Tech Feature: Detecting Misfires in OBD II Engines

fire problem may continue unnoticed and undiagnosed until the vehicle fails a tailpipe emissions test, or until the spark plugs are replaced and suddenly the engine runs like new again.

With OBD II, there's no missing misfires. Most engine control systems with OBD II monitor the speed of the crankshaft between cylinder firings to detect misfires. The powertrain control module (PCM) notes the relative position of the crankshaft via the crankshaft position sensor (CKP) each time a trigger pulse is sent to the ignition system. If the crankshaft does not rotate a certain number of degrees between cylinder firings, the change in rotational velocity indicates a misfire must have occurred.

Blind Logic
Any misfires that are detected are recorded and tracked over time. If the rate of misfires exceeds a certain threshold, the OBD II logic is programmed to log it as a potential emissions failure and set a misfire fault code. The check engine light comes on and a P030X is set where X corresponds to the cylinder that is misfiring.

A code P0302, for example, would tell you cylinder number two is misfiring. If more than one cylinder is misfiring, there will be additional codes for those cylinders as well. And if a misfire is random and jumps from cylinder to cylinder, you may find a P0300 random misfire code.

On most applications, OBD II uses a "block learn" strategy to track misfires. Any misfires that occur are recorded every 200 revolutions of the crankshaft. The tally is stored in 16 memory blocks, so every 3,200 rpm the misfire count starts over again.

As long as the number of misfires in any given memory block remains below a certain value, there is no problem and OBD II gives that block a "pass" rating. But if the number of misfires in that block is too high, the block receives a "fail" rating. By averaging the pass/fail ratings of all 16 blocks, the OBD II system gets the big picture of what's actually going on. This helps avoid the setting of false misfire codes, and also allows the system to spot pattern misfires that may cause an increase in emissions or damage to the catalytic converter.

One of the drawbacks of using a crank sensor to detect misfires is that it can sometimes be fooled by normal powertrain vibrations. Driving on a rough road, for example, may produce variations in crank speed that seem like misfires but are not. Some OBD II systems monitor inputs from the ABS wheel speed sensors to tell when a vehicle is driving on a rough road, and disable misfire detection until the road smoothes out.

The OBD II system is usually programmed to ignore misfires when the engine is cranking, and when a cold engine is first started. It will also ignore misfires during decel when the fuel is momentarily cut off. In most cases, a misfire problem will set a pending code on the first trip, but won't turn on the check engine light or set a hard code until the second trip if the misfire problem continues.

The OBD II misfire monitor is normally active when a warm engine is running under normal loads, but it may not track misfires if other fault codes are present or codes are pending for the fuel system, evaporative emission control (EVAP) system or EGR system.

One very important point to keep in mind about OBD II misfire detection is that the system does not tell you why the engine is misfiring. OBD II can give you an exact count of the misfires cylinder by cylinder (which you can find in Mode $06 with a scan tool), but it can't tell you what's causing the misfires.

Why Misfires Are Bad

Every engine will experience an occasional misfire. As long as the misfires are fairly random and spaced far enough apart, it causes no harm. But a frequent or steady misfire will cause a sharp rise in unburned hydrocarbon (HC) emissions, a noticeable drop in power and a significant decrease in fuel economy.

HC emissions are a factor in urban smog, but can also be very damaging to the vehicle's catalytic converter. When a cylinder misfires, that cylinder's dose of air and fuel passes unburned into the exhaust. When it reaches the converter, the fuel ignites and is burned up.

This causes the converter's operating temperature to shoot up hundreds of degrees. So a bad misfire can make a converter run really hot. If it gets hot enough, the ceramic or metallic honeycomb inside the converter may melt, creating a partial or complete exhaust restriction. The increase in backpressure will kill performance and fuel economy, and also may cause the engine to overheat.

Or, it may cause the engine to stall by strangling off the flow of exhaust.

If you discover a heat-damaged or plugged converter, the old converter will have to be replaced. You will also have to diagnose and fix the problem that caused the misfire that lead to the converter failure, too.

Misdiagnosing Misfires

Misfires can be caused by one of three things: fuel mixture problems (too rich or too lean, or not enough fuel), compression problems, or ignition faults.

If the cylinders are flooded with too much fuel, it can foul the spark plugs and prevent them from firing. This was often a problem with misadjusted chokes on carburetors, or bad floats or leaky fuel bowl inlet valves. With electronic fuel injection, it's much harder to flood an engine (though not impossible). Even so, a rich mixture can be caused by restrictions in the air intake system, too much fuel pressure (check for a blockage in the fuel return line from the fuel pressure regulator), or leaky fuel injectors.

A bad coolant sensor that prevents the engine control system from going into closed loop can also make the fuel mixture run rich, and possibly rich enough to foul out the spark plugs.

A much more common cause of fuel-related misfires on fuel injected engines is too much air and not enough fuel (lean misfire). The OBD II system may or may not detect the fault and set a lean code (P0171 and/or P0174) in addition to misfire codes.

Unmetered air that gets into the engine behind an airflow sensor can lean out the fuel mixture to the point where it may not ignite when the spark plug fires. Air leaks can occur in vacuum hose connections, the throttle body or intake manifold gaskets, the PCV or EGR systems, or past fuel injector O-ring seals.

Lean misfires typically affect multiple cylinders, and will often set a P0300 random misfire code rather than a cylinder-specific misfire code. If you find misfire codes for two adjacent cylinders, check for air leaks in the intake manifold near those cylinders. Also, if one or more cylinders near the EGR port in the intake manifold are misfiring, a leaky EGR valve may be the culprit.

Vacuum leaks have the most effect on the air/fuel mixture at idle, and less of an effect at higher engine speeds. If you suspect a vacuum leak, look at the fuel trim values on your scan tool when the engine is idling, and again at 2,500 rpm. If the engine is running lean only at idle, it has a vacuum leak. If it is running lean at all speeds, the problem is in the fuel supply or control system (weak pump, leaky regulator, bad sensor inputs to the PCM, etc.).

You can also use a simple vacuum gauge to detect vacuum leaks. If the reading is low and floating, air is being pulled into the engine somewhere. A smoke machine can help you pinpoint leaks that may be difficult to detect in the manifold plumbing.

Another common cause of lean misfires is a dirty mass airflow sensor. If the MAF sensor wire has become coated with dirt, carbon or fuel varnish, it may underreport actual airflow causing the engine to run lean. Cleaning the sensor element with aerosol electronics cleaner can often restore normal operation and cure the misfire.

Lean misfire also may be caused by a bad fuel injector or a bad injector driver circuit in the PCM. If a cylinder isn't getting any fuel or the correct amount of fuel, it will misfire.

Low fuel pressure due to a leaky fuel pressure regulator, weak fuel pump or plugged fuel filter may also lean out the fuel mixture to the point where lean misfire becomes a problem. So to rule out these possibilities, it may be necessary to check fuel pressure and volume.

Don't forget that a weak fuel pump may be able to achieve normal fuel pressure at idle, but may not be able to deliver enough volume at higher engine speeds to keep up with the engine's demands.

Compression misfires will occur if a cylinder fails to hold compression because of a leaky head gasket, bent valve, burned exhaust valve or broken valve spring. Low compression also can cause misfires if a cam lobe has rounded off.

These types of problems also can be found with a vacuum gauge. A flickering vacuum reading typically indicates a cylinder with a compression problem. You can follow up with a power balance test, a compression test and/or a leak down test to further isolate the fault.

Ignition Misfires

If the engine has strong, steady vacuum, no compression issues or fuel delivery problems, an ignition fault is the only other thing that can cause a misfire (except maybe for bad gas!).

Any fault that prevents the spark from jumping the electrode gap on a spark plug will result in a misfire. This includes low primary voltage to the ignition system, low output voltage from the ignition coil, excessive resistance, shorts or opens in the spark plug cables (if the ignition system has wires), excessive resistance, shorts or opens in the spark plug itself (such as a cracked insulator), a fouled spark plug, or a spark plug with worn or damaged electrodes.

When there's a misfire code for a specific cylinder, always remove and inspect the spark plug. It can save you a lot of time if the plug is fouled or damaged. Oily deposits on the plug would tell you oil is being sucked into the combustion chamber past worn valve guides or seals, or worn or broken piston rings. There's no easy fix for this kind of problem short of a valve job or overhaul. Installing a spark plug with a slightly hotter heat range may help resist fouling.

Spark plugs also can be fouled by coolant leaking into a cylinder, or short-trip driving if the plugs never get hot enough to burn off fouling deposits.

On engines with waste spark distributorless ignition systems, misfire codes for any cylinders that share a common coil would tell you the coil is the likely problem.

If a coil-on-plug (COP) ignition system has a misfire that only affects one cylinder, swapping coils between two cylinders is a quick way to see if the misfire changes cylinders. If the misfire follows the new location of the coil, it confirms the coil is bad. If there's no change, the misfire is being caused by a bad plug, a compression problem or a lean fuel condition in that cylinder.

Scope Diagnostics

Many technicians either don't have an oscilloscope, or if they do, they may not use it because it takes too long to hook up, or is too confusing to use. On coil-on-plug ignition systems, you have to use some type of adapters or inductive pickups to capture the ignition signals because there are no plug wires for an inductive pickup to clamp onto. And even if you have a scope or a scan tool with scope functions that can display ignition waveforms, it takes a certain level of training and experience to read ignition patterns.

If you do have a scope, the secondary ignition pattern generated by the spark plug when it fires can reveal a lot of useful information — if you know what to look for.

When the firing voltages for all of the cylinders are displayed simultaneously in a parade pattern, any cylinder that is misfiring for any reason will usually stand out from the rest. The peak firing voltage (peak KV) for the misfiring cylinder will either be higher or lower than the other cylinders.

Normal firing voltages at idle may vary from 5 KV to 15 KV, but there should be no more than about 3 KV variation between cylinders.

A higher firing voltage indicates higher than normal resistance in that cylinder's ignition circuit. This may be due to high resistance in the spark plug wire (if it has one), a wide rotor gap (if it has a distributor), high resistance in the spark plug itself (worn electrodes or gap set too wide), or a lean fuel mixture.

A lower than normal firing voltage means decreased resistance. Causes include shorted plug wire or spark plug, grounded or fouled spark plug, an overly rich fuel mixture, or possibly low compression.

Of course, many ignition-related misfires won't show up at idle on a scope. You have to do a cranking KV test and/or snap KV test to stress the ignition system, or put the vehicle on a road simulator or dyno to see if the engine misfires under load. The latter is often due to carbon tracking or small breaks in the coil tower insulation.

We don't have the space in this article to explore all of the nuances of reading spark firing lines, but one area worth looking at is the slope of the burn line after the initial firing of the spark plug. If it slopes up (positive), the cylinder may have a lean fuel mixture (check for a vacuum leak or a dirty fuel injector) or a compression problem. If the burn line slopes down (negative), the fault is usually ignition related such as a fouled spark plug or bad plug wire.

Comparing the ignition pattern to the oxygen sensor waveform can also help you diagnose the cause of a misfire. With every misfire, the O2 sensor will show a dip in its voltage output as the puff of unburned oxygen from the cylinder passes by the sensor. An ignition misfire or compression leak will typically produce a sharper drop in the O2 sensor voltage reading than a lean misfire.