Coil-On-Plug (COP) Ignition

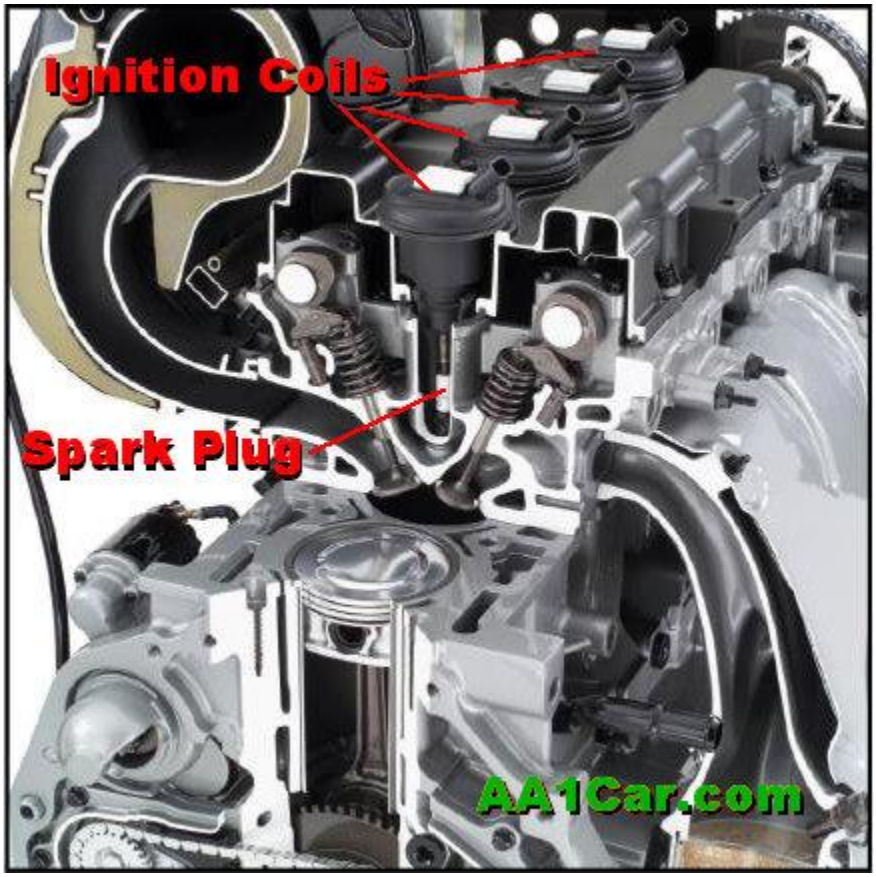
First it was the distributor that vanished. Now plug wires are starting to disappear. What is next, the spark plugs? The answer is yes, but that will not happen until direct fuel injection systems that combine the injector and spark plug into one assembly start appearing in a few years. In the meantime, you will have to learn how to diagnose and repair the current generation of coil-on-plug (COP) ignition systems.

Spark plugs wires are going away for the same reason that distributors went away. Vehicle manufacturers want to reduce costs and improve ignition performance and reliability. Plug wires are an assembly line nuisance, and are often the weak link in distributorless ignition systems. The plug wires must carry anywhere from 5,000 up to 40,000 or more volts to fire the plugs. This requires heavy insulation plus the ability to suppress electromagnetic interference (EMI). The wires must also be coated with a tough outer jacket to withstand high temperatures in the engine compartment and chemical attack.

As reliable as todays plug wires are, there is always the potential for trouble. Even the toughest insulation can burn if a wire rubs up against a hot exhaust manifold. The connection inside the spark plug boot between the wire and plug terminal can also be damaged if someone jerks on the wire to remove the boot when changing spark plugs.

Plug wires can also radiate magnetic fields that may affect nearby sensor wires or other electronic circuits.

Attaching the ignition coils directly to the spark plugs eliminates the need for separate high voltage wires along with their potential for trouble. Eliminating the individual plug wires also eliminates the need for wire looms and heat shields. That is why coil-on-plug ignition systems are being used on a growing number of late model engines.



Coil-On-Plug ignition system on a General Motors Vortec 3500 engine.

COIL-ON-PLUG IGNITION ADVANTAGES

Getting rid of the plug wires not only saves money, it also improves the durability of the ignition system. No high voltage wires means no voltage leaks and no misfires due to "bad" plug wires. Using individual coils for each spark plug also means the coils have more time between each firing. Increasing the "coil saturation" time (the time the voltage to the coil is on to build up its magnetic field) increases the coil output voltage at high rpm when misfire is most apt to occur under load.

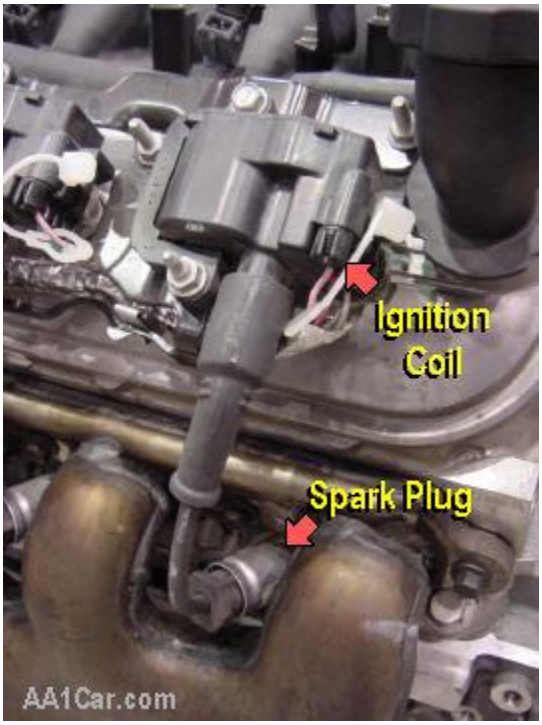
Chrysler says its COP ignition system on its LHS and 300M engines delivers 28% more spark energy than earlier ignition systems. This improves combustion and reduces the risk of misfire with lean fuel mixtures (lean mixtures require more voltage to ignite reliably).

COP ignition systems are used on many late model engines. On most applications, the plugs and coils are located on top of the cylinder head for easy mounting of the coils. A topside location is best because it keeps the coils away from the heat of the exhaust. This is the type of configuration Chrysler uses on its late model 2.7L, 3.2L and 3.5L engines in the Chrysler Intrepid, LHS and 300M models.

Some other applications with COP ignitions include General Motors "Integrated Direct Ignition" (IDI) found on the 1988 through 1995 2.3L Quad Four engine, and the 1996 and newer 2.4L engine single overhead cam engine that replaced the Quad Four, 1997 and newer Cadillac Catera 3.0L, 1998 and up Lincoln Town Car 4.6L, 1996 and up Ford Taurus 3.4L, and many import nameplates including late model Acura, Honda, Infiniti, Isuzu, Lexus, Nissan, Saab and Toyota.

Many engines cannot be equipped with COP ignitions because the location of the spark plugs does not leave enough room to mount individual coils over the plugs, or the plugs are too close to the exhaust manifold.

For example, on the current "Gen III" small block V8 in Corvette, Camaro and Firebird, the spark plugs are located on the side of the cylinder heads and surrounded by the exhaust manifolds. There is no room to mount the coils directly on the plugs, so GMs engineers put the coils on the valve covers and connected each coil to its spark plug with a short wire. This is called a Coil_Near_Plug or CNP ignition system.



A Coil-Near-Plug ignition system on a General Motors LS V8.

COIL-ON-PLUG IGNITION SYSTEM COMPONENTS

In a typical COP ignition system, a crankshaft position (CKP) sensor generates a basic timing signal by reading notches on the crankshaft, flywheel or harmonic balancer. The crank sensor signal goes to the powertrain control module (PCM), where it is used to determine firing order and turn the individual ignition coils on and off. On Chrysler 2.7, 3.2 & 3.5L COP applications, an additional timing signal is needed from a camshaft position sensor located in the timing belt housing cover just above the left camshaft sprocket.

Chrysler crankshaft position sensors produce a square wave signal that goes from a high of 5.0 volts to a low of 0.3 volts. The sensor is located on the passenger side of the transaxle housing so it can read three sets of slots in the flywheel. Two sets contain 4 slots each, and one set contains 5 slots for a total of 13 slots. Basic timing is set by the position of the last slot in each group. Once the PCM detects the last slot, it determines which piston is next in the firing order from the camshaft position sensor. This means the engine may have to crank at least one revolution before the PCM can sort out the proper firing order and start zapping the plugs.

Chrysler also uses an Auto Shutdown Relay (ASD). The ASD relay routes battery power to the ignition coils, and is energized by the PCM as long as receives signals from both the crankshaft and camshaft position sensors. If the engine stops turning (stalls), the PCM deengerizes the ASD relay and shuts down the ignition system. The ASD relay also supplies battery voltage to the fuel injectors, so when it shuts down it cuts off both ignition and fuel. At the same time, the PCM also deenergizes the fuel pump relay to turn off the fuel pump. For "limp in" capability, the Chrysler system can run with input from the crankshaft position sensor only. The ASD and fuel pump relays are both located in the Power Distribution Center.

The operation of the ignition system is essentially the same as any other ignition system. Each coil has a low primary resistance (0.4 to 0.6 ohms in the case of Chrysler), and steps up the primary system voltage from 12 volts to as much as 40,000 volts to produce a spark for the spark plug. On the Chrysler COP systems, there is also a coil capacitor for each bank of coils for radio noise suppression.

The only real difference between COP and other ignition systems is that each COP coil is mounted directly atop the spark plug so the voltage goes directly to the plug electrodes without having to pass through a distributor or wires. It is a direct connection that delivers the hottest spark possible. Resistor plugs are generally used to suppress EMI.

COIL-ON-PLUG IGNITION MISFIRES

COP problems can include many of the same ailments as other ignition systems such as misfiring, hard starting or a no start. Spark plugs can still be fouled by oil or fuel deposits as well as preignition and detonation. So COP ignition systems are not immune to trouble.

If the crankshaft position sensor fails, the loss of the basic timing signal will prevent the system from generating a spark and the engine will not start or run. A failed driver circuit within the PCM can kill an individual coil and prevent that cylinder from firing. But with COP, an individual coil failure will only cause misfiring in one cylinder.

It is important to remember that ignition misfire can also be caused by other factors such as worn or fouled spark plugs, loose or damaged coil connectors or terminals, dirty fuel injectors, low fuel pressure, intake vacuum leaks, loss of compression in a cylinder, even a tankful of "bad" gas contaminated with water. These other possibilities should all be ruled out before a COP unit is replaced.

The most common trouble codes you may encounter with COP systems on OBD II equipped vehicles are P0300 series codes such as P0301, P0302, etc. that indicate a misfire in a particular cylinder. The important point to remember here is that a general misfire code (P0300) is probably not ignition related but is due to a vacuum leak or fuel delivery problem.

A code that indicates a misfire in a single cylinder (such as P0304), on the other hand, will usually be due to a fouled spark plug, weak coil, dirty or dead fuel injector, or loss of compression (burned vale or leaky head gasket).

If a misfire is due to a bad coil, you should find a coil code that corresponds to the same cylinder (P0351 to P0358).

If a misfire is fuel related, you should also find a code that indicates an open or shorted injector in that cylinder (P0201 to P0208).

A COP engine that cranks but fails to start, in many cases, will often have a problem in the crankshaft position sensor circuit (code P0320). Loss of the camshaft position sensor signal (code P0340) may prevent the PCM from properly synchronizing the fuel injectors, but may still allow the engine to start and run in a limp-in mode.

On the Chrysler applications, a code P1388 or P1389 would indicate a fault in the auto shutdown relay circuit, while a P1282 would point you toward the fuel pump relay control circuit.

COIL-ON-PLUG IGNITION CHECKS

Individual ignition coils can be tested with an ohmmeter the same as those on a conventional distributor or DIS ignition system. Measure primary and secondary resistance and compared to specifications. If resistance is out of specifications, the coil is bad and needs to be replaced.

Also, pay close attention to the tube that wraps around the spark plug. Cracks can allow voltage to jump to ground causing a misfire. The spark plug terminal should also fit tightly.

Typical coil-on-plug ignition coil.

If a COP coil tests bad and is replaced, future problems can often be avoided by cleaning the COP connector and wiring harness terminals. Corrosion at either place can cause intermittent operation and loss of continuity, which may contribute to component failure. Applying dielectric grease to these connections can help prevent corrosion and assure a good electrical connection.

Magnetic crankshaft position sensors can be tested with an ohmmeter, and the sensor output voltage and waveform can be read with an oscilloscope. The output voltage of a Hall Effect crankshaft position sensor can be checked with a voltmeter. On most vehicles, a bad crank position sensor will usually set a fault code which can be read with a scan tool.

SPARK PLUGS

As for spark plugs, long life platinum plugs are used with most COP ignitions. Such plugs are capable of going 100,000 miles under ideal conditions. But keep in mind any plug can still succumb to fouling and misfire if an engine burns oil, develops an internal coolant leak or runs too rich.

More Ignition Articles:

Crankshaft Position CKP Sensors

Spark Plug Technology

Don't Neglect the Spark Plugs

Why Spark Plugs Still Need To Be Replaced

Ford Motorcraft Spark Plug Breakage Problem (2004 - 2008 Ford Trucks w/5.4L V8, & 2005 - 2008 Mustang GT with 4.6L V8)

Analyzing Ignition Misfires

Misfire Diagnosis Chrysler 3.5L V6

Engine Won't Start, No Spark

Diagnosing An Engine that Won't Crank or Start

Spark Plugs & Ignition Performance

Spark Plug Wires

Distributor Ignition Systems

Distributorless Ignition Systems

Ignition Coil Diagnosis & Testing

Click Here See More Carley Automotive Technical Articles