corrosion is attributed to a lack of air flow internal to the cap caused by the EIP screens being clogged with debris."

I came across a very similar problem in the mid-seventies on six-cylinder AMC vehicles. A no-start could be resolved by reinstalling the distributor cap, which had a nasty habit of blowing off the distributor on these engines. At that time, nobody knew why this was occurring, but the cure was to drill vent holes in the base of the distributor. In the mid-eighties I ran service calls on GM vehicles that would not start and had no spark. If I removed the distributor cap and replaced it with the same one, the vehicle would start and run fine. Again the cure was to drill vent holes in the distributor. Years later, I'm reading a TSB that says problems like a P0300 may occur when the distributor vents are plugged with debris.

Anything that's allowed to obstruct or clog this small fresh air vent at the bottom of the distributor housing can cause difficult to diagnose intermittent no-start problems.

What is really happening inside the distributor? A spark gap consists of two conducting electrodes — in this case the rotor blade and distributor cap terminal. When a suitable current is supplied, a spark passes between the rotor blade and the distributor terminal, ionizing the air molecules (creating ozone) and drastically reducing their electrical resistance. As the ionized spark gap continues to conduct, it acts as a large current draw that attempts to pull the coil primary voltage toward ground. The spark continues to bridge the gap until the coil's voltage supply is interrupted and/or the path of ionized air molecules is broken.
This is why proper distributor venting is so important. I am sure you have seen holes or vents in the bottom of distributor housings. Yes, these holes vent moisture. But more importantly, they also allow the ozone-saturated air to escape the distributor and fresh air to enter. The ribs on the inside of the distributor cap add dielectric strength, and the ribs or fins under the rotor promote air flow through the distributor vents.

An electrical current will seek the path of least resistance to ground. It takes more current to jump the spark plug gap inside a cylinder that's on its compression stroke than one on its exhaust stroke. Without proper venting, the air inside the distributor becomes heavily ionized, which means it will more easily support an electrical current. The abnormally ionized air helps the spark make the jump from the rotor to the path of resistance — either the wrong distributor cap electrode or ground. So instead of reaching the spark plug in the cylinder that's on compression, it reaches another with very low compression or jumps to ground. The engine will no longer start due to a loss of spark to the correct cylinder(s).

As the TSB states, the discoloration is caused by the plugged vents. I am not sure why this happens. It could be due to the concentration of ozone, the heat generated during the spark gapping process or some other factor.

How many ignition control modules, distributor caps, crank sensors, etc. have been replaced while chasing this ignition system ghost? The next time you replace a distributor cap, check the inside for discoloration. It may be time to also sell a vent cleaning, too.

We were talking about a 2002 Toyota Camry with California emissions in the last *Counter Point* issue. Three O_2 sensors had been replaced, but codes were still popping up in the PCM. The first O_2 sensor was replaced after extensive bodywork had been performed.

"Replaced after bodywork." How many times have you read this sentence on a repair order? Then the real detective work to solve the mystery begins. No offense is intended to any body repair techs who may happen to be reading this publication. But more often than not, the problem turns out to be caused by a cut wire, a loose connector or something strange and out of the ordinary. The first step in this diagnosis should be to go back to basics and ensure that the correct part replacement was performed. Remember, this vehicle has California emissions.

In the January 2004 *Counter Point*, we discussed wide range air/fuel ratio sensors —

specifically Toyota's four wire A/F ratio sensor. One thing we didn't cover in that article was the harness connector and some of the issues concerning it. Depending on whether it's set up for 49-state or California emission requirements, a 2002 Toyota Camry may be equipped with either a conventional O_2 sensor or an A/F ratio sensor. The harness connectors for both are nearly the same and can be interchanged with a little modification.

In this case, the wrong sensor for the vehicle had been installed. This was pinpointed by measuring the voltage for the O_2 — 3 volts seemed a little high for a normal O_2.

Results: After replacing the O_2 sensor with an A/F sensor, the customer had a vehicle that looked *and* ran like a new car.

Editors' Note: Comparing the TPS and MAF oscilloscope traces is a very effective means of determining the health and responsiveness of the MAF. If you would like to view sample TPS and MAF traces demonstrating this technique, go to www.wellsmfgcorp.com. Click on the Diagnostics bar at the top of the page, then locate the Fall, 2004 *Counter Point* in Volume 8. The sample traces can be found in the "Editors Notes" department.

This quarter's winner is:
Tom Fitzpatrick
Wisconsin Emission Testing Center

Diagnose The Problem Win A Shirt

I am working on a 1998 Ford Explorer with a 4.0L engine that has a problem I have not run across before. When the engine is idling, I can hear a howling or rumbling noise coming from the air intake. It doesn't seem to matter what I do; I can't make it stop. The only thing I have found is that placing my hand over part of the MAF to restrict some of the air flow will change the way the noise sounds. Do you have any ideas?

David Hebert
Patin's Tire and Car Care
New Iberia, LA

If you think you have the answer to this diagnostic problem, we accept correspondence via e-mail, fax or regular mail. Please use the following contact information:

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continued from page 1

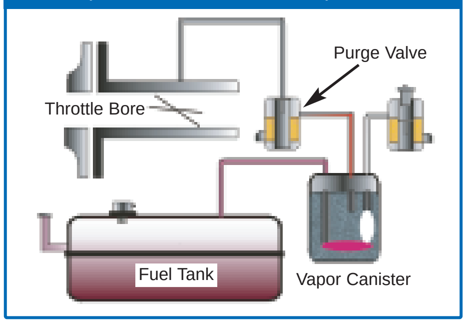
Evaporative Emissions Systems

Under normal operating conditions, the vent valve is opened during purge modes, allowing fresh air to enter the canister. The purge valve is normally closed and is pulse width modulated by the PCM to control the flow of fuel vapors. When energized, the purge valve allows fuel vapor and air to flow from the canister to the engine, where it's burned.

OBD II Self Tests or Monitors

As mentioned earlier, OBD II does not assume that the evaporative emissions system is functioning properly and has no leaks, so it conducts several very specific tests to make sure that everything is normal. Those tests, and the methods by which they are carried out, vary from manufacturer to manufacturer and even from model to model produced by the same manufacturer. What follows are generalized outlines of some basic OBD II evaporative emissions self-tests. For more information about the OBD II evaporative emissions tests conducted on a specific vehicle, consult your service information sources.

Figure 1: *The evaporative emission system's vapor canister traps fuel tank vapors as they escape from the fuel tank. There, they mix with air and wait to be recycled.*



The *power-up test* is a passive test designed to detect restrictions or blockages in the vent path. The test runs when the vent valve is open, the purge valve is closed, the engine is cold and the ignition key is in the RUN position with the engine OFF. The test only runs when all of the enable criteria are met. For example: the fuel level must be somewhere between 15 and 85%. Under normal conditions, the fuel tank pressure sensor should not indicate excessive vacuum during this test.

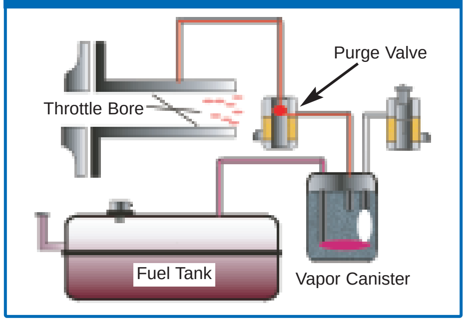
The *excess vacuum test* is another passive test designed to detect vent path restrictions. The test runs during normal canister purging, when the vent valve is open. Under normal conditions, the fuel tank pressure sensor should not indicate excessive vacuum during this test. Enabling criteria must be met before the test will run, and like the power-up test, fuel level must be between 15 and 85%.

The *loaded canister test* on non-ORVR systems is a passive test which monitors the PCM's duty cycle command to the purge valve to determine canister loading. A relatively large amount of vapor stored in the canister will cause a slow change in duty cycle rate, indicating that the canister is sufficiently loaded. A faster change in the duty cycle rate indicates insufficient canister loading.

The *weak vacuum test* is an active test designed to detect very large leaks. The PCM commands the vent valve closed during normal canister purging, which should cause the fuel pressure sensor to indicate a vacuum. A large leak would keep a vacuum from being created in the system and the PCM would set a large leak DTC. This test is only conducted during normal canister purge, after the loaded canister test has been run, and it has been determined that the canister is not sufficiently loaded. The fuel tank level must be between 15 and 85%.

The *small leak test* is an active test designed to detect minor leaks. The test runs immediately after the vehicle passes a weak vacuum test and will only run when the fuel tank level is again between 15 and 85%.

Figure 2: *The PCM opens the duty cycle-controlled purge valve and fuel vapors are allowed to reach the throttle bore. They mix with the incoming air and are burned as fuel.*



While a vacuum is still present in the fuel tank, the vent and purge valves are commanded closed to seal the system. The PCM then monitors the fuel tank pressure sensor to determine the rate of vacuum loss (decay). If the decay rate is too fast, the PCM will store a small leak DTC. Early systems are calibrated to detect leaks as small as 0.040-inch (1 mm), while newer systems can detect leaks half that size (0.020-inch or .5 mm).

What If?

Under ideal circumstances, the vehicle will always pass every test the OBD II system subjects it to. But that gets harder to accomplish as time and mileage accumulate, especially with such tight leak detection thresholds. If (or when) a vehicle fails an evap test, it will store a DTC, which is where you'll enter the picture. In the next *Counter Point* issue, we'll provide additional guidance on evap system diagnosis and repair. See you then. WELLS

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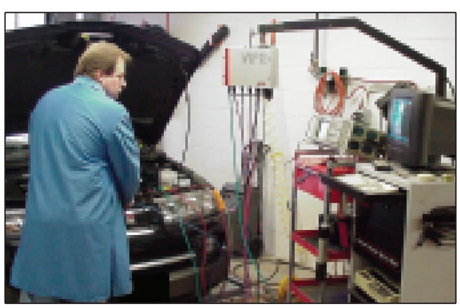
Quality Points

Wells Dyno Testing

After reading earlier *Counter Point* articles, you may have gotten the impression that our component testing begins and ends in the laboratory with active environmental testing. This and other tests are essential to prove our components will withstand the test of time and the environment. That's why we shock-test components from one temperature extreme to the other, while subjecting them to maximum output to verify solder connections and the ability for the component to breathe or flex. But our component testing doesn't end there.

We also subject our components to a final, very important test by installing them on vehicles and monitoring their performance over time. These tests are conducted by the technicians overseeing the operation of the dynamometer room. Whether it is an OE revision or a new component, the ultimate test is to install it on a vehicle and test it under actual operating conditions.



Engineering Technician Dan Crain conducts component testing, using a chassis dyno and other test equipment.

The dyno room is filled with enough equipment to make most technicians turn green with envy. We have incorporated an in-ground dynamometer, a portable five-gas analyzer, scan tools, ignition analyzer, lab scopes and any other resource you can imagine to test and measure late model as well as older vehicles. Vehicles can be operated under a controlled load while precisely monitoring the function of any of its systems. WELLS

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