

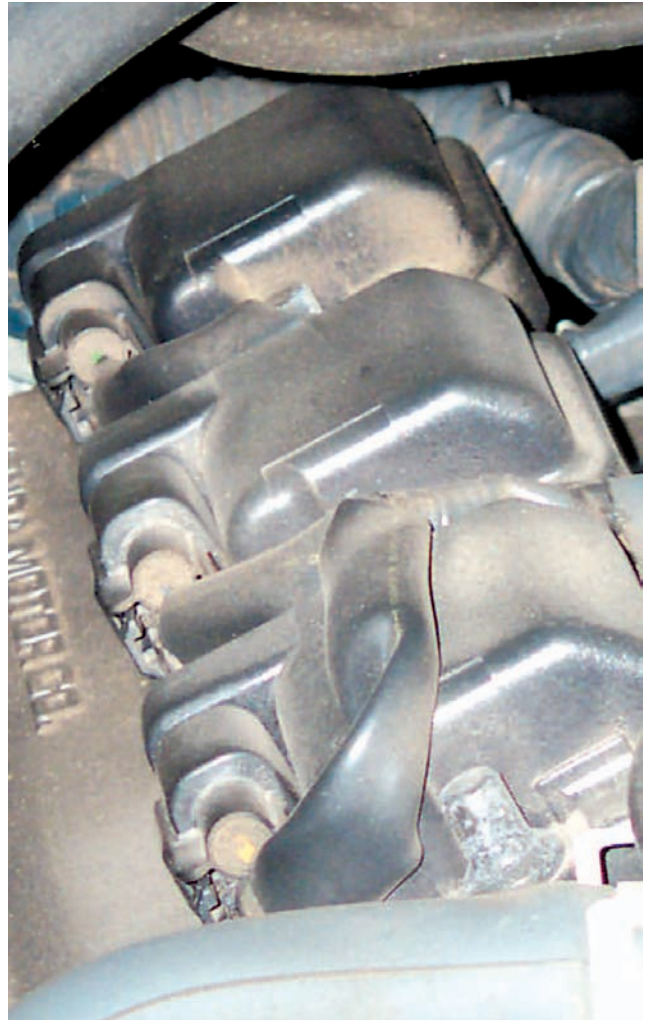
# Coil-on-Plug Ignition

## What did they do that for?

**A** coil atop every spark plug. OK, it's easy enough to see it's possible. But the question is, why is this a reasonable way to set up an ignition system? Obviously, it costs more to build and buy (as well as to diagnose or fix) than any other kind of ignition system, but what are the positives? Why have some carmakers chosen to go with this system for specific vehicles? While we're at it, let's look at the fastest ways to test the system if it's not working.

COP (coil-on-plug) ignition sparks the fire for many different cars, among them Audi, BMW, Daimler-Benz, Honda-Acura, Lexus, Nissan, Toyota and Volvo. Generally COP ignition is reserved for the more expensive and/or higher performance models in a carmaker's line since the system is more expensive to build and is not necessary for most cars in most driving conditions. Many carmakers using COP also build systems using waste-spark ignition, which we discussed in the March 2000 *Import Service*, so be sure you understand the difference between the two multi-coil systems. Waste-spark ignition always uses one coil for every *two* spark plugs; COP always uses one coil for *every* plug. Dual ignition is something else entirely: That's when the enginemaker uses two separate spark plugs per cylinder and two separate ignition systems; dual ignition can be conventional, waste-spark or COP.

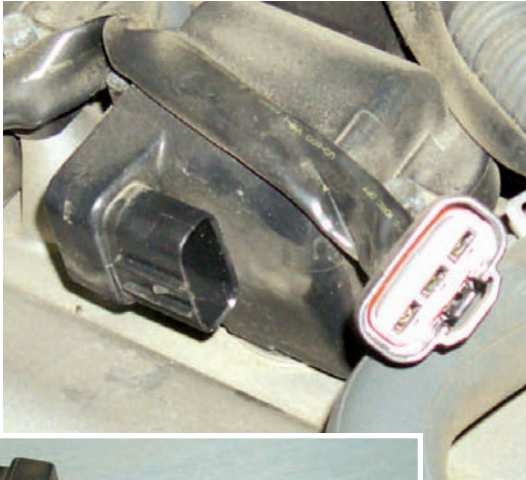
What does coil-on-plug do, then? Having an individual coil for each spark plug solves several problems; notably it gives each coil much longer to build the magnetic field — the collapse of which generates the high-voltage secondary spark.



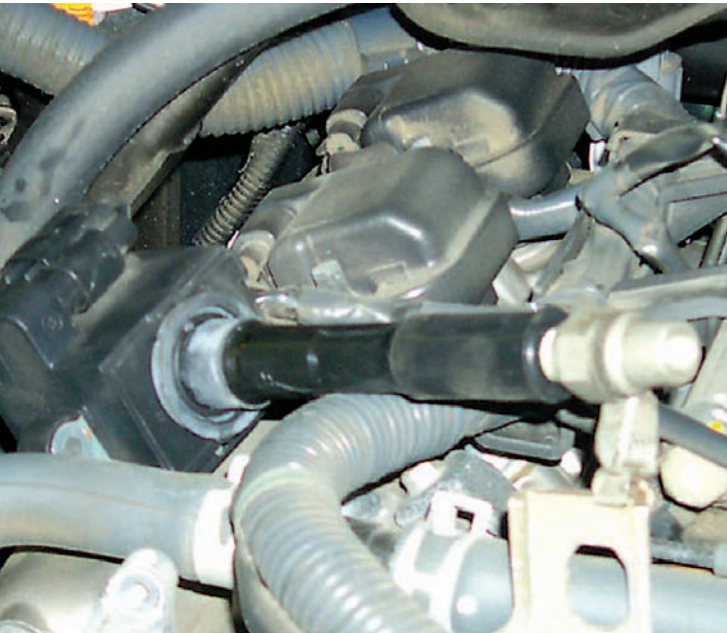
On a six-cylinder engine, that means the coil has six times as much time to build the field as would the single coil of a conventional distributor-ignition system or twice as much time as each paired coil of a waste-spark system. Having more time means it needs lower current — it will still take the same amount of electrical *energy* to build the electromagnetic field, but the magnetic buildup can be more leisurely.

Why should that be a good thing? Who cares how hard or how fast an electric circuit has to work? Well, EMI-sensitive components on adjacent circuits care, particularly those wired to the computer. Induced interference is the result of oscillating magnetic fields, and they correspond directly to the amount of current going through their circuits. If you can reduce that current, you reduce the magnetic field in direct proportion.

What's more, with the COP system, you scatter the source of ignition EMI around the engine, burying most of the secondary circuit in the cylinder head.



**Above:** Could hardly be simpler. Two terminals are the primary circuit; the third is the ground for the secondary (but read the text for why you can't check that last).



**Below:** Checking for spark is elementary. Disconnect the coil from its plug, connect a plug tester, ground the tester and crank, watching for the spark.

With smaller currents building different magnetic fields in different places, your chance of a troublesome EMI-buildup is much reduced. You can also be sure of a hot spark for each plug even if the battery or charging system is temporarily down-voltage, and you can more closely tie the sequence of the ignition system together with the sequence of the fuel injection. Last, with what amounts to a separate ignition system for each plug, your chances of a no-start or a dead-on-the-road are much reduced since the likelihood that the same problem will occur to all of them simultaneously is low — except for the components they share, like the charging system, the computer and the sensors that factor the spark distribution and timing.

### On the Job

Just like the cop on the beat, COP ignition is right there where the action is, at the spark plug. Some systems installed on engines with deeply buried spark plugs include a short conductor to bridge the gap between the coil secondary output terminal and the plug connector; others have a coil squatting immediately atop the plug.

On each system so far except Toyota's, there are four electrical connections, three to the harness coming to the coil and one to the plug. Toyota uses five connections since each coil includes its own 'igniter' (module) and requires independent power and a ground for that.

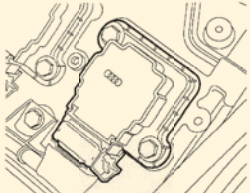
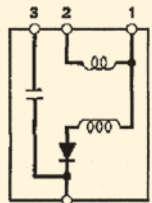
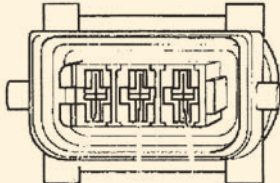
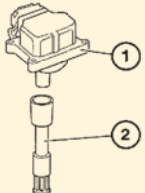
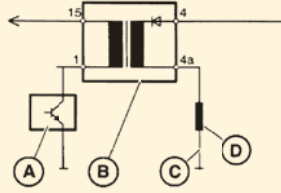
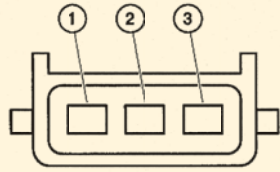
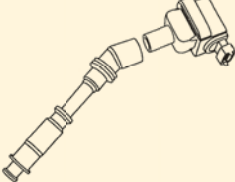
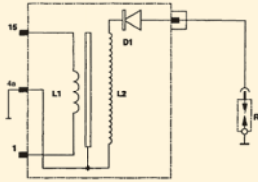
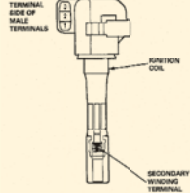
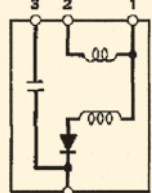
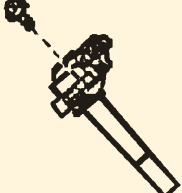
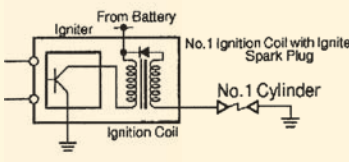
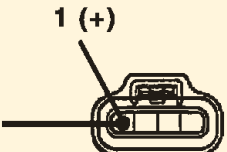

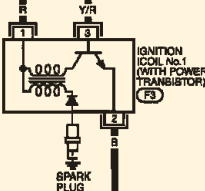
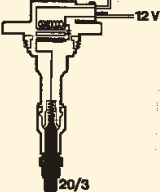
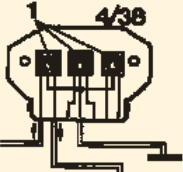
On the other systems, the three connections to the vehicle harness include two for the ignition primary and one serving as the ground for the secondary. On early COP ignitions, it was as simple as that. The problem was that if the ignition coil shorted, this could and often did melt the circuit driver in the computer, a rather expensive no-spark. Later versions use ignition driver stages separate from the computer and either diodes or capacitors to insulate the computer from the ground spike generated when the electromagnetic field collapses and fires the spark.

These more prudent designs have an odd diagnostic consequence: You can measure the resistance of the primary circuit (typically from 0.4 to 1.1 ohms at ambient, but varying by carmaker), but not of the secondary. The diode or the capacitor installed to protect the upstream computer and module (or driver stage, or whatever they choose to call it) can block the several hundred volt induced spike on the secondary ground circuit. It's no matter at all for them to block the wisp of a volt your ohmmeter will try to drive through them. Most systems' computers monitor that ground circuit to identify problems for that cylinder's ignition. A capacitor block, for instance, can allow evidence of the peak secondary voltage through, and some systems include DTC's for that.

# Coil-on-Plug Ignition

## Coil-on-Plug Ignition Systems

The similarity between the COP ignition systems is striking. Not only do the coil units resemble one another outwardly, most of them are internally wired in almost exactly the same way. Only Lexus/Toyota includes some module zelectronics with the unit.

Carmaker	Line Drawing of Coil	Wire Diagram of Coil	Primary Test Points
Audi			
BMW			
Mercedes Benz			
Honda/Acura			
Lexus/Toyota			
Nissan			
Volvo			



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So how do you check the secondary? You don't. If the primary circuit ohms out right at ambient temperature and you have the right electrical inputs and a functional spark plug but no spark, all that's left is the secondary winding. As Sherlock Holmes says, if you eliminate the impossible, what's left, however improbable, is the truth.

### What Comes Out?

How do you test for spark on these latest and highest-technology ignition systems? In the simplest of all ways: Pull one loose from its plug and connect it to a spark tester. *Make sure the test plug is grounded! Don't hold the coil in your hand during the test!* You won't do it twice, in any case, because 50 kV has a way of remaining fresh and vivid in your mind, even over time. Crank the engine, and watch for a half-inch blue one.

But how can you observe the secondary pattern with all the works buried deep in aluminum? There are several ways. Some COP units include a surface against which you can connect your inductive pickup, especially the HEI-type; some will yield a pattern to a cone of metal foil carefully wrapped around the base of the coil; all of them can be rigged with a short length of regular spark plug wire between the business end of their coil and the plug, though this is a little time-consuming. Then just grab around the wire with your regular pickup.

There's nothing exotic about the coil patterns exhibited by COP systems, and since everything's in the one package, the repair technique is simple. If the pattern is bad, replace that COP unit. If there's no pattern, of course, better check the wiring upstream before you fork over coin. *Junk-in, junk-out* is a good rule, provided you know you've

got *junk-in*.

### What Goes In?

You should already know this, at least in principle. Something has to turn on the electrical circuit through the primary windings at the right time. Something has to break that circuit at the moment the spark should occur. Because there's no distributor, the system obviously needs to know the engine's place in the Otto cycle (which cylinder is where in its squish-blam! — blow-suck sequence) from a camshaft position sensor. Some systems let it go at that; most use a crankshaft position sensor to fine-tune the spark timing.

If you crank the engine while measuring through the terminals connected to the primary circuit, you should see a square wave corresponding to the computer's commands to that coil to turn on and turn off. If you find that pattern, the problem is in the coil, connector or plug (or a mechanical or fuel problem). If you don't, the problem is upstream, in a sensor, a driver stage or the computer itself. Obviously, if you have no spark at any of the coils, the likelihood that all the COP coils have simultaneously failed is low. If you find one coil that doesn't work when the others do, the problem is more likely in that coil or its portion of the wiring harness.

COP ignition looks complex, but really isn't. Rather than a single complex ignition system, it's a number of relatively simple ignition systems, one for each cylinder. This should make the system easier to diagnose than some of its 'simpler' predecessors. ■

—By Joe Woods