AIRTEX®
ENGINE MANAGEMENT COMPONENTS
Counter Point
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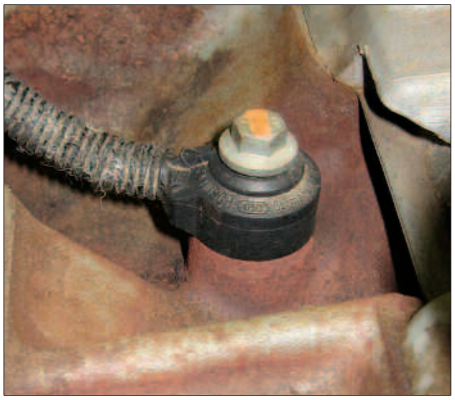
THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

Engine Knock Sensors

Engine knock limits performance and can cause permanent damage. This time, we'll look at its causes.



Under certain conditions, combustion in a spark ignition engine can degrade into an abnormal preignition process that causes a "knocking" or "pinging" sound. This undesirable combustion process limits the engine's output and specific efficiency levels. It occurs when the fresh air/fuel mixture preignites in spontaneous combustion before being reached by the expanding flame front.

Under normal combustion chamber conditions, the spark at the spark plug starts the burning process. A wall of flame spreads rapidly in all directions from the spark, moving outward through the compressed mixture in the combustion chamber until all of the charge is burned. The speed with which the flame spreads is called the *rate of flame propagation*. During combustion, the pressure in the combustion chamber increases to several hundred pounds per square inch (psi), and may exceed 1,000 psi in a modern high compression engine.

Under certain conditions, the last part of the compressed air/fuel mixture, or *end gas*, will explode before the flame front reaches it. The end gas is subjected to increasing pressure as the flame progresses through the air/fuel mixture. This increases the end gas temperature (due to the heat of compression and also radiated heat from combustion). If this temperature increases beyond the critical point or is maintained for a sufficient length of time, the end gas will detonate before the flame front arrives. Flame velocities in excess of 2000 meters per second (m/s) can occur, compared to speeds of roughly 30 m/s during normal combustion.

When the end gas explodes before the flame front reaches it, there will be a sudden and sharp pressure increase, followed by a very rapid oscillation of pressure in the combustion chamber. Shock waves from this explosion progress rapidly through the burned gases in the combustion chamber and strike the exposed surfaces of the piston, cylinder head and cylinder walls. These shock waves, or pressure pulses, bounce off the metal surfaces and pass back and forth at sonic speeds through the gases, creating a series of pressure pulses in the gases which cause the characteristic engine knocking noise.

The repeated shock wave blows can impose severe stress on engine parts. Shock loads are applied to the piston, connecting rod, crankshaft and bearings. Bearings, in particular, are susceptible to rapid failure under severe knocking conditions, although pistons, rods and crankshafts have also failed from this condition. Chronic preignition also causes increased thermal stresses at the cylinder head gasket and in the vicinity of the valves. All of these factors can lead to permanent mechanical damage.

A number of environmental factors can influence an engine's tendency to knock. For example, a hot engine will knock more easily than a cold engine. A 20° F rise in air temperature increases an engine's octane requirement by about three octane numbers. An increase in humidity from 40 to 50 percent at 85° F reduces an engine's octane requirement by one octane number. This follows the common perception that an engine will run better and more quietly in damp weather. Engine deposits increase octane requirements because they increase the compression ratio. Advancing the spark or leaning the air/fuel ratio increase the engine's octane requirement. Last of all, higher altitudes reduce an engine's octane requirement because the air is less dense.

It requires an appreciable time, measured in microseconds (0.000001 second), for the mixture to begin to burn. Increasing the temperature in the combustion chamber reduces this time. So if the temperature in the combustion chamber gets hot enough or is maintained long enough, the end gas will explode prematurely. Several methods may be used to prevent knock. Increasing the rate of flame propagation allows the flame to reach the end gas in time. Subtracting heat from the end gas reduces the likelihood that it will preignite. And using a fuel that is chemically more stable will allow the engine to tolerate higher temperatures without knocking.

Knock can also be controlled by limiting the amount of spark advance. On engines with a

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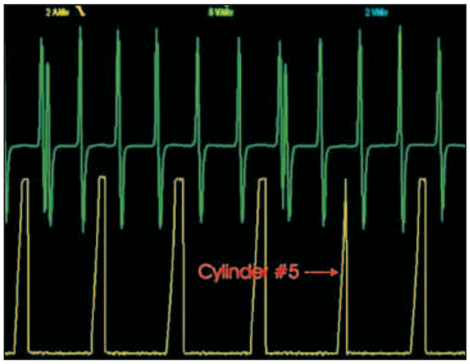
Fine Tuning

Fine **Tuning** *questions are answered by Mark Hicks, Technical Services Manager. Please send your questions to: Mark Hicks c/o* ***Airtex Engine Management, P.O. Box 70, Fond du Lac, WI 54936-0070*** *or e-mail him at* ***mhicks@airtexproducts.com****. We'll send you a very nice golf shirt if your question is published. So please include your shirt size with your question.*

In our previous issue we were working on a 1995 Pontiac with a 3.1L engine. Our scan tool indicated cylinder number 5 was misfiring. We amp clamped the ignition control module feed wire and received an interesting result. The number 5 cylinder amperage reading was much different from the others.

An amp clamp can be an extremely valuable tool. But to use it effectively we first need to understand what it is displaying. Amperage is the amount of electrical energy flowing through an application at any given time. This measurement is expressed in units called amperes, often shortened to amps. It is also referred to as current or current flow.

In our scope pattern we are looking at the amperage draw or current flow through each of the ignition control module transistor drivers for the primary windings of each coil. When the current flow begins it is not a 90 degree vertical rise. It will ramp up until the current limiting built into the module turns ON. When this happens the flow will level or flatten. When the transistor turns OFF the amperage will fall nearly vertical to zero.



On certain types of GM control modules, including this one, the point the transistor is turned on is determined by the module, based upon the input data it receives. The point the transistor is turned off is determined by the ECM through the EST signal. It's what is between those two points that is really interesting. The dwell time or actual coil primary winding charge time is determined to a great extent by the coil inductance. Inductance (L, measured in henries) is an effect that results from the magnetic field surrounding a current-carrying conductor.

Electrical current through the conductor creates a magnetic flux proportionate to the current. Now that's a mouthfull. Inductance is a term techs don't hear very often. What matters to us is this: if the secondary resistance changes, the primary winding charge time will also change.

Take another look at the diagram. Notice how the other cylinders are firing. They all ramp up, reach a plateau, then plunge nearly vertical to the zero line. The number 5 cylinder never comes to a plateau. It ramps up and comes to a point, indicating the charge time is abnormally short. It didn't take much current flowing through the primary winding to fire the coil's secondary winding. The inductance for this coil was very low at the point of firing the number 5 cylinder.

When I first looked at this pattern, I wondered about the companion cylinder (cylinder number 2). Why don't we see a change in the amperage when it fires? After all, both cylinders are being fired by the same coil. The answer was simple: waste spark. When number 5 cylinder is on the compression stroke, number 2 is on the exhaust stroke. Low compression equals low resistance and inductance.

What could cause this pattern to occur?

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Quality Points

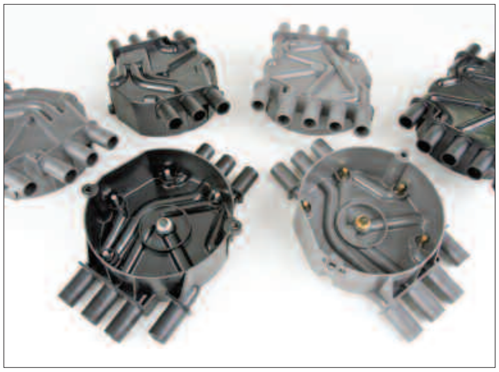
5D1078 & 5D1079 Distributor Caps

The first high-tension distributor was developed around 1904. Distributors were used in GM vehicles up to the 2003 model year. The distributor has been around almost as long as we have. All of us at Airtex Engine Management are celebrating our company's 105th year of business.

Distributor output demands have steadily increased through the years. Due to the limited amount of space available in the engine compartment, the last GM distributor cap had a very unique design. A typical cap would have the suppression ignition wires crisscrossing the top because several of the wires must reach from one side of the cap to spark plugs on the opposite side of the engine.

This design has all the wires on each bank connect to the corresponding side of the cap. Due to the firing order, connections to the wires must crisscross inside the cap. This design is a candidate for early destruction. With the internal high current paths placed very close together and made of either brass or aluminum, any void in the plastic or a tiny misrouting of a wire will cause an internal arc and cap failure.

During the construction of these distributor caps, every single wire is checked in a gauge at the time of bending to verify accuracy. We also utilize a high grade polyethylene–terephthalate plastic, which has a dielectric strength of 750 volts per .001 inch. This plastic must be a superior grade because it is the only barrier between the high voltage carrying wires. Before the plastic injection process begins the wires are placed in another gauge to verify accuracy and to prevent any movement during the plastic molding process. After the molding process is complete every



cap is once again tested, this time to ensure that it has no voids in the plastic and is high voltage tight.

Since 1904, engineers have been looking for the perfect distributor cap. This cap's design and the meticulous processes that are used to manufacture it have moved the industry closer to perfection than ever before. AIRTEX

I have already given you a hint to the cause and that was low compression. I am sure you know the spark has little resistance under low compression. That's right, anything that could cause a low resistance situation will cause this scope pattern. On this vehicle it was a shorted spark plug. It could just as easily have been a defective ignition wire, coil, low compression, etc. But, our amp clamping led us in the right direction.

How about high resistance? What happens to our scope pattern then? You guessed it, dwell or ON time will increase to help the coil bridge the gap. As the spark gap increases the coil will need more time to charge the windings. The module will recognize this and adjust accordingly on this system.

If you have never used your labscope and amp clamp to perform this test, maybe you will give it a try. And if you have been using it, perhaps this article gave you some additional insight. I know it has for me. I'd like to thank the engineering team at Airtex Engine Management for their help.

Diagnose The Problem Win A Shirt

We are working on a 2001 Chevrolet Pickup with a 4.3L engine. The engine runs pretty well, but it has a diagnostic trouble code P0300 (random cylinder misfire) and the scan tool shows the number 4 cylinder has a misfire. I checked cylinder number 4 for spark. It looked good but I still replaced the wires, plugs and distributor as a precautionary measure. I also checked for vacuum leaks and found a small leak at the intake manifold. I replaced the gaskets, MAP sensor and EGR valve, but the problem remained. Fuel pressure is good at 65 lbs. After replacing the fuel injectors and the PCM, the problem is still there. I checked compression and all the cylinders are between 158 and 172 lbs, with cylinder number 4 at 160 lbs. I also replaced the valve springs on cylinder number 4 and guess what? The problem is still there. I also checked the crankshaft sensor and it looked good but I replaced it anyway and the problem is still there. What am I missing?

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Jacksonville, FL

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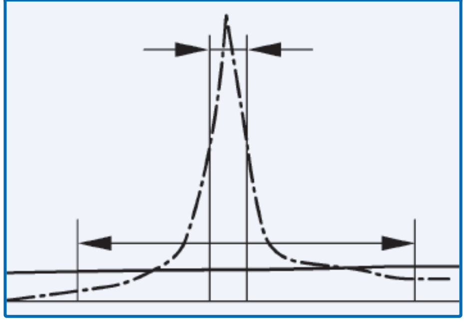
Engine Knock Sensors

fixed spark advance curve, the advance is normally designed with a safety margin to limit total advance at a point before the knock limit is reached. Because the knock limit depends upon fuel quality, as well as engine and environmental conditions, the spark advance is normally retarded more than necessary to maintain an adequate safety margin. The result is increased fuel consumption and reduced performance.

If allowed to continue, preignition can cause serious internal engine damage, as this damaged spark plug illustrates. Before systems were developed to monitor and control knock, spark advance was limited to avoid the possiblility of engine knock and knock damage.

This disadvantage could be avoided if the knock limit were determined continuously during operation. The ignition advance then could be continuously adjusted, in a closed loop operation, just below the point where knock begins. The only problem is, how do we let the control unit know when the engine has begun to knock?

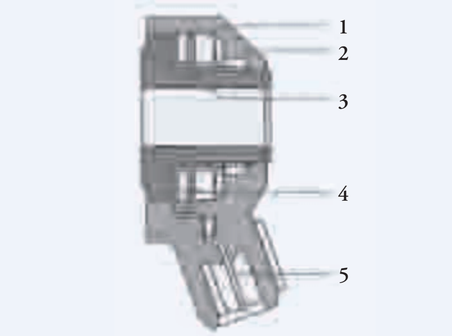
A piezoelectric knock sensor is capable of registering engine vibrations within a set frequency range that has been associated with engine preignition and knock. The weak voltage signal generated by the sensor is sent to the PCM for evaluation and corrective action.



In 1880, Jacques and Pierre Curie made a discovery regarding the characteristics of certain crystalline minerals. The crystals became electrically polarized when subjected to a mechanical force. Tension and compression generated voltages of opposite polarity that were in proportion to the applied force. The converse of this relationship was also confirmed. If a voltage-generating crystal was exposed to an electric field, it lengthened or shortened according to the polarity of the field, and in proportion to the field strength. These behaviors were labeled the *piezoelectric effect* and the *inverse piezoelectric effect*, respectively. *Piezo* is taken from the Greek word *piezein*, meaning to press or squeeze.

The magnitude of piezoelectric voltages, movements or forces are small and often require amplification to make them useful. A typical piezoelectric ceramic disc will increase or decrease in thickness by only a fraction of a millimeter, for example. Despite these limitations, piezoelectric materials have been adapted for use in a wide range of applications, including the subject of our discussion: the *knock sensor*.

In this cutaway view of a flat response-type knock sensor, its seismic mass (1), cast mass (2), piezo-electric cereamic (3), contacts (4), and harness connection (5) are visible.



The knock sensor consists of a *piezoceramic ring*, a *seismic mass* and *contact electrodes*. The complete unit is attached to the engine block at an appropriate location. The knock sensor is accelerated due to engine vibrations, causing the seismic mass to generate a force to the piezoceramic ring. The piezoceramic ring generates an electrical signal which is proportional to the vibrations in a specific frequency range. If the engine starts to knock due to low octane fuel or other operating condition changes, the knocking signal is detected by the PCM and the ignition timing map is adjusted accordingly.

Two major knock sensor designs are used today: *broadband single wire* and *flat response two wire* knock sensors. Both sensor designs use piezoelectric crystals to produce and send signals to the PCM. The amplitude and frequency of this signal varies, depending upon the vibration levels within the engine. Broadband and flat response knock sensor signals are processed differently by the PCM.

We will dig deeper into knock sensor design and operation in the next ***Counter Point.*** We also will share some valuable information on engine management system strategies and knock sensor diagnosis.

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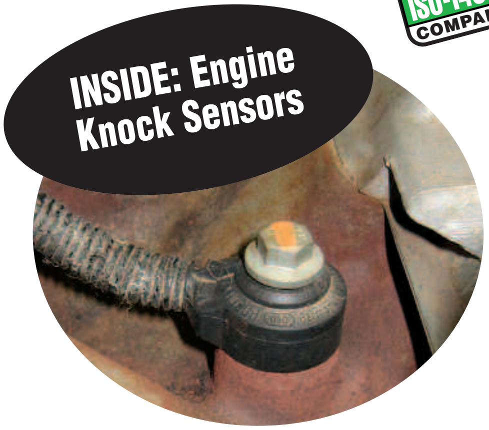

INSIDE: Engine Knock Sensors

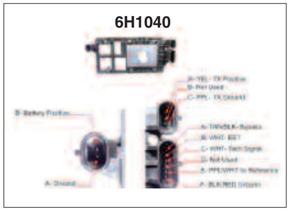
Hot off the Wire

Airtex Engine Management Website

As promised, we are keeping you up-to-date with additions to our website. What a great tool it has turned out to be! If you have not visited recently, go to www.airtexengmgmt.com. We're sure you'll be pleased with the plethora of available information.

For example, you will find all the previous *Counter Point* newsletters available for PDF downloads, OBD-II trouble code descriptions with up to five of the most common causes are at your fingertips, as well as coil specifications with connection diagrams, etc.

We've recently added more tools to your diagnostic arsenal. One is Component Pin-Out (shown below). Just enter the component part number you are testing and the part image and pin-out explanation come up.



We have also added process and instructional videos of real world failures and fixes. The videos stream very quickly, even on a dial-up connection, or you can download them for carside use with your MPEG4-compatible media player. Stay tuned — we have lots of additions coming!

Publisher's Information

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